

“GREEN REVOLUTION IN FOUNDRY – LOST FOAM PROCESS”

SHREE NARAYAN GREENTEK PRIVATE LIMITED



Lost foam casting classic

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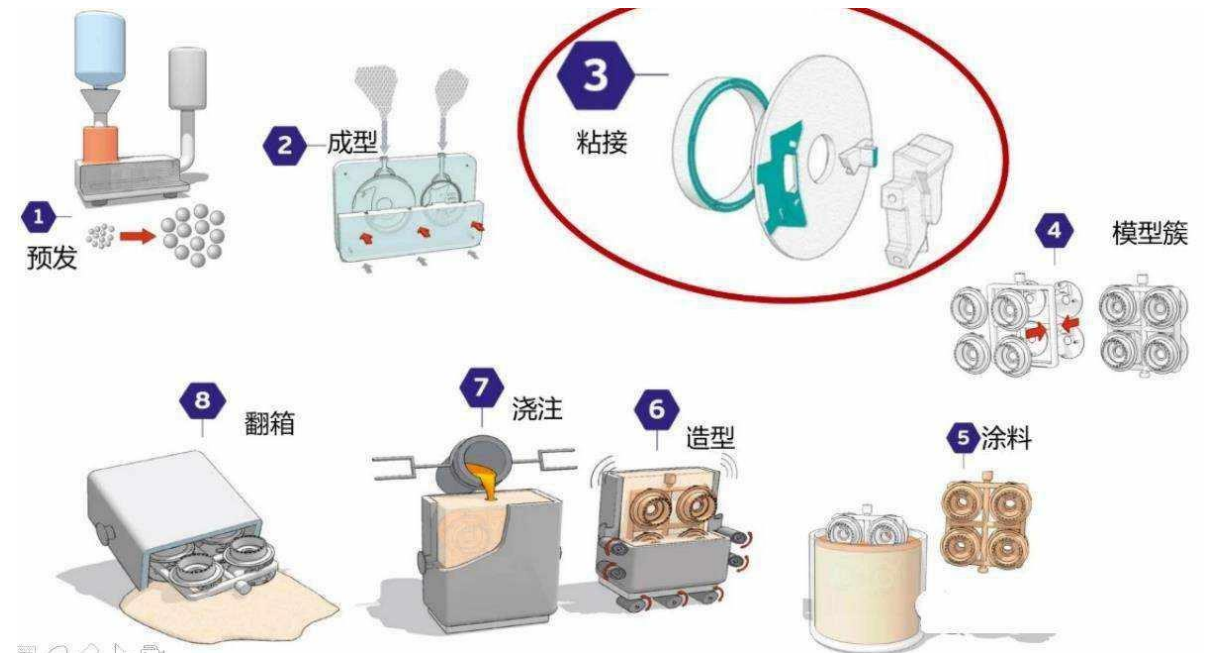
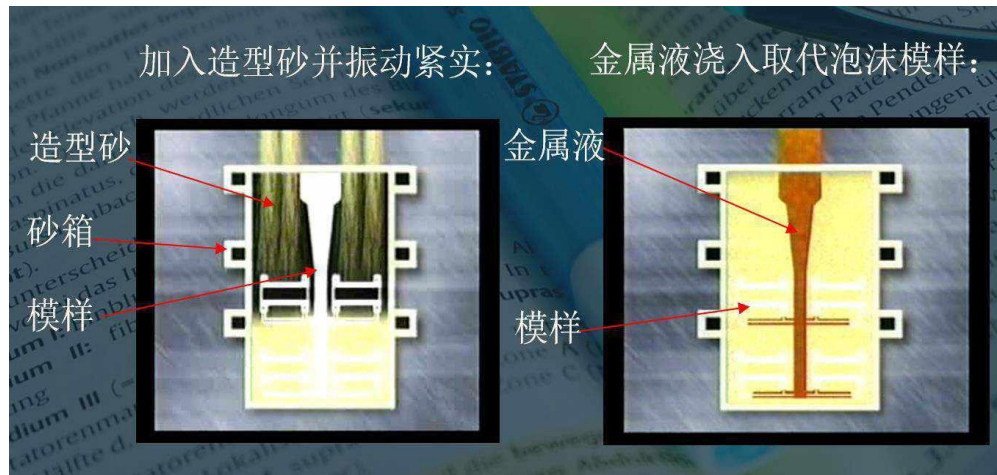


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Chapter 1: Brief introduction of lost foam casting process

1.1 Brief history and recent development status of lost foam casting

Lost foam casting (also known as full mold casting) is made of expandable polystyrene (EPS, STMPA, EPS) into a foamed pattern that is exactly the same as the structure and size of the parts to be cast, and is coated with refractory coatings (to strengthen, smooth, and air-permeable) and dried, buried in dry sand and subjected to three-dimensional vibration modeling. The molten metal is poured into the casting flask under negative pressure, so that the polymer material pattern is thermally decomposed, gasified and extracted, and in which liquid metal replaces cooling and solidification to form castings.



Chapter 1: **Brief introduction of lost foam casting process**

1.1 Brief history and recent development status of lost foam casting

1958: H.F.SHROYER in the United States invented a patented technology for manufacturing metal castings with expandable polystyrene (patent number USP2830343)

1961: German company GRUNZWEIG and HARRTMANN purchased and developed this patented technology, and in 1962 it became industrial application. The technology of using binder-free dry sand to produce castings was patented by H.NELLEN of Germany and T.R.SMITH of the United States in 1964.

1967: Germany's A.WITTEMOSER uses magnetized iron pellets instead of silica sand as modeling materials, and uses magnetic field as a binder, This is the so-called magnetic casting.

1971: Japan's NAGANO invented the V method (vacuum casting method). Lost foam casting is also fixed by vacuum in many places to mold the sand.

1980: Before 1980, the dry sand process without binder must be approved by the United States "FULL MOLD PROCESS INC". After that, the patent became invalid, and the lost foam technology has been developed rapidly all over the world.

Chapter 1: Brief introduction of lost foam casting process

1.1 Brief history and recent development status of lost foam casting

※ The history of lost foam casting:

From 1990 to 2000, a group of world-renowned industrial companies such as General Motors Corporation of the United States, Fiat of Italy, and BMW of Germany launched the lost foam casting process in phase order.

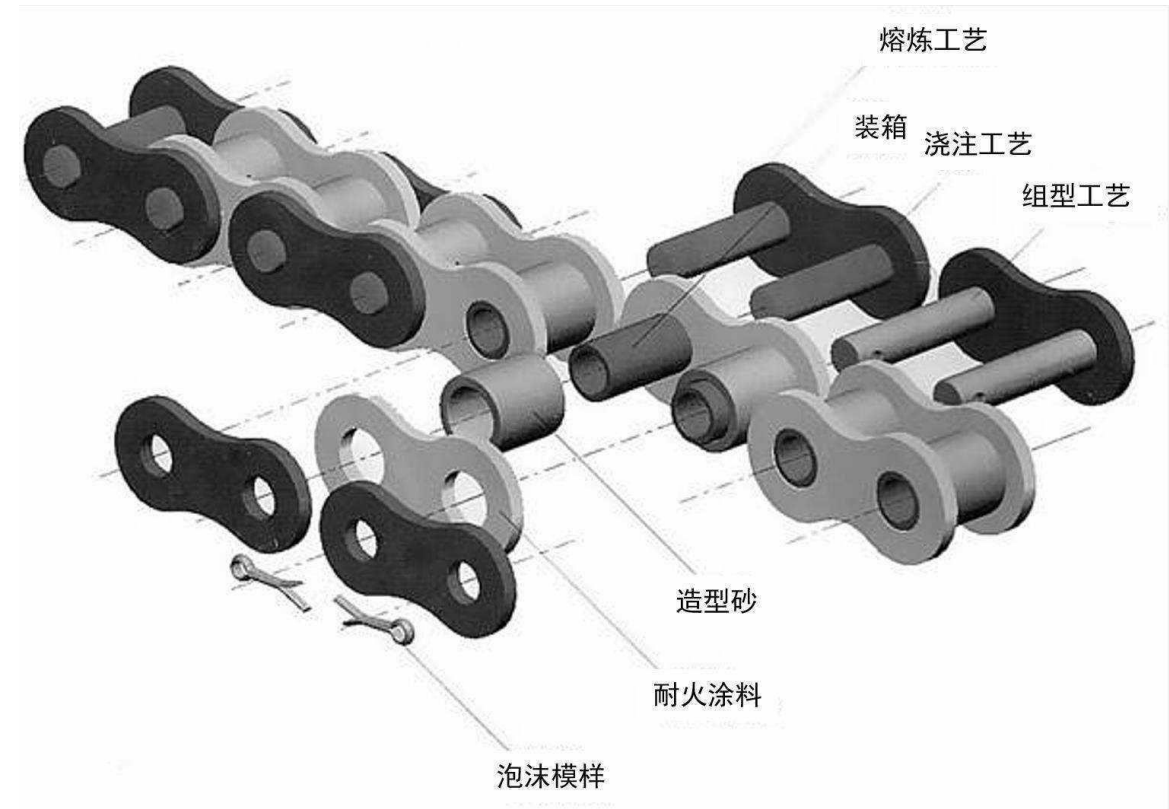
Lost foam casting in my country began in the late 1990s, and institutions and related companies began to study lost foam casting. In the early stage, due to the shortcomings of raw and auxiliary materials and related equipment, there has been no significant improvement.

In 2000, the country began to use the lost foam casting process to produce pipe fittings, auto parts, mining machinery parts, agricultural machinery parts and other related castings on a small scale. In 2007, it began to use the lost foam casting process to produce related casting products for multiple industries on a large scale. There are about 1,800 mold casting companies.

In recent years, the production of lost foam casting in China has developed rapidly. The quality and production technology of castings have been continuously improved. The varieties of castings range from simple wear-resistant parts and gray iron parts to the mass-produced engineering machinery parts and auto parts (Huaen, Long Engineering and other companies), pipe, pump and valve products that require pressure test (produced by Xinxing Casting Pipe, Liaoning Aiweier and other companies), complex structure cylinder blocks and cylinder heads (produced by Quanchai and other companies), water-cooled products (Produced by Fujian Juneng and other companies) and ductile iron (produced by Jiangsu Juyuan, Gaoyou Jingcheng Hydraulics, etc.), low-carbon steel (produced by Ningbo Tongda, Luoyang Gangfeng, etc.), aluminum alloy (Fast Group Ltd produces). Such as those produced by special companies have made great progress in production technology and product quality.

1.2 Characteristics of lost foam casting process

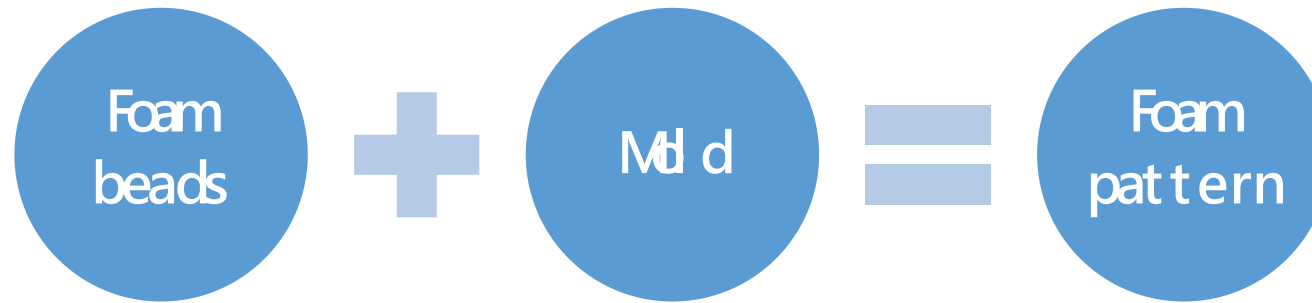
Lost foam casting is a typical "big process, small step, chain type" system engineering. Any small omission in any step can lead to defects. There is no distinction between the severity and the priority. Once the defect is formed in the process step, since the follow-up cannot be remedied, the product out of each process step must be a finished product.



1.3 The essence of lost foam casting process

The essence of the lost foam casting process is to complete the replication of three processes, as follows:

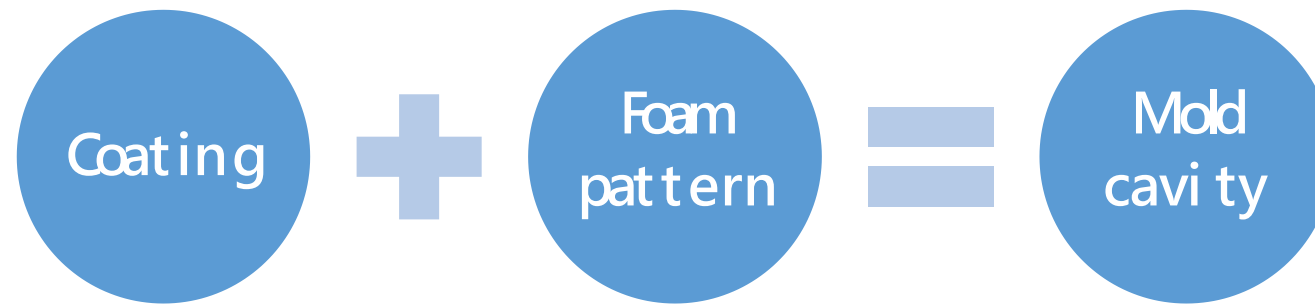
a. Foam beads copy into the pattern



The expandable polystyrene beads are pre-expanded to foamed beads. The foamed beads are filled into the mold cavity, and then foamed to form a foam pattern. Therefore, the quality of the foam pattern is related to the quality of the beads, the accuracy of the mold cavity, and the foam molding. Process is directly related

1.3 The essence of lost foam casting process

b. Coating copy into the mold cavity



The dry powder of refractory coating is mixed and stirred with water, and then coated on the surface of the foam pattern. After drying, the model cavity is finally formed. Therefore, the quality of the foam pattern and coating directly affects the quality of the model cavity.

1.3 The essence of lost foam casting process

c. Molten metal copy into the model cavity



High-temperature molten metal is poured into the mold cavity to decompose and vaporize the foam pattern at high temperatures. The liquid products and gases produced in the process are discharged through the coating layer, and finally form metal castings; therefore, the quality of the castings is related to the foam pattern and refractory coating layer, molten metal quality control and pouring process.

1.4 Research objects of lost foam casting

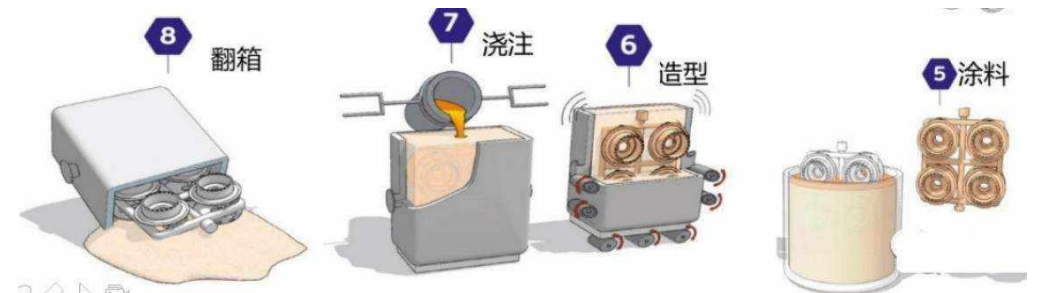
Lost foam casting process control mainly studies two directions:

a. The production of foam pattern, which is how to produce high-quality foam patterns

Research objects include: foam beads, steam quality, white side related equipment, production technology, related environmental control and human factors, etc.

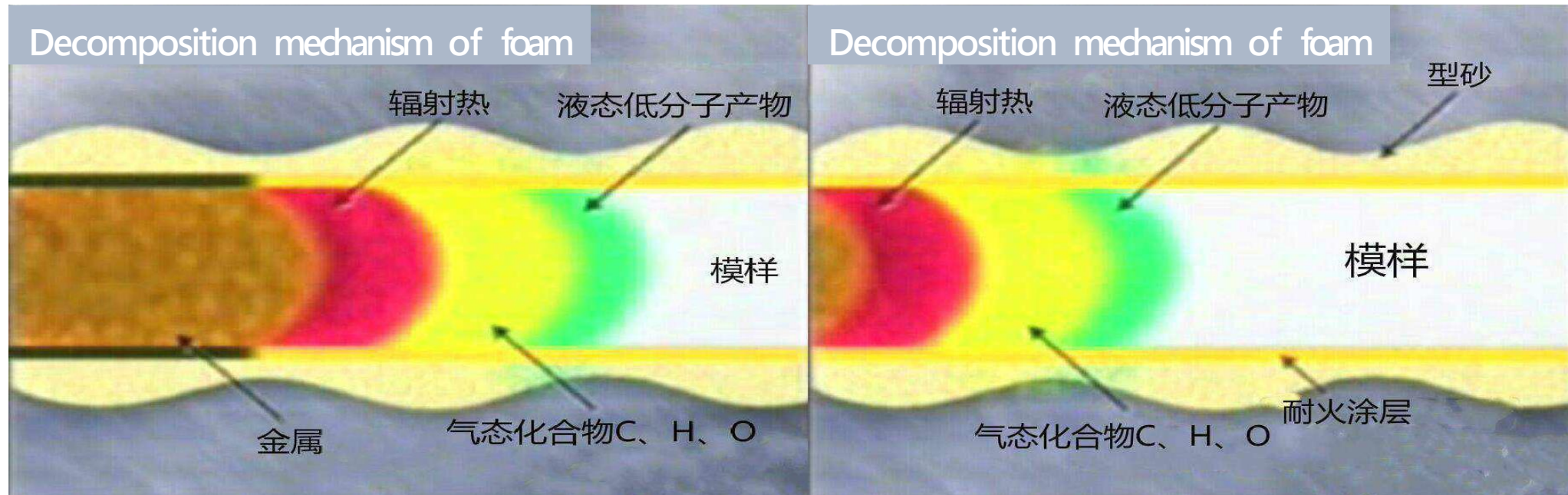


b. The vaporization of the foam pattern, which is how to make the foam pattern vaporizing faster and more completely within the effective filling time. The research objects include: foam pattern quality, coating properties (especially coating permeability and adsorption), black side related process knowledge (such as: pouring process, negative pressure, modeling sand, pouring temperature, speed), etc.



1.5 The goal of lost foam casting process control

The goal of lost foam casting process control is to ensure the stable and fast filling of molten metal, and to ensure that the foam pattern is completely vaporized, so as to obtain qualified castings.





- 2.1 Preliminary preparation for lost foam casting
- 2.2 Selection of foam beads and density
- 2.3 Pre-foaming process of foam beads
- 2.4 Ageing time and process control
- 5. Control of molding process conditions
- 6. Drying and anti-deformation treatment of pattern pieces
- 2.7 Bonding combination of model pattern and mold clusters
- 2.8 Process design, pouring and riser system design and pattern cluster combination process

2.1 Preliminary preparation for lost foam casting

Any casting process is not omnipotent. When choosing different casting processes, you should consider product quality, yield and production efficiency to find a more suitable casting process for each casting product. Lost foam casting is no exception. When the product drawings are obtained, the following points must be understood first:

- a. Understand whether the company's current equipment (such as molding machine, sand box, smelting equipment, etc.) meets the appearance size and weight requirements of the product.
- b. Understand the material of casting products to facilitate the selection of suitable foam materials (FD, EPS or STMPA), and communicate the shrinkage of the product according to the company's melting and pouring casting conditions and the mold manufacturer.
- c. Understand the specific dimensions and technical requirements of the drawings, and determine the machining allowance of the castings according to the requirements of the drawings. It is recommended that the machining volume be greater than 3mm for more important or special requirements.
- d. Understand the product model classification problem, and communicate with the mold manufacturer about the mold classification problem; here is a suggestion: if it can be formed as a whole, it is better not to design in pieces. For example, for some products with air tightness requirements, if the operating conditions are convenient, it is recommended to use manual molds for integral molding. Here, the treatment of post-sticking mold seams is mainly considered. Nowadays, automatic gluing machines of various models and functions are emerging endlessly. Considering the appearance of castings and special requirements, the overall molding and comprehensive cost are more reasonable.
- e. Understand the relevant process and tooling. After the mold is determined, the preliminary plan for the preliminary process trial production should be considered, and the corresponding tooling equipment and raw and auxiliary materials should be actively prepared to shorten the trial production time in the later stage and strive for early batch supply.

2.2 Selection of foam beads and density

2.2.1 Recommendations for the selection of foam beads

A. Recommendations for foam bead category selection

In the selection of foam beads, generally, after the material of the casting product is determined, the choice of foam beads is basically determined. In actual production, it is generally recommended to use EPS or FD beads for gray cast iron (HT) castings. Copolymers (STMMA) can be used if conditions or products have special requirements; copolymers are better used for ductile iron (QT) castings, because temperature of nodular graphite casting is limited by the spheroidization process (high temperature, late spheroidization, severe alloy burnout, and severe impact on the spheroidization effect). In addition, the molten iron made of nodular casting is not as fluid as gray cast iron. Wall parts or castings with severely uneven wall thickness will have various defects caused by incomplete foam vaporization when molten iron is filled. This is also why most manufacturers have no chance or dare not produce ductile iron in the early stage of the development of lost foam. Since the copolymer material (STMMA) was introduced to the market in 2000, the production of ductile iron castings in lost foam has only begun to expand on a large scale. It has developed rapidly in recent years, mainly reflected in: auto parts (subtractive shells, boxes, wheels, etc.) , ductile iron pipe pump valve industry, agricultural machinery accessories, etc.

At present, the ductile iron made water supply and launch fittings (pipe joints, tees, elbows, flanges and sockets, etc.) produced by several large-scale lost foam manufacturers in China have thin walls and large diameters, and they still use EPS or FD Beads are mainly affected by the environment in which they are used. Most of these accessories are buried underground after coating treatment, and the pressure requirements are low. EPS beads can play some advantages in cost saving.

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2.2 Selection of foam beads and density

The current opinions on the use of EPS beads or STMMA beads for steel castings are not very uniform, but the author believes that it should be determined according to the product structure and technical requirements. Most domestic manufacturers of mining machinery parts and engineering machinery parts choose to use EPS beads. The main reason is that these castings are of multiple varieties and small batches. Many patterns are hand-cut from EPS foam blocks. In addition, the STMMA copolymer foam bead block has only recently been developed successfully. However, STMMA copolymer beads have unique advantages in solving the defects of steel casting appearance and carbon increase.

STMMA、STMMA-FD and EPS comparison:

ITEM	Unit	STMMA	EPS	STMMA-FD
Formula		$[(C_5H_8O_2)_x(C_8H_8)_y]_m$	$[C_8H_8]_n$	
C content	%	63	92	82
Tf	℃	85-95	80-85	85
Decomposition Temp	℃	860	920	900
Gas volume (900℃)	m ³ /g	900	600	700
Pouring	℃	1450-1470	1500-1460	1480-1450

2.2 Selection of foam beads and density

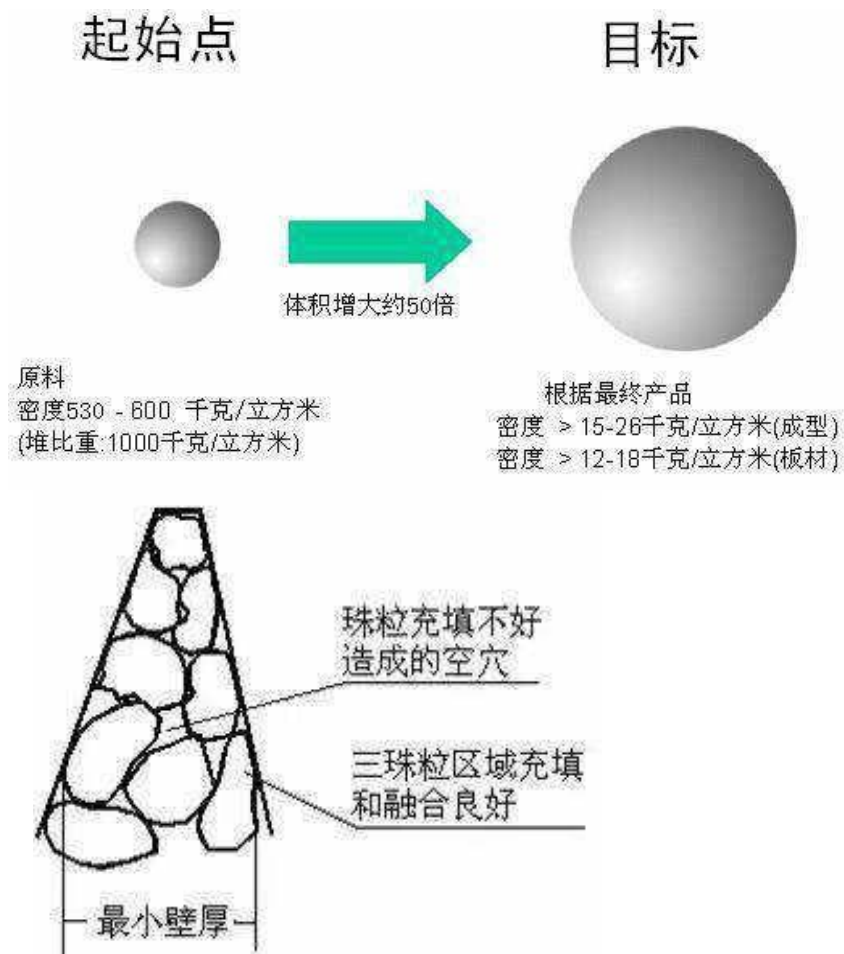
2.2.1 Recommendations for the selection of foam beads

B. Recommendations for selecting the size of foam beads

In lost foam casting, foam pattern manufacturing is very critical. The manufacture of foam patterns should pay attention to the selection of the original beads. First, choose the beads for lost foam casting reasonably according to the material, performance and process requirements of the casting. After confirming the use of FD, EPS or STMMA beads, choose the right one bead size.

When the beads are pre-expanded, the expansion ratio is 40-50 times, and the diameter of the beads increases about 3 times.

In order to obtain a better surface quality of the foam pattern, during the secondary foaming (molding), the minimum wall thickness of the pattern should be arranged with 3 beads in the lowest direction, as shown in the right graph.



2.2 Selection of foam beads and density

The selection principle of bead size (particle size): When choosing any bead size, customers must first understand the size, wall thickness, surface quality requirements of the produced castings, etc.

Under normal circumstances, we choose the bead size (specification) according to 1/10 of the minimum wall thickness of the casting, that is: foam bead size = minimum wall thickness of the casting/10, and then according to the beads provided by the raw material manufacturer diameter and specifications comparison table to select the bead type corresponding to the foam particle size. If the casting surface requires higher quality, then choose a smaller size is enough.

STMMA		STMMA Size	
Beads	Size	STMMA	Size
Beads			
STMMA-1#	0.6-0.85mm	FD-Sp	0.9-1.25mm
STMMA-2#	0.45-0.6mm	STMMA-FD1B	0.71-0.9mm
STMMA-3A#	0.4-0.55mm	STMMA-FD1S	0.6-0.71mm
STMMA-2#	0.25-0.5	STMMA-FD2	0.45-0.6

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2.2 Selection of foam beads and density

EPS for lost foam

King Pearl EPS						Jiachang Xingda EPS		
Beads	Size	1*Ratio	1*Ratio	Beads	Size	1*Ratio	size	1*Ratio
E-SA (Normal) H-SA	E:0.8-1.2mm H:0.9-1.4mm	E:60-70	A\B-105A-105 (N) B-105 (GP)	0.7-1mm	A:60-75 B:60-80	PKF-303XB (M) PKF-303XJ (L)	0.7-1mm	60-75
E-SB (Normal) H-SB	E:0.6-0.9mm H:0.7-1.1mm	E:50-65	A\B-106A-106 (N) B-106 (GP)	0.5-0.8mm	A:55-65 B:60-70	PKF-401XB (M) PKF-401XJ (L)	0.5-0.8mm	55-70
E-S (Normal) H-S	E:0.4-0.7mm H:0.5-0.9mm	E:35-50	A\B-107A-107 (N) B-107 (GP)	0.4-0.6mm	A:45-60 B:55-60	PKF-501XB (M) PKF-501XJ (L)	0.4-0.6mm	50-65
E-4S (Normal) H-4S	E:0.3-0.6mm	E:20-35	A\B-108A-108 (N) B-108 (GP)	0.3-0.5mm	A:35-50 B:40-60	PKF-601XB (M) PKF-601XJ (L)	0.3-0.5mm	35-50

2.2 Selection of foam beads and density

2.2.2 Selection of pre-expanded density of foam beads

Each manufacturer of raw beads will have a recommended pre-foaming density according to its expansion ratio. We can choose a suitable pre-foaming density according to the molding conditions and the appearance requirements of the foam model. For some products with high requirements for appearance of the foam pattern, you can choose a smaller size than usual. In general production, in order to facilitate the later pouring, the lower limit of the appearance should be taken under the condition that the strength and size shrinkage of the foam pattern are satisfied. The lower the foam density, the lower the probability of waste products in the later pouring.

Density recommendation

Beads	Size	Density g/l	Suggestion for product	每吨铸件需要珠粒 (kg)
LFC 1#	0.70mm-0.90mm	16—18	板材和机床类产品，铸件最薄壁厚在20mm 以上的模样	3.3
LFC 2A#	0.55mm-0.70mm	18—20	消失模铸造浇道用料 或铸件最薄壁厚在 13mm以上的模样	3.3
LFC 2#	0.45mm-0.60mm	19—21	多数箱体、壳体、管	3.5

2.2 Selection of foam beads and density

2.2.2 Selection of pre-expanded density of foam beads
Practical case of bead selection:

Product name: ductile iron shell

1. Material: ductile iron 450-10
2. Thinnest wall thickness: 6mm
3. The thickest wall thickness is 26mm
4. Rough casting weight: 37kg
5. Processing requirements: no defects in the end surface processing, No shrinkage in hole processing.



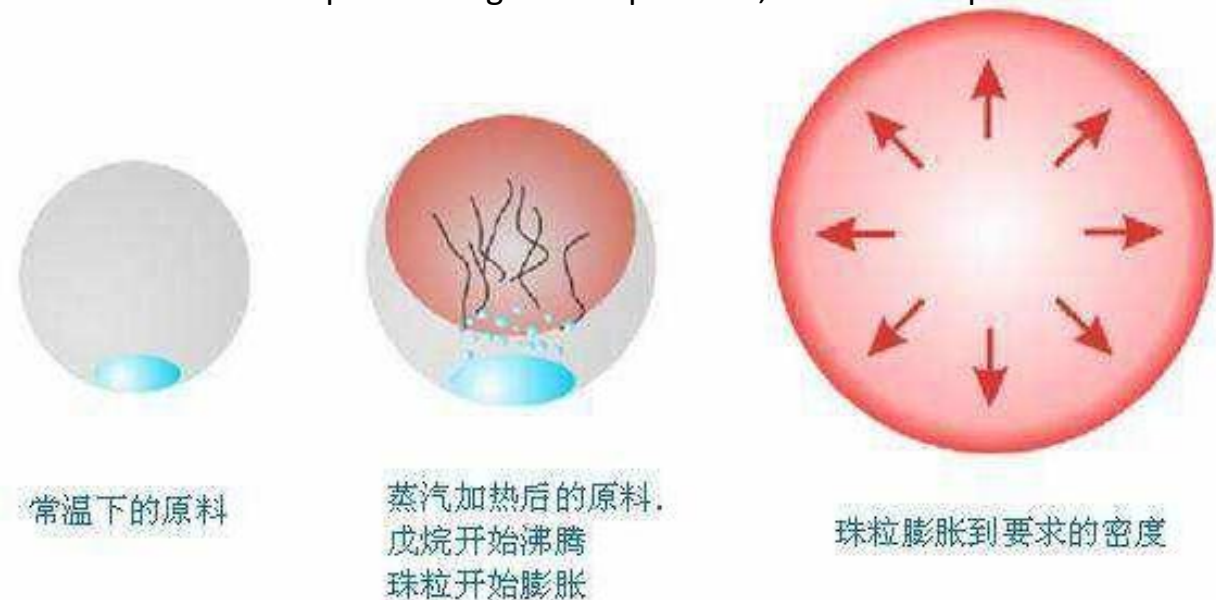
As described above: Should choose STMMA copolymer beads Select specifications: STMMA-2# If the surface quality of the casting is required to be high, It is recommended to have a smaller size, namely STMMA-3A# beads.



2.3 Pre-foaming process of foam beads

The pre-expansion of the foam beads is to obtain a foam pattern or foam sheet with low density and uniform cells. The resin beads must be pre-expanded before the pattern is formed. The pre-expanded quality of the beads has a great influence on the molding process and quality of the pattern. Depending on the heating medium and heating method, there are many methods, but most of the commonly used methods currently use steam pre-foaming. Principle of steam pre-expansion: When the resin beads are heated to the softening temperature by steam, the beads do not foam, but the blowing agent escapes; when the temperature rises to the softening temperature of the resin beads, the beads begin to soften and become plastic; Because the blowing agent in the beads is heated and vaporized to generate pressure, the beads expand and form a honeycomb structure that is not connected to each other.

Once the cells are formed, the steam will penetrate into the cells, so that the pressure in the cells will gradually increase, and the cells will expand further; during the process of cell expansion, the foaming agent also diffuses outwards and escapes until the inside and outside of the cells The expansion stops when the pressure is equal. After cooling, the size of the foamed beads is fixed.





2.3 Pre-foaming process of foam beads

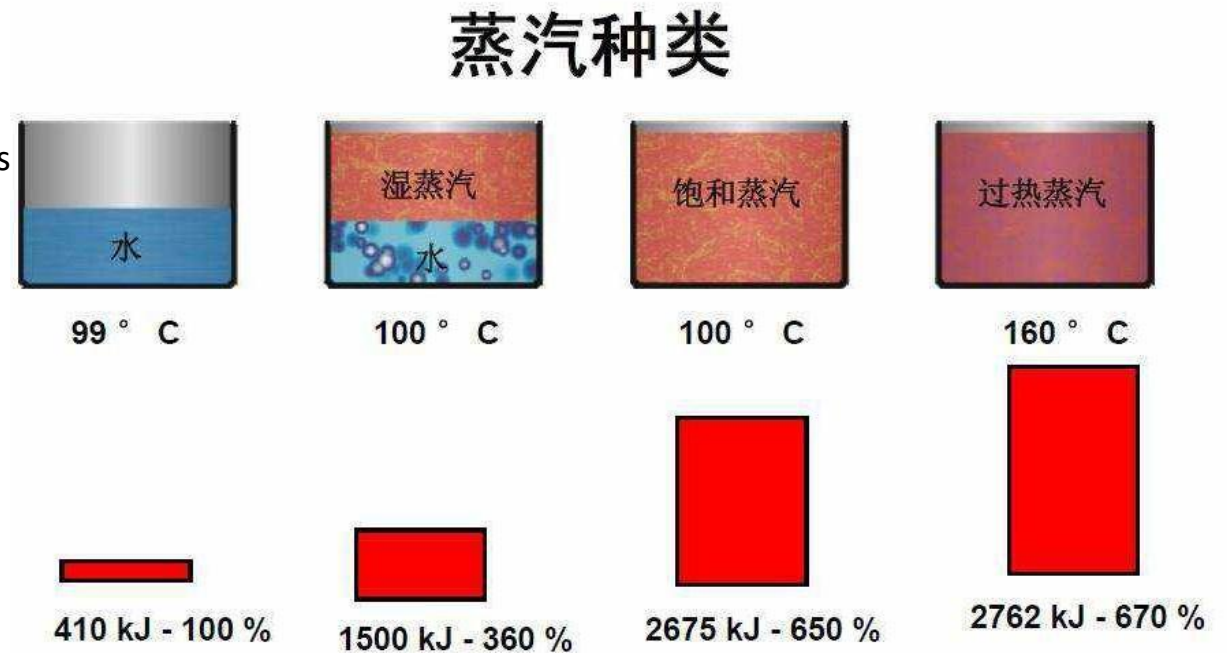
- a. Equipment requirements for pre-foaming: The white area equipment and mold of the lost foam are different from the packaging mold: the lost foam and packaging are also made of white area equipment and molds, but the system is not the same thing. Lost foam casting has many technical requirements for the pattern, so it is right The requirements for related equipment and molds are also high. In order to make a good lost pattern appearance, the concept must be transformed from packaging molds. Lost foam, lost foam, bad mode only disappears...

The choice of lost foam white zone equipment: As an lost foam casting company newly installs or renews lost foam white zone equipment, you must choose a professional equipment supplier. Professional equipment suppliers sell you not just a few simple equipment, but It is a complete set of lost foam system, perfect after-sales service and complete process technology concept.

2.3 Pre-foaming process of foam beads

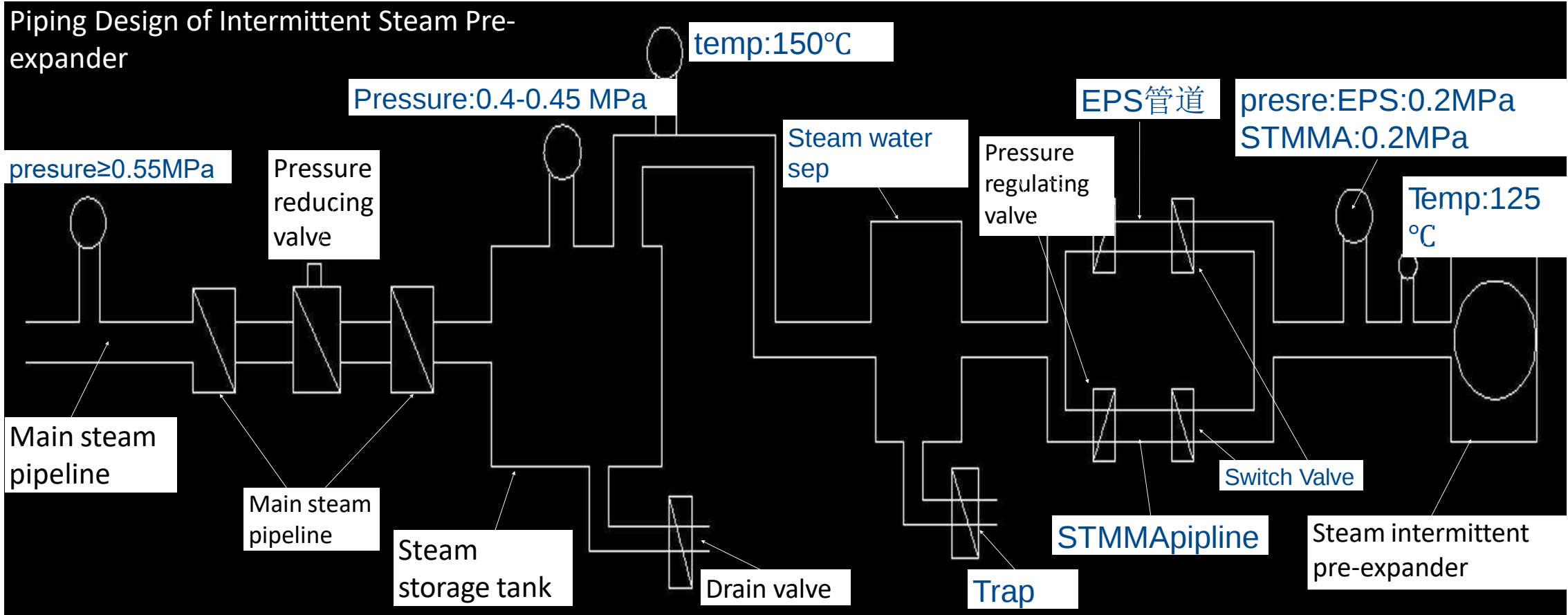
b. Pre-foaming requirements for steam: Analysis of the steam state in the pattern making process: During the pre-expansion and pattern forming of the beads, we put forward the steam state requirements of "low pressure, large flow, saturated slightly superheated, and stable pressure". Some people may ask why this state is needed?

※The function of low pressure and high flow rate: Let steam penetrate the beads instantly (shorten the steam penetration time during pre-emergence and molding), 1. Make the pre-emitted beads uniform and not agglomerate; 2. Make the molded appearance thin No shrinkage, no growth in thick areas. ※The function of saturated slightly superheated steam: reduce the moisture content in the steam and increase the utilization of heat efficiency (wet steam: 1500KJ-360%, saturated steam: 2675KJ-650%, superheated steam: 2762KJ-670%). ※The function of stabilizing the steam pressure: make the density of the pre-expanded beads for a long time consistent, and make the appearance of foaming consistent.



2.3 Pre-foaming process of foam beads

c. Suggestions for the design and installation of the steam pipeline of the intermittent pre-engine



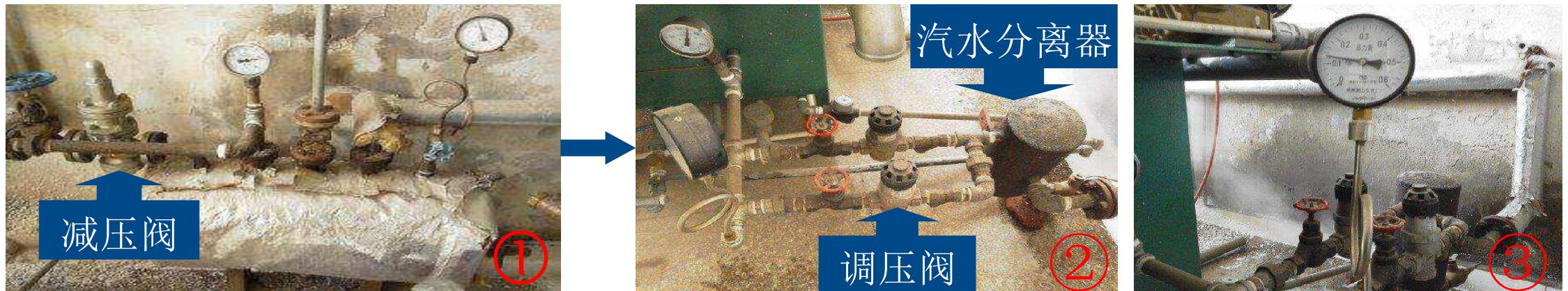
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2.3 Pre-foaming process of foam beads

c. Suggestions for the design and installation of the steam pipeline of the intermittent pre-engine

·Requirements for steam pipelines of intermittent steam pre-generators:



- ① The pressure of the steam storage tank after decompression of the steam pipeline should be controlled at about 0.45Mpa; (about 150°C)
- ② The steam before entering the pre-engineering equipment needs to pass through the steam-water separation device to fully remove the excess water in the steam.
- ③ After the second pressure adjustment, the pipeline pressure of the pre-engine must be stably controlled at STMMA: 0.2Mpa; EPS: 0.2Mpa. (125°C)



2.3 Pre-foaming process of foam beads

d. Pre-foaming process and operating parameter control Pre-expansion of beads is generally carried out in a batch steam expansion machine. Different pre-expansion machines have different operating parameters, but the operating process is basically the same. The process is such as: preheating---feeding---heating and foaming---discharging---drying---cleaning the silo

1. Preheating: The purpose of preheating is to reduce the moisture in the preheating barrel and shorten the preheating time. When the preheating temperature reaches the requirement, the prepared beads can be added to the preheating machine. Remarks: Preheating is divided into two steps: 1. Steam preheating ; 2. Inlet and exhaust steam cycle preheating. Inlet steam preheating makes the temperature in the pre-heating barrel reach 90-95°C; afterwards, the steam inlet and exhaust cycle preheating (cycle time 15-20 minutes) makes the temperature in the pre-heating barrel stable (small fluctuations), during the preheating process Manual blowdown is required.
2. Feeding: Take the SJ-KF-450 pre-expansion machine produced by Fuyang Jiangnan (Fuyang Lianfa) as an example, the feeding amount is generally controlled at about 0.6kg (about 1000ml)
3. Heating and foaming: the steam pipeline pressure is 0.45Mpa (after decompression); the pipeline steam pressure of the pre-expander is controlled at 0.14-0.18Mpa (after pressure adjustment), Copolymer beads: The pressure in the expansion chamber is controlled at 0.03-0.06Mpa, the temperature is 95-105°C, and the time is 30-60 seconds. Ordinary (EPS\FD) beads: The expansion chamber has no pressure, the temperature is 80~95°C, and the time is 12~30 seconds.
4. Drying: The pre-expanded beads should be dried on a fluidized bed; the purpose is to reduce the moisture of the pre-expanded beads and avoid agglomeration. (Note: The drying time of the fluidized bed should not be too long. The static electricity generated by the beads is too long, and the temperature of the fluidized bed should be 25-35°C)
5. Cleaning the silo: After each pre-foaming, the silo and the pre-expansion barrel must be carefully cleaned to avoid mixing in the next pre-expansion.
6. The density of the pattern should be controlled at 18~26g/L. When the density is less than 18g/L, the pattern is easy to deform; when the density is greater than 26g/L, the pattern has a higher density, which may cause a large amount of gas during casting, which may cause back spray And other defects.



2.3 Pre-foaming process of foam beads

d. Pre-foaming process and operating parameter control The control of the specific gravity of the beads depends on the particle size of the original beads and the thickness of the model. The general situation can be in accordance with the following table:

Particle size range	0.7-0.9mm	0.5-0.7mm	0.35-0.55mm	0.3-0.5mm
Specific gravity range	18~21g/L	20~22g/L	21~23g/L	23~26g/L

※Judgment of qualified beads after pre-release: (4 requirements for pre-release qualified beads)

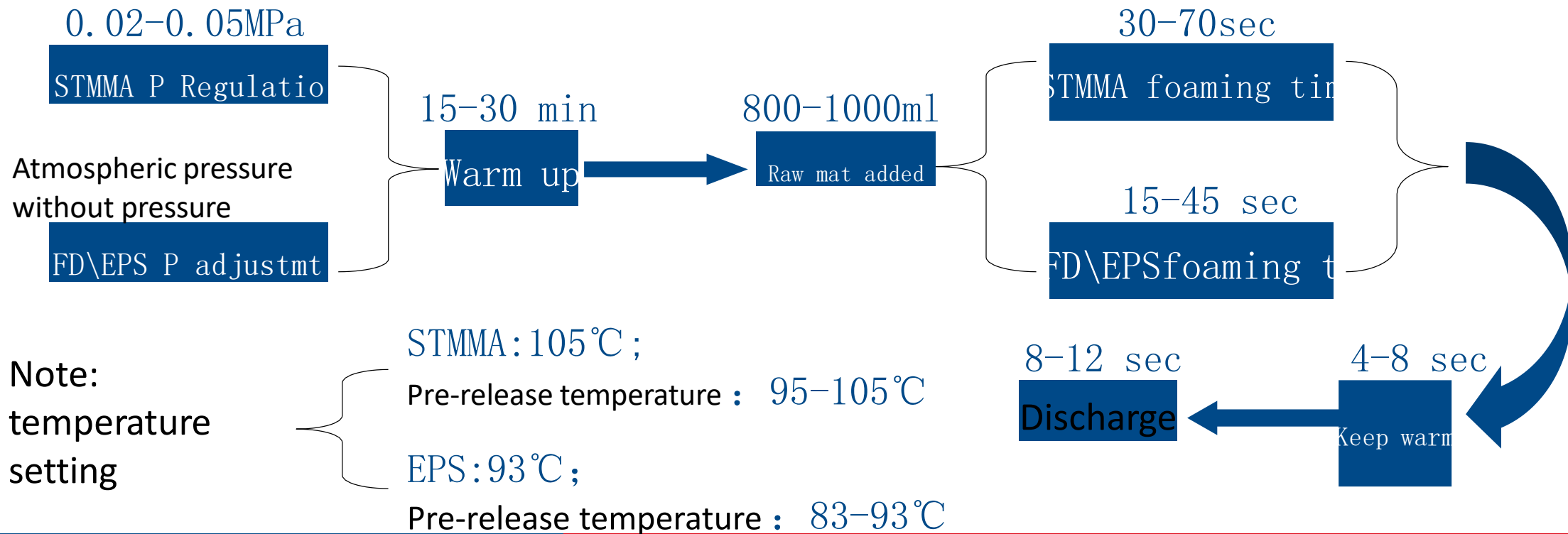
- 1.The water content of the pre-emitted beads should be less (the steam quality and the preheating of the pre-heater should be considered)-the water content of the beads is <5%;
- 2.The pre-released beads should be uniform (feeding amount, preheating, pre-expansion machine scraper, steam quality, pre-expansion time, bead quality)-the density fluctuation of pre-release beads should be controlled within $\pm 0.5\text{g/l}$;
3. The pre-emitted beads should have a moisturizing feeling (pre-emission time, pre-emission density, pre-emission temperature);
- 4.Reasonably control the pre-emergence density (control of the water content and volatile content of the beads) according to the curing requirements-the difference between the matured beads and the pre-emerged beads is 1-1.5g/l.

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2.3 Pre-foaming process of foam beads

d. Pre-foaming process and operating parameter control Analysis of pre-foaming process parameters



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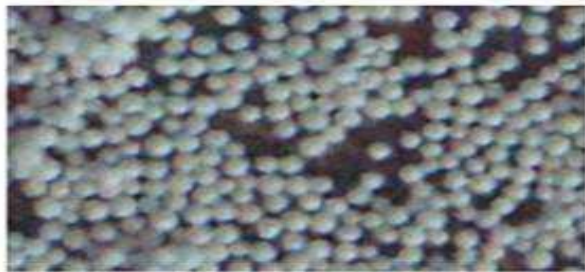


2.3 Pre-foaming process of foam beads

d. Pre-foaming process and operating parameter control

Common problems with pre-made beads

- Uneven pre-emitted beads
- Agglomeration of pre-expanded beads
- Damaged bead spheroids

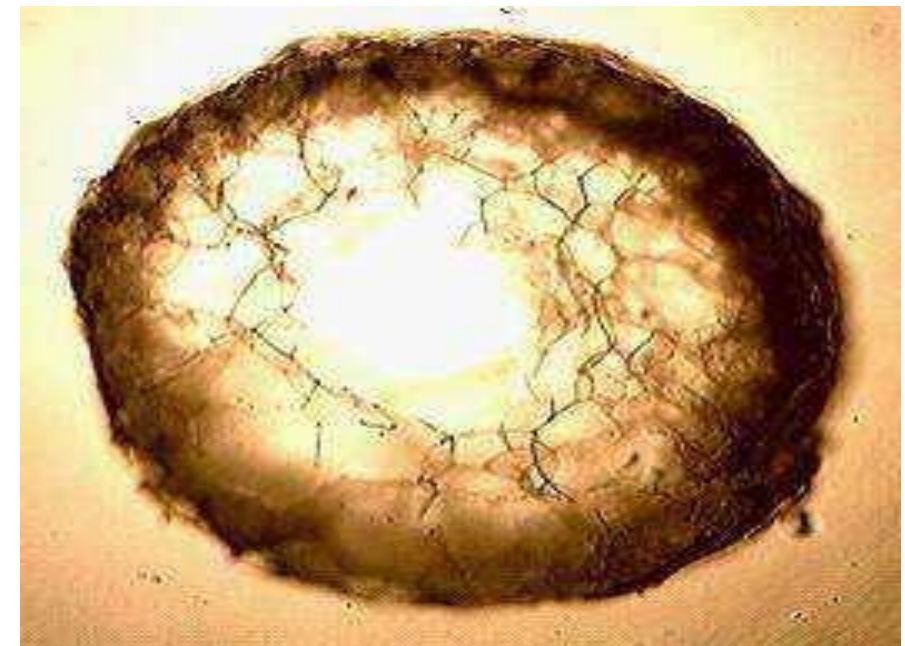


Teubert 预发泡机发泡珠粒



国产预发泡机发泡珠粒

图 5 Teubert 消失模专用预发泡机和国产预发泡机预发泡珠粒对比





2.4 Maturation time and process control

After the pre-emitted beads are cooled, the foaming agent and water vapor in the cells are cooled and liquefied, so that a vacuum is formed in the cells. During the curing process, air penetrates into the cells, so that the internal and external pressures of the cells in the beads tend to be balanced. The best curing temperature of the beads is 25~35°C, and the curing time is related to the moisture and density of the beads and the temperature and humidity of the environment. For example: the relationship between the density of EPS beads and the curing time, as shown in the figure below:

Bead Density (g/l)	15	20	25	30
Best curing time/hour	20~48	12~30	10~24	8~20

If the pre-emitted EPS foam beads are cured by a hot air drying bed (fluidized bed), the curing time is ≥ 4 hours, and then they can be formed. After STMA copolymer beads are pre-expanded, the maturation time is generally ≥ 24 hours; the maturation of the pre-expanded beads is an important process to obtain a high-quality appearance.

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2.4 Maturation time and process control

Store the pre-expanded beads in a storage bin for maturation-called a maturing bin, as shown in the figure below:

The maturation bin for the maturation of the foam beads in the white area of the lost foam is generally $1\sim 3\text{m}^3$, made of plastic net or stainless steel net. In order to prevent the static electricity of the conveying beads from causing the beads to escape and the pentane burns, it is generally not

recommended to use plastic tubes

(If it is used, it must be equipped with a grounding sheet) for transportation, it is recommended to use a metal pipe and grounding effect is better. The maturation warehouse should be placed under good ventilation conditions, so that the foam beads can better meet the maturation requirements and reduce the appearance and molding defects caused by poor maturation effects.



Chapter 2 The manufacture of foam models and the combination of mold clusters



2.4 Maturation time and process control

1. Requirements for the maturation warehouse during maturation: ①The volume of the maturing warehouse is not easy to be too large (preferably about 1m^3). ②The maturing warehouse net is not easy to be too fine (smaller than the diameter of the smallest pre-made beads) ③The maturing warehouse should be made of anti-static materials.



Simple but not simple, this can be very good Solve the problem of inconsistent bead maturation



The maturation warehouse is too high and the space cannot be reached Reasonable utilization and bead maturation are inconsistent



2.4 Maturation time and process control

2. Environmental requirements during maturation:

- ① The maturation warehouse should be placed under good ventilation conditions
- ② The best curing temperature for beads: 30~40°C; humidity <30%.
- ③ Curing time: Copolymer beads ≥ 24 hours; ordinary (EPS\FD) beads 4 to 48 hours. (This data also needs to be adjusted according to the user's equipment and special environmental conditions).

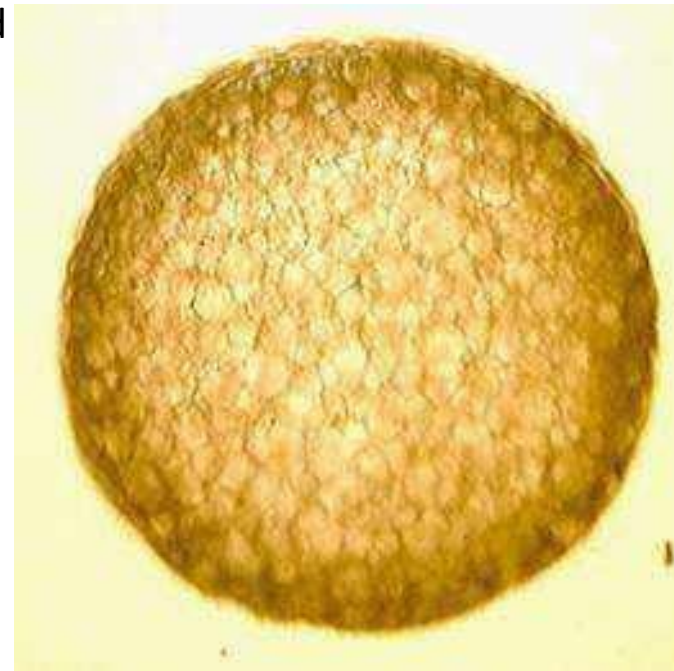
Note: If the maturation environment does not have good ventilation conditions, compressed air or a fan should be used to churn or dump the beads in the maturing chamber every 2-3 hours (purpose: to replace the position of the beads on the surface and inside of the maturing chamber, Let the beads in the entire maturation bin achieve a good maturation effect).

Chapter 2 The manufacture of foam models and the combination of mold clusters

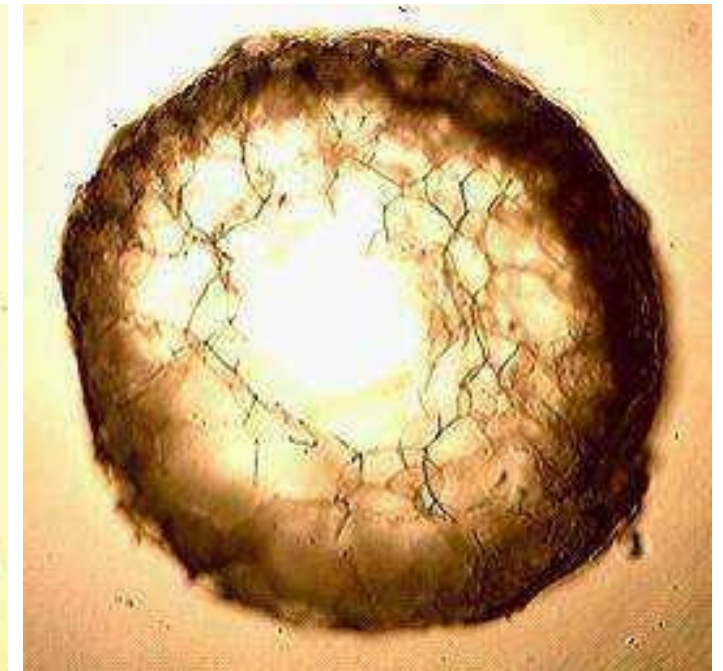


2.4 Maturation time and process control

3. Judgment of matured qualified beads: Good beads generally have a shiny, round surface and good resilience by hand pinching; if the pre-expanding is not good, the surface will foam, some will be oval, not elastic, and the volatile content will run relatively fast. In this curing process control, the best control point for volatile content is (copolymer beads: 7-7.5%; ordinary (EPS\FD) beads: $\geq 5\%$) to reduce the three-time foaming or melting after the beads are formed. Possibility of knot not dense.



After pre-release and maturation Anatomy of a normal bead



After pre-release and maturation Anatomy of a broken bead



2.5 Control of molding process conditions

There are many methods for foam molding of the shape due to different heating methods, mainly including steam cylinder (steam box) molding method and compressor air chamber molding method.

a. Steaming cylinder (steam box) forming: Steaming cylinder (steam box) molding, commonly known as manual molding, the molding process is: the mold structure is complex, there are multiple live blocks on the left and right or up and down that need to be manually disassembled, when the demand for white molds is large, the entire production process of the pattern does not need to be carried out Bonding. After the matured beads are filled into the mold cavity by the material gun, they are put into the steaming cylinder (steam box), steam is injected and the pressure and temperature are controlled, and after foaming, they are taken out of the steaming cylinder (steam box). Cooling and shaping, demoulding. Since the re-expansion of the beads during the molding of the steaming cylinder (steam box) is mainly the heating steam that penetrates into the beads through the air plug holes, there are both steam, air and condensed water between the beads, which requires ample time for air And the condensed water is discharged through the air plug hole. Therefore, the expansion speed of the steaming cylinder (steam box) molded beads is slower and the time is longer.

Chapter 2 The manufacture of foam models and the combination of mold clusters



2.5 Control of molding process conditions

For example, for a pattern with a thickness of 7 to 30 mm, the heating time is about 3 to 5 minutes. The heating steam pressure of the steaming cylinder (steam box) is as follows:

Material	EPS	STMMA
SteamP/MPa	0.08~0.1	0.1~0.14

The assembly and disassembly of the steaming cylinder (steam box) forming mold is manual operation, which has low production efficiency and is not suitable for mass production. The steaming cylinder is shaped as shown in the picture on the right:





2.5 Control of molding process conditions

b. Compressor air chamber forming method: Mold press air chamber molding, commonly known as machine mold molding, is to fill the pre-foamed and matured beads into the mold cavity with the air chamber through the material gun. The mold is horizontally divided into two parts, the upper steam cabinet and the lower steam cabinet. , The upper steam cabinet is fixed on the moving template of the forming machine, and the lower steam cabinet is fixed on the solid template of the forming machine. The moving template is raised or lowered to complete the mold opening and closing action. The superheated steam enters the mold cavity through the air plug hole on the mold wall, passes through the gap between the beads, and drives away the air and condensed water, so that the steam quickly fills the beads and penetrates into the cells. When the pressure inside the cell, that is, the sum of the vapor pressure of the blowing agent, the saturated vapor pressure at the molding temperature, and the expansion pressure of the air is much greater than the external pressure of the beads, and the beads are softened by heat, the beads expand again Foam molding. Then, cooling water is introduced from the air chamber to cool and set the mold and the molded pattern, and the desired foam pattern or mold can be obtained by demolding.

Chapter 2 The manufacture of foam models and the combination of mold clusters



2.5 Control of molding process conditions

The use of compressor air chamber molding can obtain low-density foam patterns, short molding time, stable process, and good quality of patterns. This method is the main forming method for producing lost foam casting foam patterns. .



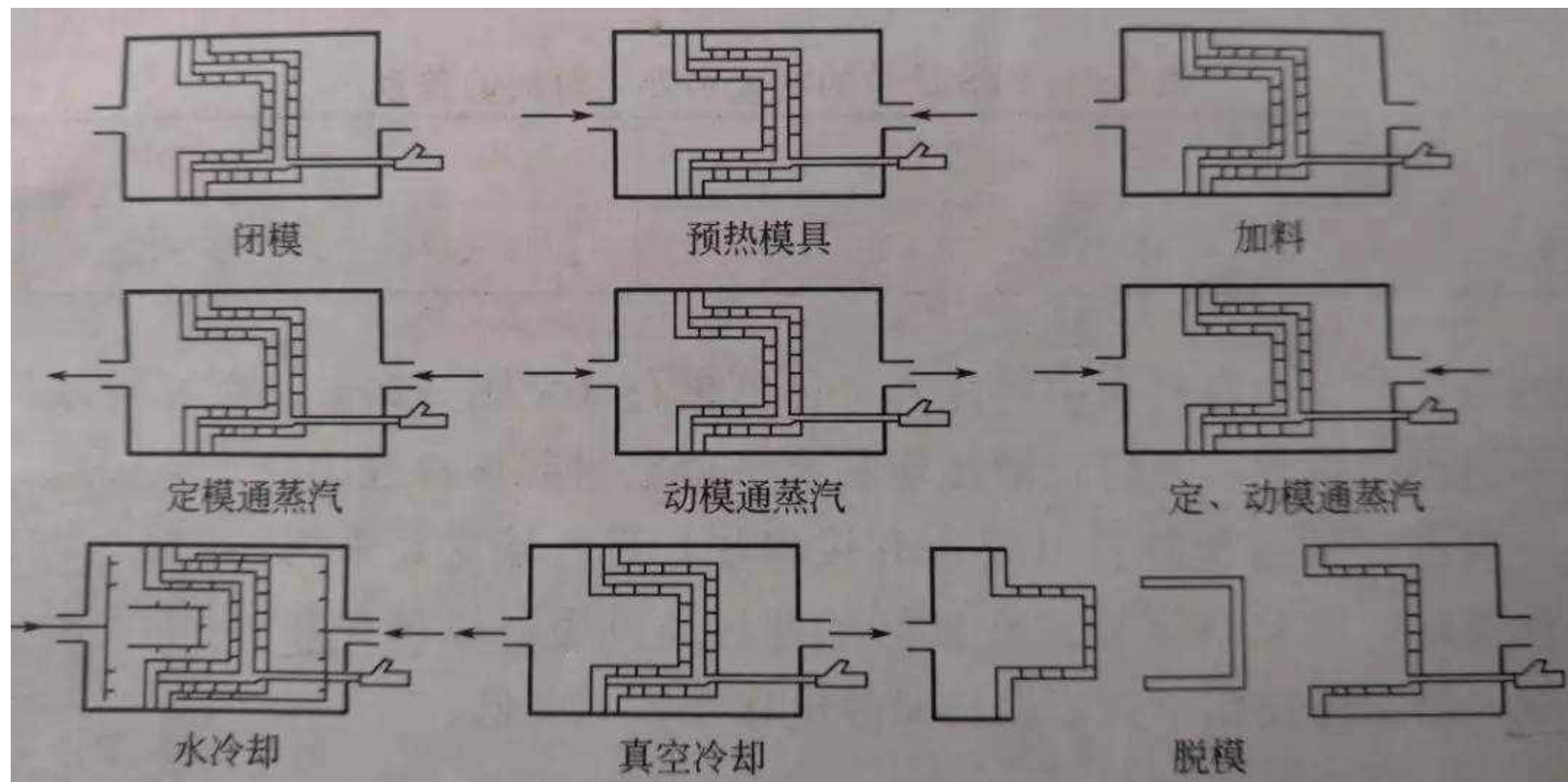
Chapter 2 The manufacture of foam models and the combination of mold clusters



2.5 Control of molding process conditions

(1) The process of forming the compressor air chamber (As shown in the figure below)

Schematic diagram of compressor air chamber forming process:





2.5 Control of molding process conditions

- Closed mold: Close the foaming mold. When using large-diameter beads (EPS packaging material), there is often a gap smaller than the radius of the pre-expanded bead at the parting surface of the mold, so that the compressed air can be discharged from the air plug hole and the gap at the same time when feeding, which is beneficial. The beads fill up the mold cavity quickly; and when heated by steam, the air and condensed water between the beads can be discharged from the cavity through the air plug holes and gaps at the same time. However, when the special material for lost foam casting is used, due to the small particle size of the beads, there are generally no gaps when the mold is closed, and the air and condensed water between the beads can only be discharged from the cavity through the air plug hole. In addition, the practice of leaving gaps often produces flashes at the parting surface of the pattern.
- Preheating the mold: Preheating the mold before feeding is to reduce the condensation of steam when the beads are foamed and shorten the foaming time.
- Feeding: Open the air outlets of the fixed and movable mold air chambers, and use a compressed air feeder to blow the pre-expanded beads into the mold cavity through the feeding port of the mold. After the beads fill the entire mold cavity, plug it with a feeding plug. Live the feeding port. Feeding is the basis of bead foam molding. If the feeding method is improper, the beads in the cavity will be filled incorrectly or unevenly, even if the mold and beads are good, it will cause appearance defects. Therefore, the feeding method is one of the important steps of the foam molding process.

Chapter 2 The manufacture of foam models and the combination of mold clusters

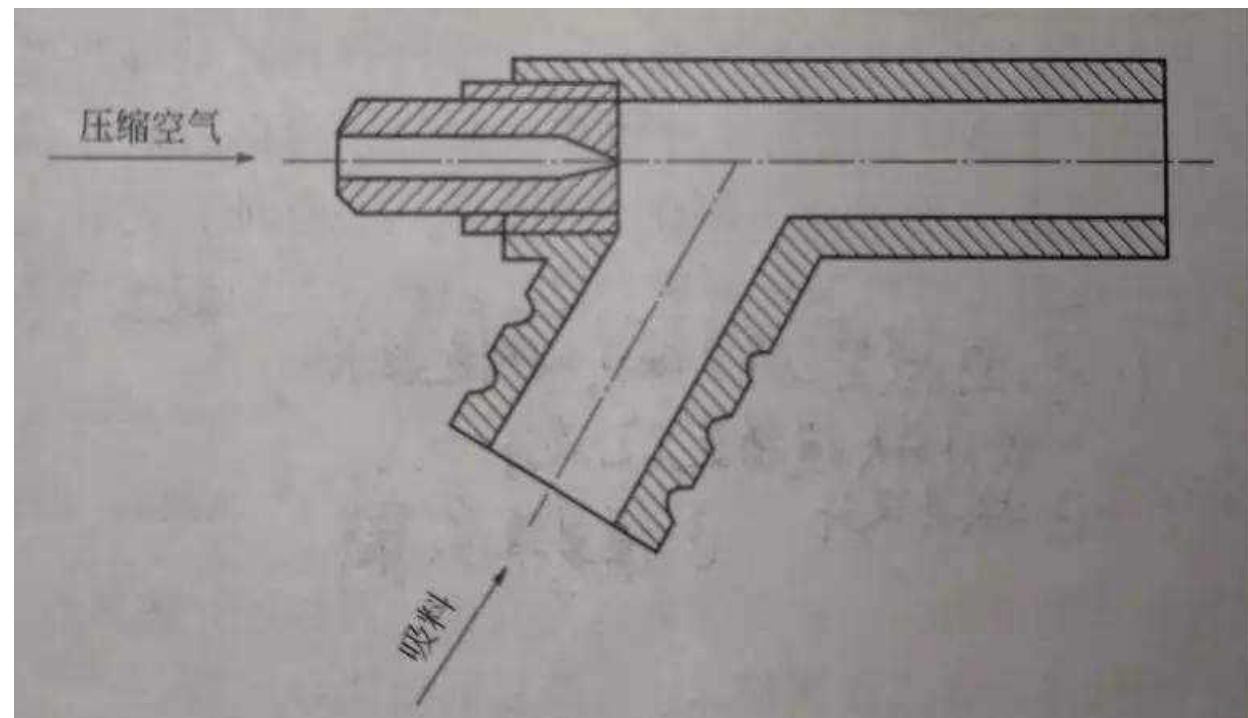


2.5 Control of molding process conditions

At present, there are three feeding methods commonly used in production, namely, suction filling, pressure suction filling and negative pressure suction filling.

① Suction filling is a feeding method commonly used by manufacturers in my country.

This method uses a common material gun—Vonturi gun, which uses compressed air to suck the beads into the mold cavity. For a mold with a simple cavity structure, this method has better feeding effects. But for a mold with a more complicated cavity structure, this method cannot completely fill the cavity with beads, resulting in a lack of material. A schematic diagram of the structure of a common material gun, as shown on the right:



2.5 Control of molding process conditions

② Pressure suction filling. This method is to press positive pressure on the beads when feeding, so that the beads fill the mold cavity and have a certain degree of compactness.

③ Negative pressure suction filling, this method is to add negative pressure to the back of the mold at the same time as the suction, filling, and the double action of negative pressure traction and compressed air suction to fill the mold cavity with beads.

In order to solve the problem of feeding complex thin-walled beads, a method of simultaneous feeding with multiple guns can also be used. For the above various feeding methods, the best effect can be obtained by feeding multiple guns at the same time.





Additional Filling of beads during molding

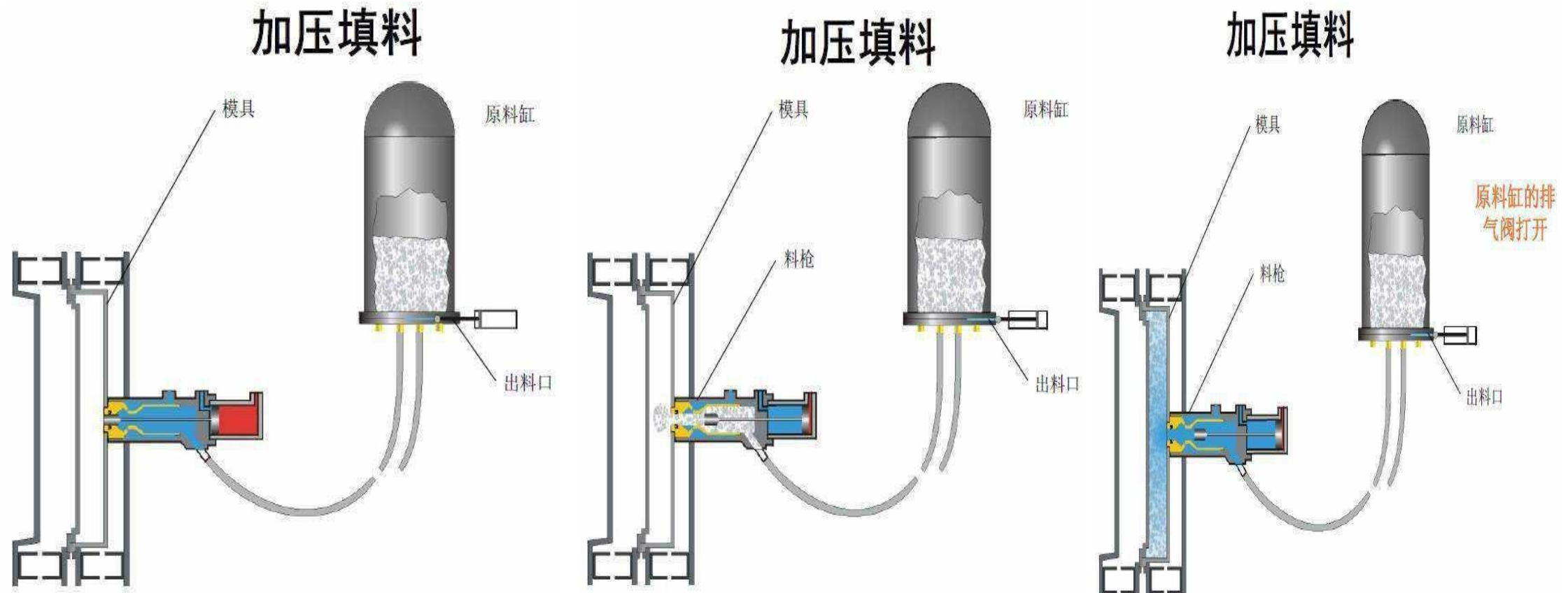
The production of high-quality shapes is guaranteed by a complete filling system and complete craftsmanship. Perfect filling of the shape is very important for good castings! Perfectly filling the matured beads into the mold cavity is an important link in the production of the mold, which is a very important issue. Poorly filled patterns will cause pattern shortage and pattern density steps. Foreign automatic molding machines can better solve this problem! Most domestic manufacturers use press molding, and the pressure filling system (feeding tank) has been used all the time. It requires low filling pressure from the hopper to the mold cavity, and the filling pressure must be evenly matched to ensure that the beads are sprayed back to the tank. , To avoid blockage of the filling pipeline. Using a filling hose with a smaller caliber than the general diameter is a reliable method, but filling defects often appear in the appearance.

Chapter 2 The manufacture of foam models and the



Additional Filling of beads during molding

➤ Pressurized filling process





Additional Filling of beads during molding

- Filling analysis of appearance We know that when the beads flow in, a large amount of compressed air is sent into the mold cavity, and it is very difficult for the compressed air to escape the mold through the air lock. Therefore, the pressure inside the mold cavity will increase, and the mold with insufficient air permeability will be filled with high pressure, resulting in uneven density of the beads, especially in the area of the filling gun port. Due to the inconsistent density of the patterns, this phenomenon can cause casting problems. It is more difficult to fill materials with thin walls and complex shapes. We do not recommend the use of lifting mold for filling; a dry mold can achieve better filling.



Additional Filling of beads during molding

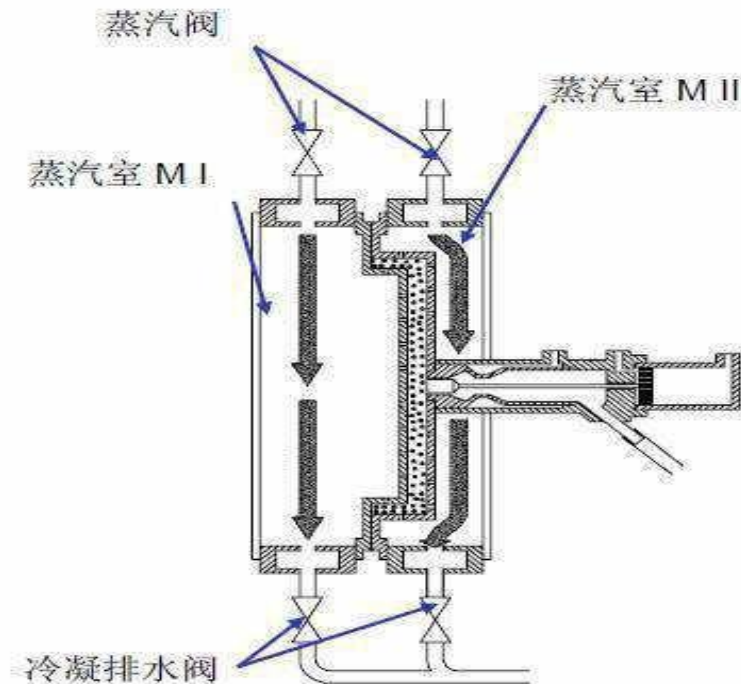
- How to effectively reduce the appearance of filling defects ✕Control during pre-release: ensure that the pre-released beads are smooth and moist. The pre-released beads are of uniform size and low water content; when the fluidized bed is dried, the residence time is not easy to be too long (to reduce the generation of static electricity). ✕Control during maturation: When the beads are matured, the beads in each place should reach the maturation standard, and the matured beads have good resilience. ✕Control during molding: preheat the mold before punching, and blow the condensed water in the mold cavity with compressed air; pay attention to the material tube not to be too long (increased resistance) when filling the material, and the filling tank when filling the tank The internal pressure is generally 0.2MPa (adjustable according to different conditions). When filling the material, attention should be paid to the control of the size of the compressed air (to avoid turbulence in the cavity); when the density of the beads is lighter (<18g/l), select the appropriate lift Mold feeding. ✕Mold control: According to the different mold cavities, the position of the punching port and the specifications of the mold air plug (the size of the air plug hole) should be reasonably selected; the mold air plug should be cleaned regularly to avoid clogging by beads and sewage impurities.

Additional mold preheating and steam delay

- Steam delay
- • Let the beads in the mold temporarily pause to stabilize them in the mold
- . • Used for more complex products.

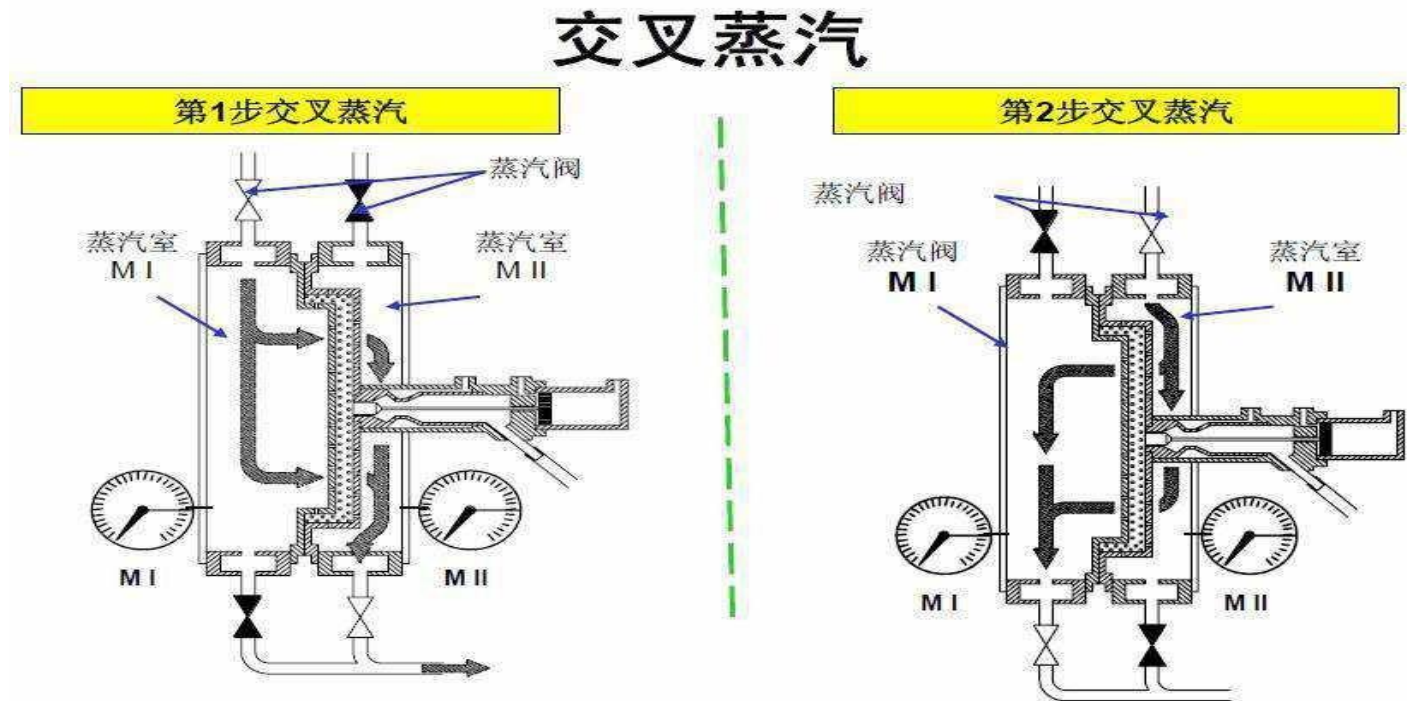
冲模

- 预热模具
- 把冷空气从汽室从赶走，因为空气的热传导能力很差



2.5 Control of molding process conditions

- Steam through the solid mold: Steam enters the air chamber of the movable mold, enters the cavity through the air plug hole on the mold wall, and discharges the air and condensed water between the beads through the air plug hole on the mold wall from the moving mold cavity.
- Mould moving through steam: steam enters the air chamber of the movable mold, enters the cavity through the air plug hole on the mold wall, and discharges the air and condensed water between the beads through the air plug hole on the mold wall from the solid mold cavity.

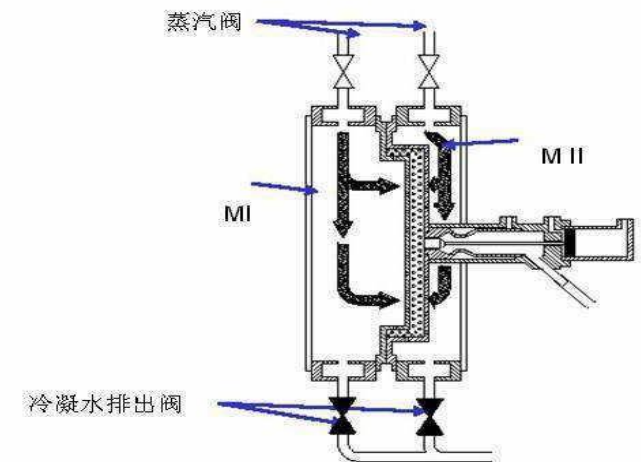


2.5 Control of molding process conditions

- Steam for solid and moving molds: The air chambers for solid and moving molds are steamed at the same time and kept at the set pressure for a few seconds. The beads are heated to soften and expand again to fill all the gaps between the beads and bond each other into a whole.
- Water cooling: Turn off the steam, and at the same time pass the cooling water into the solid and moving mold air chambers to cool the shaped pattern and cool the mold to the demolding temperature, which is generally below 80°C.
- Vacuum cooling: Let off the cooling water, turn on the vacuum to cool the pattern in one step, and reduce the moisture content in the pattern. Mold opening and demolding: Open the mold on the press and select a suitable mold-taking method, such as water vapor superposition, mechanical ejector or vacuum suction cup and other devices to take out the pattern.

双面蒸汽

- 真正的膨胀过程开始。
- 达到熔结温度, 珠粒熔结在一起。





Additional, stable fusion of the shape during molding

- For more complex products
 - Let the corners of the product and the place where there is no steam plug can be better integrated by the heat of the mold (we often say heat preservation)
- ✂Forming process: the surface is not densely fused and prolongs the heat preservation time.
- ✂Operation process: the time between stopping steam intake and venting water cooling. (Holding time depends on different molding equipment and shapes; generally recommended holding time: 8-12")



Additional cooling of the shape during molding

➤ Traditional water cooling

- The water inlet valve is always open, the mold enters water, and the heat is taken away by the flow of water. Until the mold reaches the required demolding temperature.
- Cooling water is sprayed onto the pattern through a steam plug. Generally speaking, traditional water cooling is used for slow pattern forming.

✂Notes: the cooling rate and water inflow of the solid mold and the movable mold.

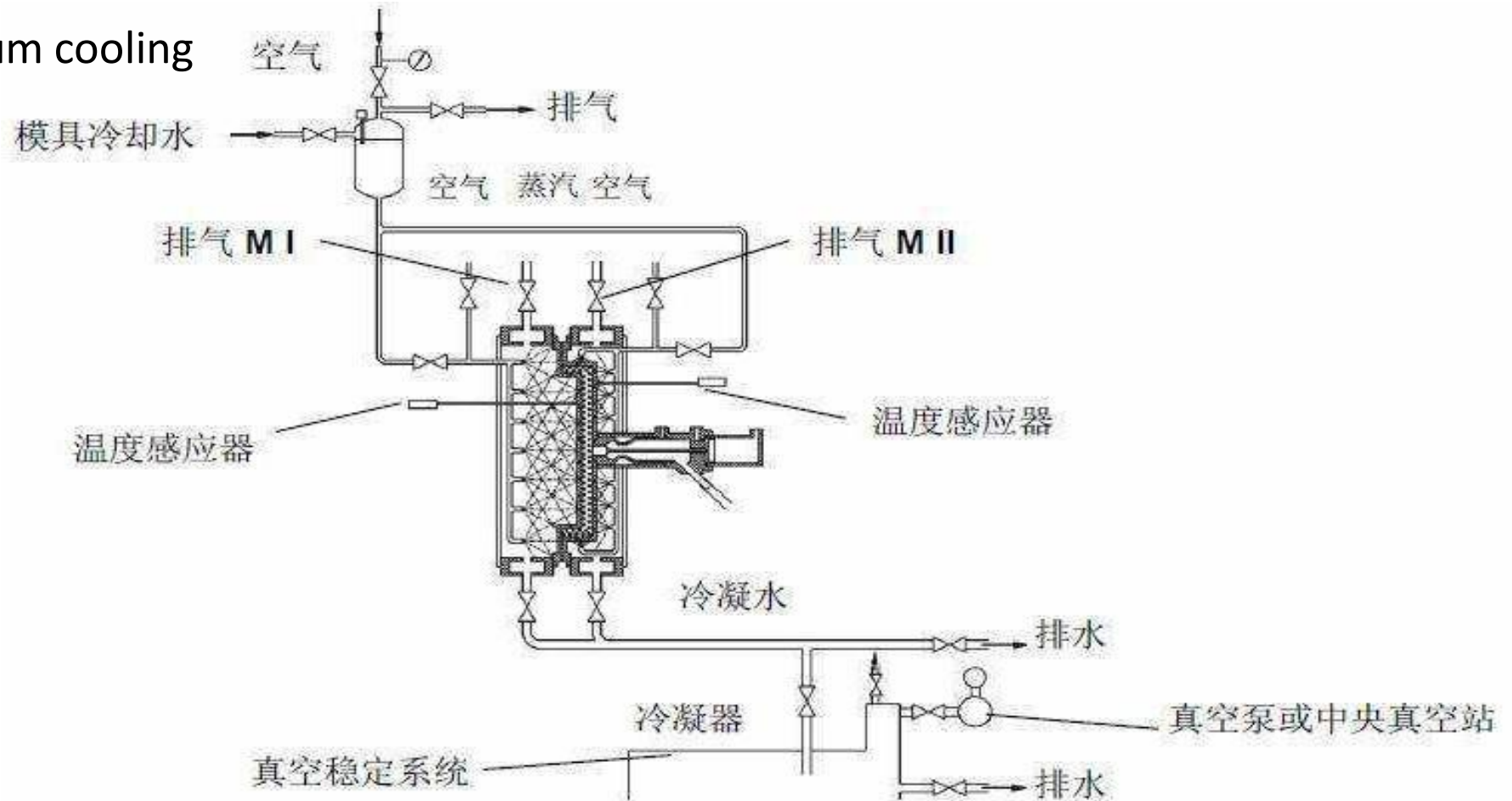


Additional cooling of the shape during molding

- Combination of water cooling and vacuum cooling
 - The heat required to heat 1 kg of water from 20°C to 100°C: 335 kj.
 - The heat required to convert 1 kg of water (100°C) into 1 kg of steam (100°C): 2256kj.
 - Spray atomized water on the surface of the mold to absorb a large amount of heat, so that the water is vaporized, and the heat is absorbed by the evaporation of the water, and the mold is initially cooled.
 - Create a vacuum in the steam chamber, the water evaporates, and the vapor water is pumped out to take away heat.
 - Mainly used for rapid pattern forming.

Additional cooling of the shape during molding

Principle of vacuum cooling

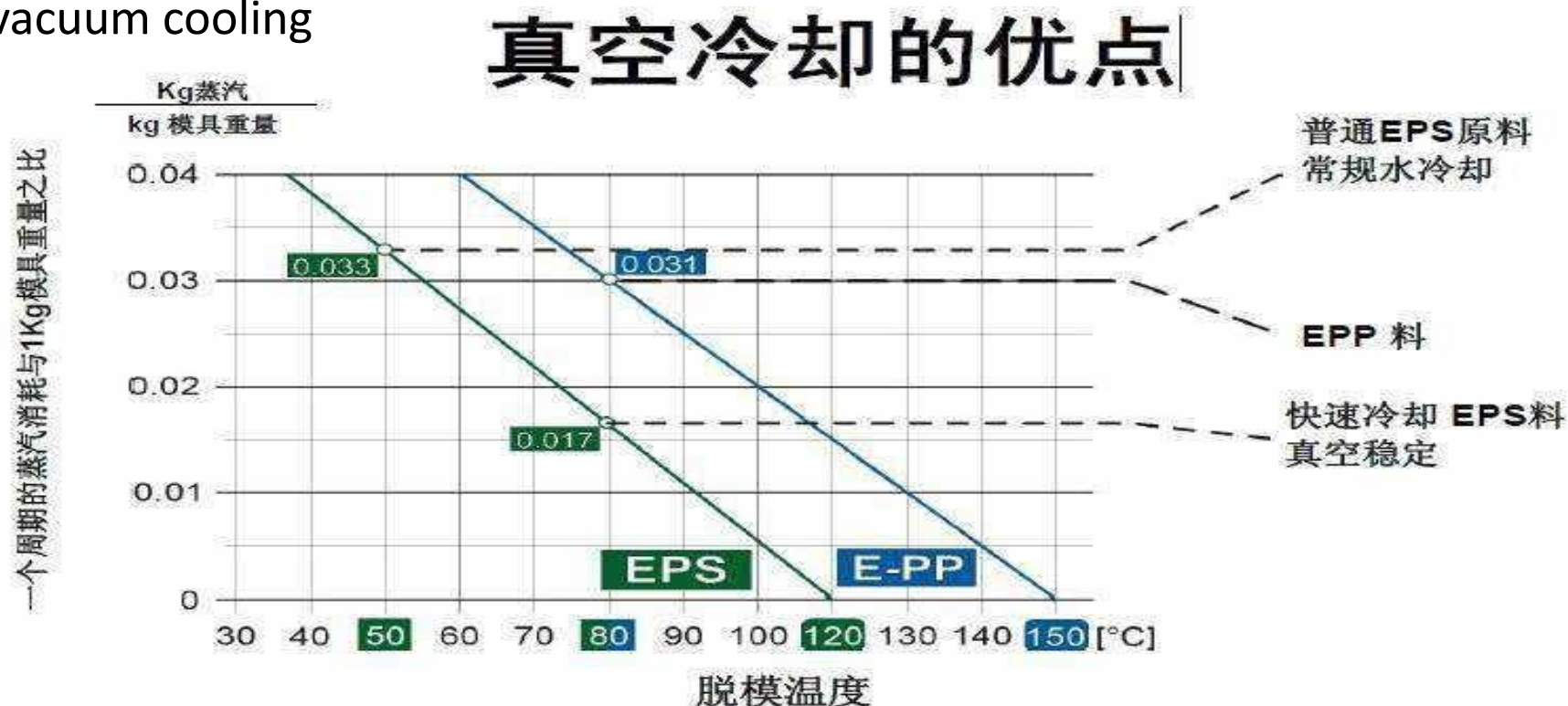


Chapter 2 The manufacture of foam models and the



Additional cooling of the shape during molding

Advantages of vacuum cooling



真空冷却容许EPS产品高温脱模, 因此提高了生产速度, 节约了能源.

真空冷却模具的温度变化范围: 70-80 °C -- 105 °C

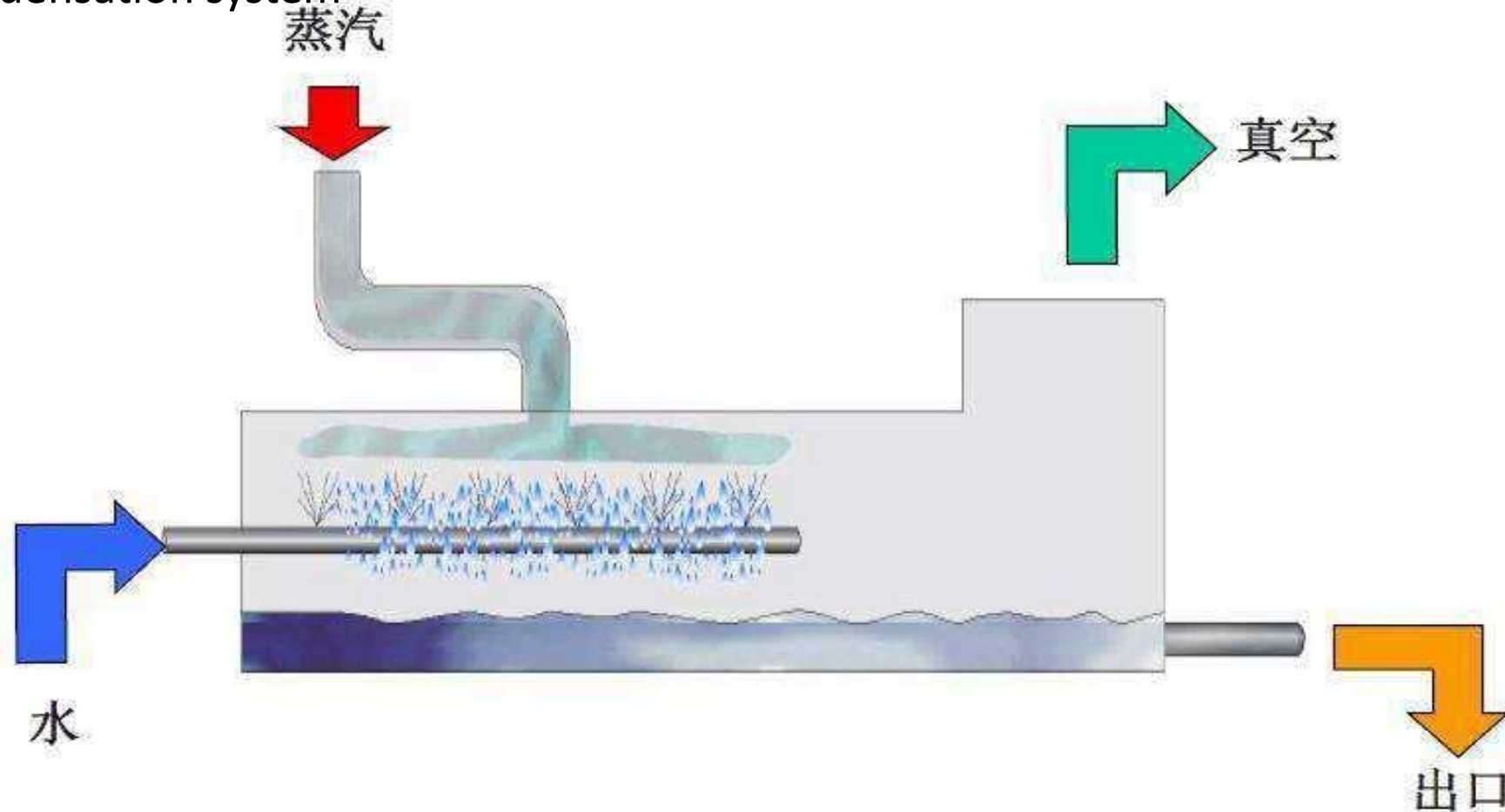
水冷却模具的温度变化范围: 40-50 °C -- 105 °C

Chapter 2 The manufacture of foam models and the



Additional cooling of the shape during molding

Vacuum condensation system





2.5 Control of molding process conditions

(2) Precautions for compressor air chamber forming The type of the original beads, the size of the beads, the pattern structure and the way the steam is introduced into the mold should be considered when selecting the heating steam pressure using the compressor air chamber. In addition, in order to obtain a qualified appearance, 4 issues should be paid attention to in the production process:

1. According to the structural characteristics of the mold, an appropriate feeding method should be selected to ensure that the beads evenly fill the mold cavity. Unsatisfactory filling can easily lead to defects of insufficient molding, and excessive filling will increase the density of the pattern.
2. Control the state of steam heating. The foaming mold is heated by using steam as the heat energy medium. When using superheated steam for bead foam molding, the steam enters the mold cavity through the air plug hole of the air chamber, so that the beads in the vent plug area rapidly expand, overheat and stick together, preventing the steam from continuing to diffuse inward and causing the cavity The internal beads are poorly fused. The moist steam will form a lot of condensed water on the surface of the beads and also prevent the beads from fusing together. Therefore, it is best to use slightly superheated steam to penetrate into the beads in a relatively dry state.
3. The steaming time should be appropriate to make the beads in the mold fully expand and fuse together. Excessive steaming time will cause the pattern to shrink during cooling.
4. Cool down immediately after the shape is formed. At the beginning, the mold wall that the pattern touches is quickly and evenly cooled to a certain temperature, and the pattern is also cooled accordingly and strengthened below the glass transition temperature. Due to the poor thermal conductivity of the foam pattern, only the surface of the pattern cools and hardens, and the internal expansion pressure of the pattern that is still in the hot state is absorbed by a hard shell on the surface. As the surface temperature of the pattern drops, the expansion pressure decreases rapidly until it reaches the pattern. After reaching sufficient stability, the mold can be demolded. If the temperature inside the pattern is not lowered enough, the mold will be released, the expansion force inside the pattern will cause the pattern to expand and deform.



5. Control of molding process conditions

1. Some requirements of foam molding process For many manufacturers, due to the lack of reasonable planning during the initial installation of the equipment, the steam storage tank is far away from the pre-expansion machine and the forming machine, and the steam pipe insulation measures are not in place. In the later pre-expansion process, there is too much condensation in the steam, Resulting in uneven particle size of the pre-emitted foam beads, serious agglomeration, and large waste. Therefore, it is recommended to install a steam-water separation device at the place where the pre-foaming machine enters the pipeline. In the process of visiting companies in the past few years, we have also found that many companies have installed soda-water separation devices, but many are just furnishings. The main problem is that the installed drain valves are not automatic or lack maintenance and the soda-water separation devices do not work continuously. Some manufacturers use manual valves to drain water, and the operators only row once before going to work. This operation not only wastes a lot of steam, but also contains a lot of condensed water in the steam pipe during the production process, which seriously affects the normal production of the pre-foaming process. The foam molding process also has a similar situation. In general, we recommend that the end of the steam pipe be installed with an automatic drainage device and regularly inspected; in addition, the water droplets attached to the surface of the mold cavity also seriously affect the filling of the foam beads. The surface smoothness (flatness) of the foam model.



5. Control of molding process conditions

1. Some requirements of foam molding process It is recommended that in the actual production process, the mold is required to have a better water cooling system. The spray pipe water cooling method designed by most mold manufacturers has a good effect on the cooling of the foam model with more complex structure and higher density, so it is recommended Everyone goes to some more professional manufacturers to customize the mold; finally it is more important to set reasonable molding parameters. Now most manufacturers use semi-automatic molding machines produced by domestic equipment manufacturers. In order to produce high-quality foam models with high quality and quantity, it is reasonable. It is more important to optimize the molding parameters. Regarding the filling method, there are generally two types, namely suction filling and pressurized filling. Regardless of whether you use an automatic gun or a manual gun, the position of the feeding port is very important. How to ensure that the foam beads are in the cavity of the mold The minimum filling resistance is a problem that should be considered carefully in the mold design process, so I again recommend that you choose a professional manufacturer; now the vacuum suction equipment and molds that are already in use on the market, the manufacturers who need it can contact the author to find out. Make a narrative.



2.5 Control of molding process conditions

2.5.2 Foam pattern forming process specification

1. Preheating of the mold: Preheating the mold before feeding is to reduce the condensation water during the foam molding of the beads and shorten the foam molding time; Mold preheating temperature: 50~70°C (a reasonable choice of preheating method according to different seasons). The residual water in the mold must be blown dry before filling to avoid surface defects of the pattern.
2. Matters needing attention when filling:
 - ① When using large beads (specific gravity <18g/L), there is often a gap smaller than the radius of the pre-expanded beads at the parting surface of the mold to facilitate the filling of the beads; use a feeding tank for feeding or the specific gravity of the beads $\geq 18\text{g/L}$. Generally, it is not recommended to raise the mold and add materials when L is used.
 - ② When using the feeding tank to feed, it is not easy to pour too many beads into the feeding tank (usually about 2/3 of the total volume of the feeding tank).
 - ③ When the feed tank is used for feeding, the feed tank pressure is generally about 0.18Mpa (sometimes it can be reasonably selected according to the structure of the mold and the thickness of the pattern).
 - ④ Pay attention to the compressed air intake when using the Vento gun to avoid insufficient charging.



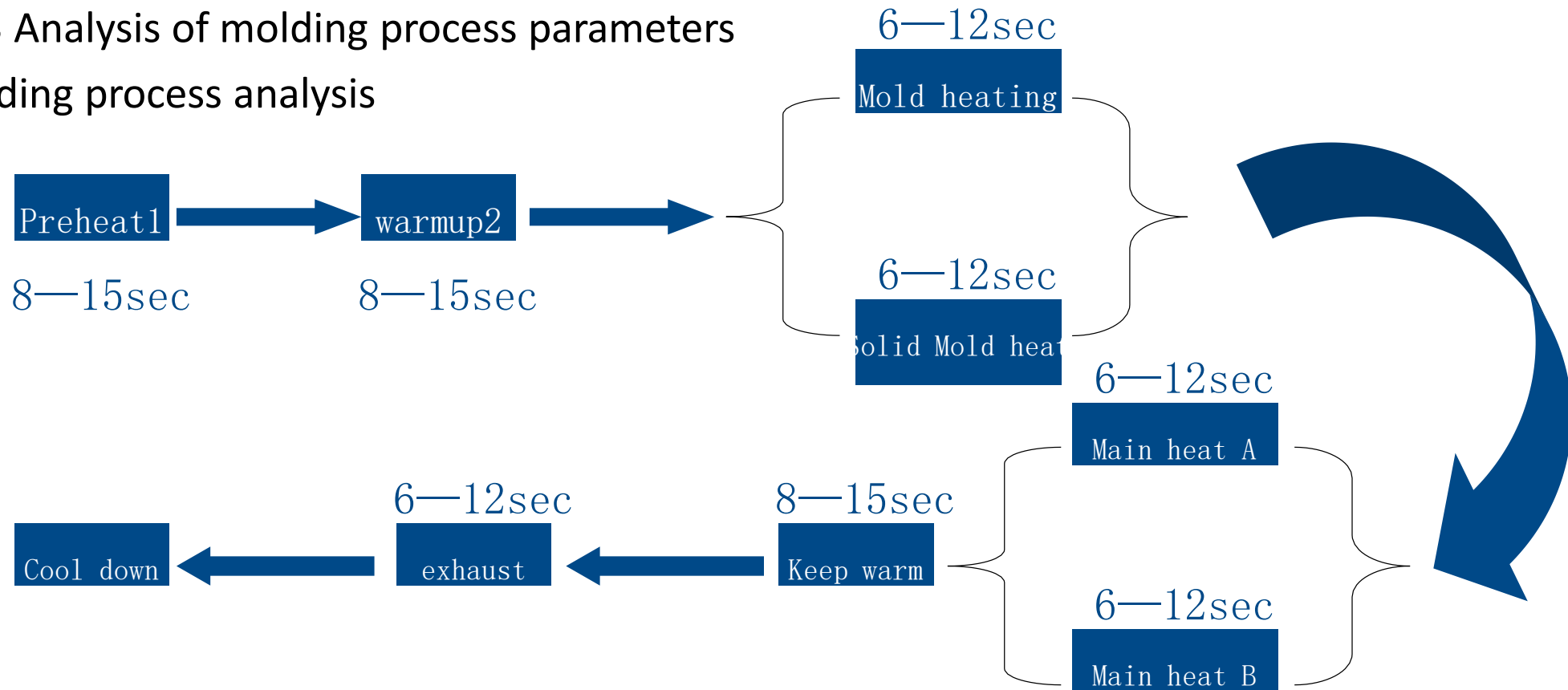
2.5 Control of molding process conditions

2.5.2 Foam pattern forming process specification 3. Heat forming parameter control: ①The molding process should be selected reasonably according to the thickness of different shapes and the density of the beads; the molding process complies with: internal fusion is not dense, prolonging the penetration time; surface fusion is not dense, and the holding time is prolonged. ②Under the premise of ensuring the quality of the pattern, try to use low pressure, large flow and multiple heating molding methods (to reduce the residual volatile matter in the pattern). 4. Cooling appearance: • After the intake valve is closed, water cooling can be performed after the steam and waste heat in the mold steam chamber are exhausted; when using water cooling, pay attention to the water temperature, water pressure and cooling time. • On the premise of no appearance defects, shorten the cooling time and water intake as much as possible.

2.5 Control of molding process conditions

2.5.3 Analysis of molding process parameters

Molding process analysis



Note: pressure setting 0.06-0.14MPa



2.5 Control of molding process conditions

2.5.3 Analysis of molding process parameters

Analysis of sheet forming process parameters



Detailed explanation: The operation of the heating stage has a great influence on the quality of the plate (sintering degree); in general, the forming process needs to go through: heating 1, heating 2, heating 3, several times of heating. Heating 1: The remaining air between the beads in the mold cavity is replaced by steam, and the beads are heated by steam to soften the beads and expand them again; (parameters: pressure control 0.07-0.1MPa, time 60-100 seconds) Heating 2: The surface of the beads is softened by steam layered heating, and there is a slight bonding between the beads; (parameters: pressure control 0.1-0.12MPa, time 15 seconds) Heating 3: The real expansion process begins, reaching the sintering temperature, and the beads are fused together; (parameters: pressure control 0.14-0.16MPa, temperature: 110~115°C + 5°C (at this temperature, the beads can be made Better integration between))



Additional molding: good quality requirements

- Optimal material distribution during mold filling (avoid areas with improper filling)
- The best fusion of the entire die in the steam stage (to avoid poor fusion and local over-burning)
- The best density distribution of the entire die (the entire pattern, the density steps everywhere are controlled within $\pm 1\text{g/l}$)
- The best shrinkage rate of the entire die (copolymerization pattern shrinkage $< 0.3\%$; ordinary (EPS\FD) pattern shrinkage $< 0.6\%$)
- Dense surface, no gaps between beads (the gap between the beads on the surface of the model is less than 0.3mm)

Chapter 2 The manufacture of foam models and the



Three states of shape molding



正常熔合



熔合不好



熔融 (过烧)





Additional appearance of aging treatment

At this stage, the two most difficult problems to solve in the lost foam white zone: Density ladder Control of residual moisture and volatile matter in the appearance

✂The density ladder of the appearance involves:

1. Consistency of pre-expanded beads (uniformity, density fluctuation, bead quality)
2. 2. Filling system
3. 3. Human factors, etc.

✂The residual volatile matter in the sample mainly relates to the loss ratio of volatile matter content



Additional appearance of aging treatment

※Specific performance of the pattern density ladder:

Uniformity of pre-expanded beads Lifting and feeding (generally flat-like appearance)

Selection of feeding system

Placement of the feeding port

The size and reasonable distribution of mold air plugs

Control of uneven thickness



Additional appearance of aging treatment

✕The loss ratio of volatile content: The volatile content of STMA copolymer beads is: 9.5%-10.05%; EPS: 6%-7.5% The control of the volatile matter of the original beads:

- The control of the volatile matter should start from the original beads, (according to the season and time of use), especially the beads with a larger particle size.
- Control of volatile matter during pre-expansion: 1~2% loss of volatile matter when beads are pre-expanded
- Control of volatile matter during bead maturation: The main thing when bead maturation is to remove the moisture content in the bead, and the loss of volatile matter is less (<1%).
- Control of volatile matter during molding: 3~5% loss of volatile matter during molding.
- Control of volatile matter when the pattern is dried: The loss of volatile matter is about 1% when the pattern is dried.)



Additional appearance of aging treatment

✕Control of moisture content in the pattern: We require the residual moisture content in the pattern before pouring: gray iron parts and ductile iron parts $<1\%$ (casting steel parts $<0.5\%$), which requires us to quickly and thoroughly remove the excess in the pattern after the white mold is made Most of the lost foam companies put the formed white molds into the drying room immediately (drying for 2-5 days), and the method to check whether they are dried is: weigh on an electronic balance and weigh When the weight change is small after 3-4 times, the appearance is considered to be dry. Here I would like to ask you a question: Under what environment can moisture escape from the appearance faster and more thoroughly? (Humidity, temperature, ventilation conditions) ✕Some thoughts about drying room: The purpose of putting it in the drying room? Under what environment does it look like in the drying room, the moisture escapes faster and more? How big should the drying room area be according to different products? In most lost foam enterprises, is there a reasonable use of the drying room space? Is the humidity in the drying room effectively controlled?



Additional appearance of aging treatment

✕The loss ratio of moisture content: We require that the formed shape escape 60%-70% moisture under natural conditions. Then enter the drying room for forced drying, and let the moisture in the appearance escape 20%-30% in the drying room. After the moisture has basically escaped, the bead on the surface of the pattern is slightly expanded by the temperature of the drying room to lock the surface of the pattern to avoid anti-moisture absorption. Remarks: If the dried white molds are not used immediately, please put them in the transfer warehouse (Environmental requirements: temperature around 20°C; humidity $\leq 20\%$)



6. Drying and anti-deformation treatment of model pieces

1. Dryness and stability of foam Since the foam pattern is in contact with water vapor and water during the molding process, the freshly produced pattern has a higher water content. There are many factors that affect the water content of the pattern, but the main ones are the foaming molding method, heating steam pressure, steaming time, and cooling method and time. Under normal circumstances, the moisture content of the pattern just after demolding is 5~15%; in order to ensure the quality of the lost foam casting, the pattern or the pattern must be dried before assembly and coating to reduce the moisture content in the pattern to 1 %the following. In addition, the foaming agent remaining in the drying process of the pattern also diffuses and escapes from the inside of the cells. As the moisture and foaming agent content of the pattern decreases during the drying and storage process, the size of the pattern also changes. For the first hour after demolding the EPS pattern, the pattern expands 0.2%~0.4%; the pattern shrinkage within 48 hours is 0.4%~0.6% (relative to the size of the mold cavity). When stored for 15-20 days, the shrinkage can reach 0.8%. The residual foaming agent and water content in the foam pattern, as well as whether the molding process and the structural characteristics of the pattern are reasonable, will affect the shrinkage rate of the pattern. In this regard, it is necessary to continuously research and accumulate data in production to meet the accuracy requirements of castings.



6. Drying and anti-deformation treatment of model pieces

1. Dryness and stability of foam

The size shrinkage experiment of some foam patterns is as follows:

Experiment 1:

The relationship between the shrinkage rate of the foam pattern and the particle size of the beads Experimental model size:

300mm*75mm*25mm Experimental pattern density: 25g/l Experiment placement temperature: 23°C The experimental data is shown on the right :

Beads Size	EPS		STMMA	
	0. 4mm	0. 5mm	0. 4mm	0. 5mm
Leave for 3 days Shrinkage	0. 3%	0. 22%	0. 13%	0. 11%
10 Days	0. 35%	0. 26%	0. 125%	0. 1%
15 Days	0. 38%	0. 3%	0. 12%	0. 09%
20 Days	0. 43%	0. 33%	0. 11%	0. 08%
30 Days	0. 48%	0. 38%	0. 11%	0. 06%



6. Drying and anti-deformation treatment of model pieces

1. Dryness and stability of foam

Experiment 1: The relationship between the shrinkage rate of the foam pattern and the particle size of the beads

It can be seen from the test data:

1. Regardless of whether it is EPS beads or copolymers, the smaller the particle size of the beads, the greater the shrinkage rate of the foam pattern produced; the larger the particle size of the beads, the smaller the shrinkage rate of the foam pattern produced.
2. In an environment of 23°C: the shrinkage rate of the foam pattern made by EPS beads increases with the prolonged storage time; while the shrinkage rate of the foam pattern made by the copolymer beads varies with As the storage time is prolonged, the shrinkage rate is getting smaller (it can be seen that: the foam shape made by the copolymer beads, if the density is higher, the shrinkage rate of the shape will gradually decrease with the prolongation of the storage time (mainly The pattern has a higher density, and the pattern has swelled).



6. Drying and anti-deformation treatment of model pieces

1. Dryness and stability of foam

The size shrinkage experiment of some foam patterns is as follows:

Experiment 2: The relationship between the shrinkage rate of the foam pattern and the drying temperature

Particle size of sample copolymerized beads:
0.4mm

Density of sample foam pattern: 25g/l

The experimental data is shown on the right:

Look dry temperature	23℃	40℃	60℃
Leave for 6 days Shrinkage	0.11%	0.18%	0.32%
10 Days	0.1%	0.2%	0.33%
15 Days	0.09%	0.21%	0.36%
20 Days	0.08%	0.23%	0.4%
30 Days	0.06%	0.27%	0.48%



6. Drying and anti-deformation treatment of model pieces

1. Dryness and stability of foam

Experiment 2: The relationship between the shrinkage rate of the foam pattern and the drying temperature

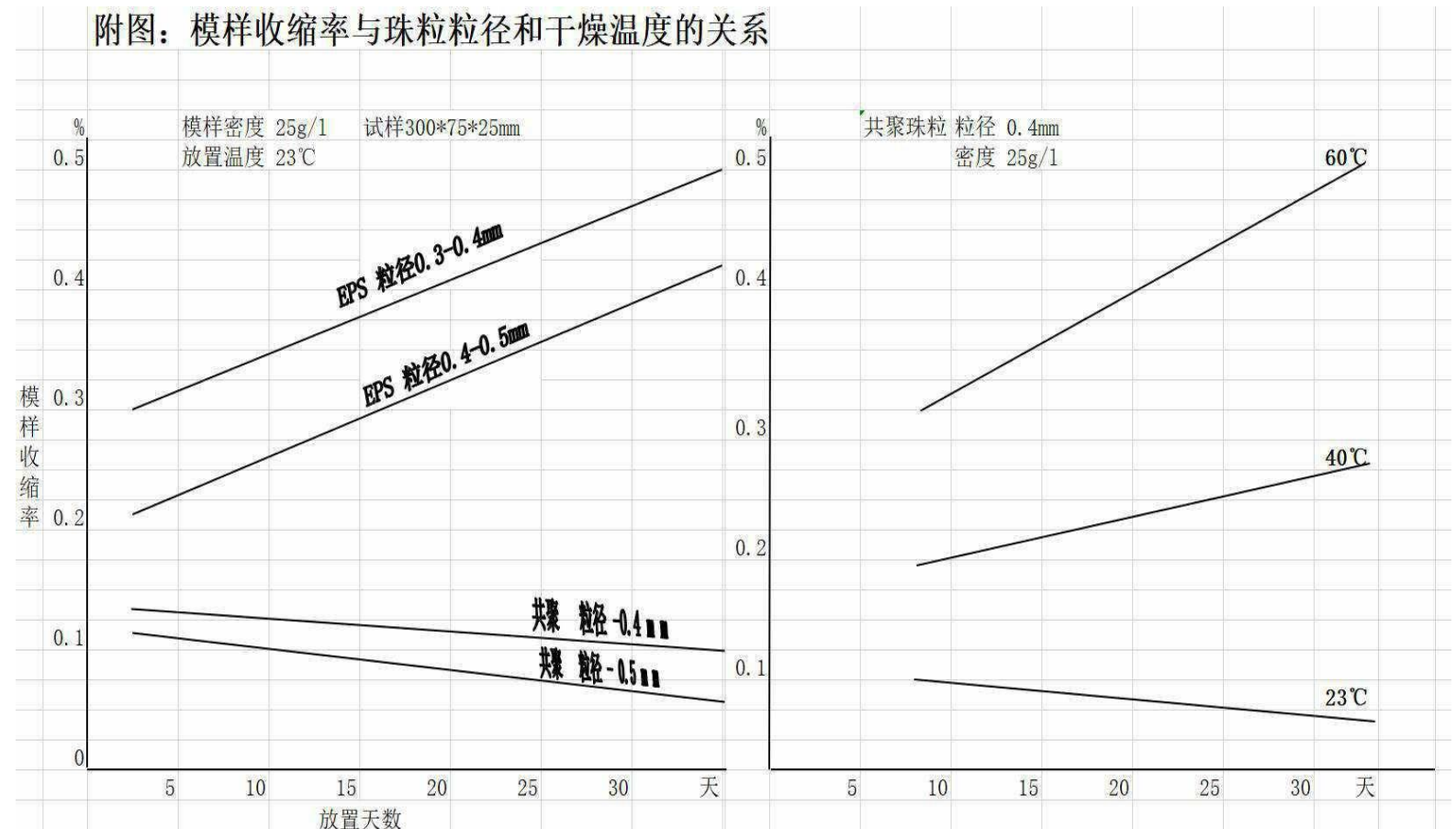
It can be seen from the test data:

1. When the pattern is dried (drying temperature) is low, the foam pattern made by the copolymer beads, if the density is higher, the shrinkage rate of the pattern will gradually decrease with the prolonged storage time (mainly the pattern is higher in density) , The pattern has swelling); when the pattern is dried (drying temperature), the shrinkage of the pattern will increase, which is why we recommend the drying temperature of the pattern at 35-40°C.
2. The longer the pattern is placed, the greater the shrinkage of the pattern; therefore, the produced pattern should not be extended indefinitely (recommendation: EPS pattern is recommended not to be placed for more than 15 days, copolymer pattern is recommended not to be placed for more than 30 days) .

6. Drying and anti-deformation treatment of model pieces

1. Dryness and stability of foam

In actual production, the drying and stabilization of the pattern generally use a combination of drying at room temperature and forced drying in a drying chamber. The temperature of the drying chamber is generally controlled at 35~45°C.



2.6 Drying and anti-deformation treatment of model pieces

2.6.2 Anti-deformation treatment of foam shape

When the foam model is just removed from the mold, due to the high water content and high temperature, this is the softest time of the foam model. At this time, the probability of deformation of the foam model is very large.

Two considerations should be taken in the subsequent drying. aspect: ✕The first deformation: It is necessary to set up a special cool mold frame for some foam model products with easily deformable structure, and carefully consider its placement method.



2.6 Drying and anti-deformation treatment of model pieces

2.6.2 Anti-deformation treatment of foam shape

※Second Deformation: During the drying process, reasonable molds should be used to prevent and correct the deformed foam or easily deformable foam model, otherwise the foam model will have a higher rejection rate in the later stage, and the mold will be closed in the late



2.6 Drying and anti-deformation treatment of model pieces

2.6.3 The actual effect and drying treatment of the foam appearance The drying of the foam model is generally divided into two parts: ✕The first is natural drying. The foam model is softer and has a higher water content when it is taken out from the mold. In addition, the foaming agent residue in the beads is higher. If it enters the drying room directly, it will increase the deformation and at the same time. Causes three expansions of the beads on the surface of the foam model 。

The effect of the three-time foaming of EPS and FD beads is not too obvious, and the effect of the three-time foaming on the surface of the STMMA copolymer beads will be greater. We generally call the "orange peel" phenomenon, which seriously affects the surface quality of the castings. The natural drying time is determined according to the product structure, site and tooling conditions. The shortest time is when the water droplets on the surface of the foam model are completely volatilized, and the stiffness of the foam model is significantly enhanced (generally more than 4 hours). If the conditions are met, it can be placed directly The day before use.



2.6 Drying and anti-deformation treatment of model pieces

2.6.3 The actual effect and drying treatment of the foam appearance ※The second is high temperature drying in the drying room

Drying temperature is 40-45°C and humidity is less than 15%. Let the foaming agent evaporate as much as possible. The drying time is preferably more than 24 hours. This control can be determined by making a drying curve and detecting moisture and volatile residues. It is not left to nothing or random operation. Many problems in the later coating operation and pouring are related to whether the foam model is completely dried. In principle, the longer the foam model is placed, as long as the size shrinkage is not a problem, the later the pouring pressure will be higher. Smaller, the smaller the probability of problematic defects.



7. Bonding combination of model pieces and mold clusters

1. Three ways of bonding model pieces For some more complex casting products, in order to facilitate the operation of foam model forming, the mold is generally designed to be divided into pieces. Before bonding the runner, two or more mold pieces must be fixed together with cold glue or hot glue. Some corporate bonding methods can be roughly divided into the following categories: ✕ First, manual gluing and bonding: cold glue is applied to the parting surface of the model by hand, and then the mold is manually closed after waiting for a few minutes.

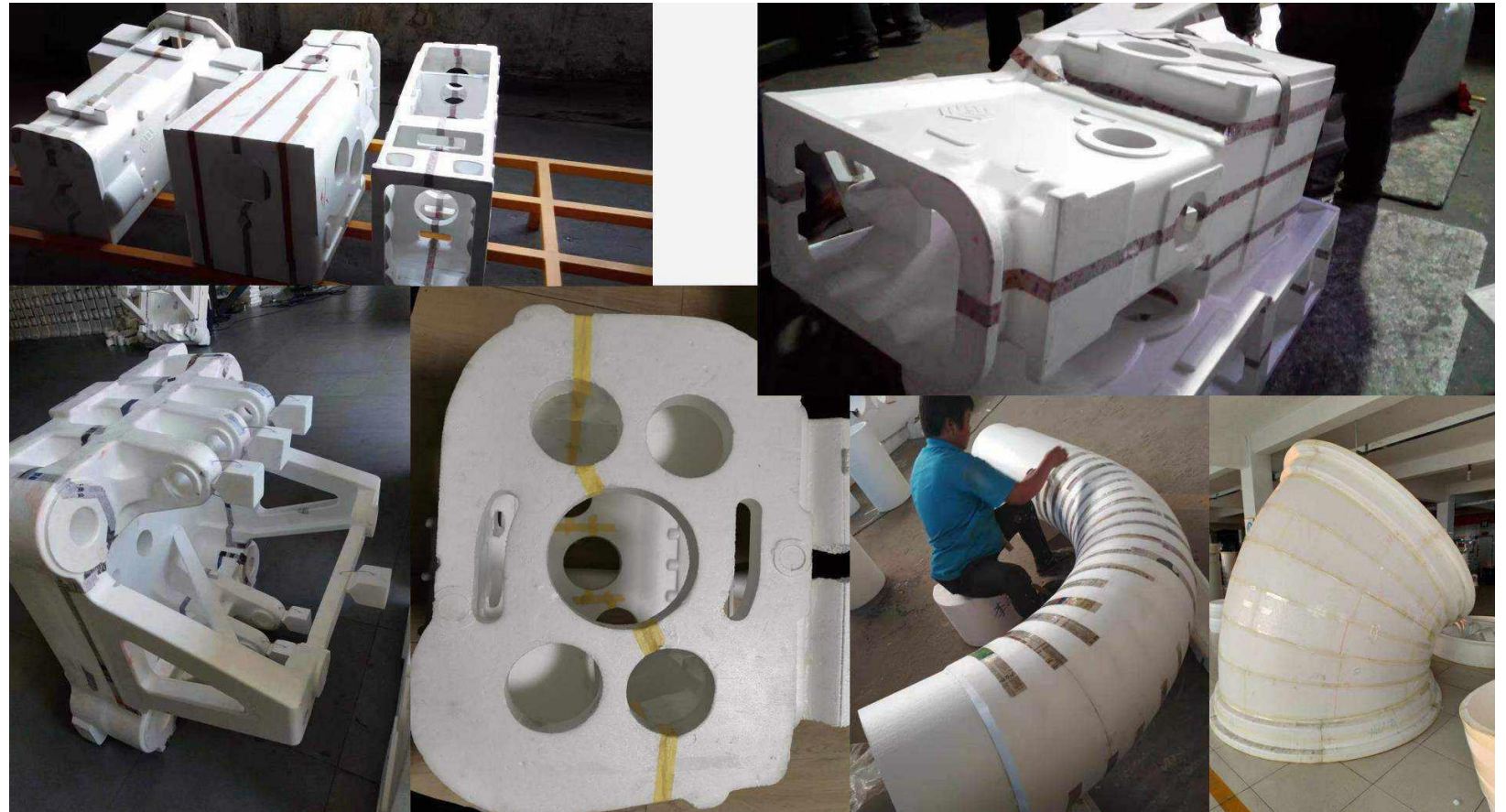
Some products require simple tooling due to their large size and complex structure. This operation method is relatively simple and practical, and the investment cost is not high. However, the level of operation of workers depends entirely on "practice makes perfect", and it is difficult to guarantee standardization of operation. The working level of workers is uneven, and the glue joints must be treated with repairing paste or tape to prevent the later paint from penetrating and causing slag holes.



7. Bonding combination of model pieces and mold clusters

1. Three ways of bonding model pieces ✕First, manual gluing and bonding

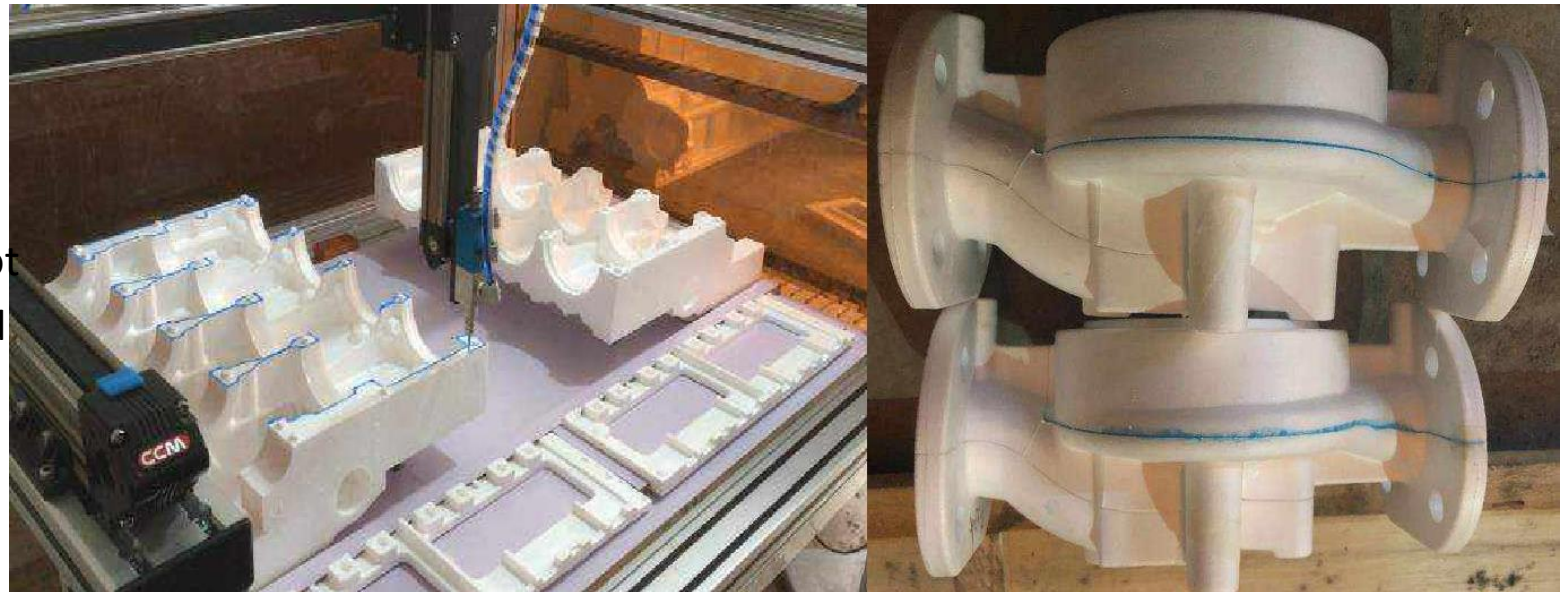
Bonding seam
Adhesive tape,
newspaper deal
with



7. Bonding combination of model pieces and mold clusters

1. Three ways of bonding model pieces ✖ Second, gluing machine gluing and bonding: In some of the companies we visited, automatic gluing machines are also widely used. In the past, this equipment was mainly used in the leather and shoe industries, and was modified by some equipment companies. The die was coated with glue, which was further designed and improved by professional organizations.

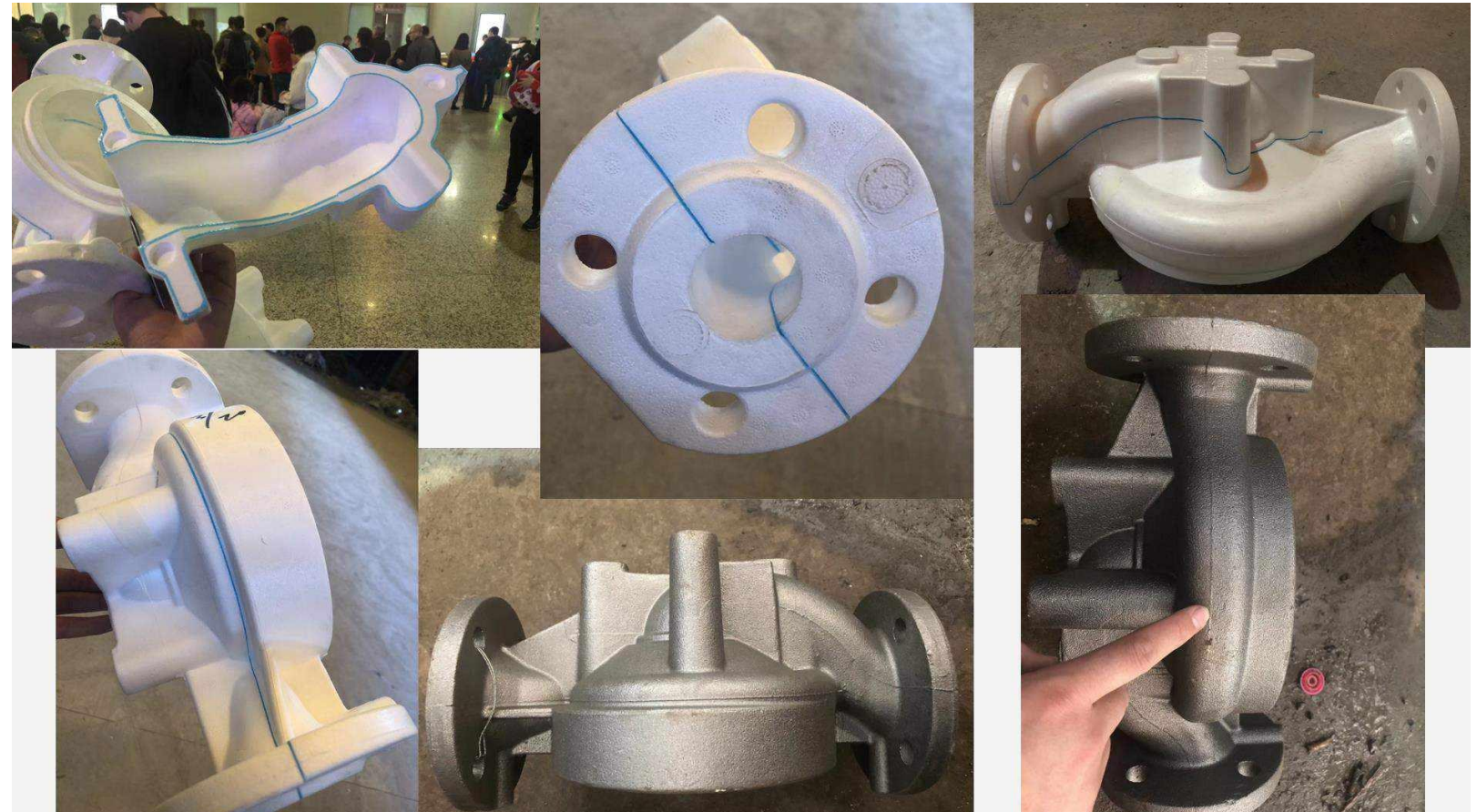
In addition, with the successful development of special glue, the automatic gluing line is uniform and efficient, and the glue seam does not need to be processed after the mold is closed, which simplifies the operation process, improves labor efficiency, and facilitates the standardization of operation. It is favored by many manufacturers. .



7. Bonding combination of model pieces and mold clusters

1. Three ways of bonding model pieces ✕Second, gluing machine glue bonding

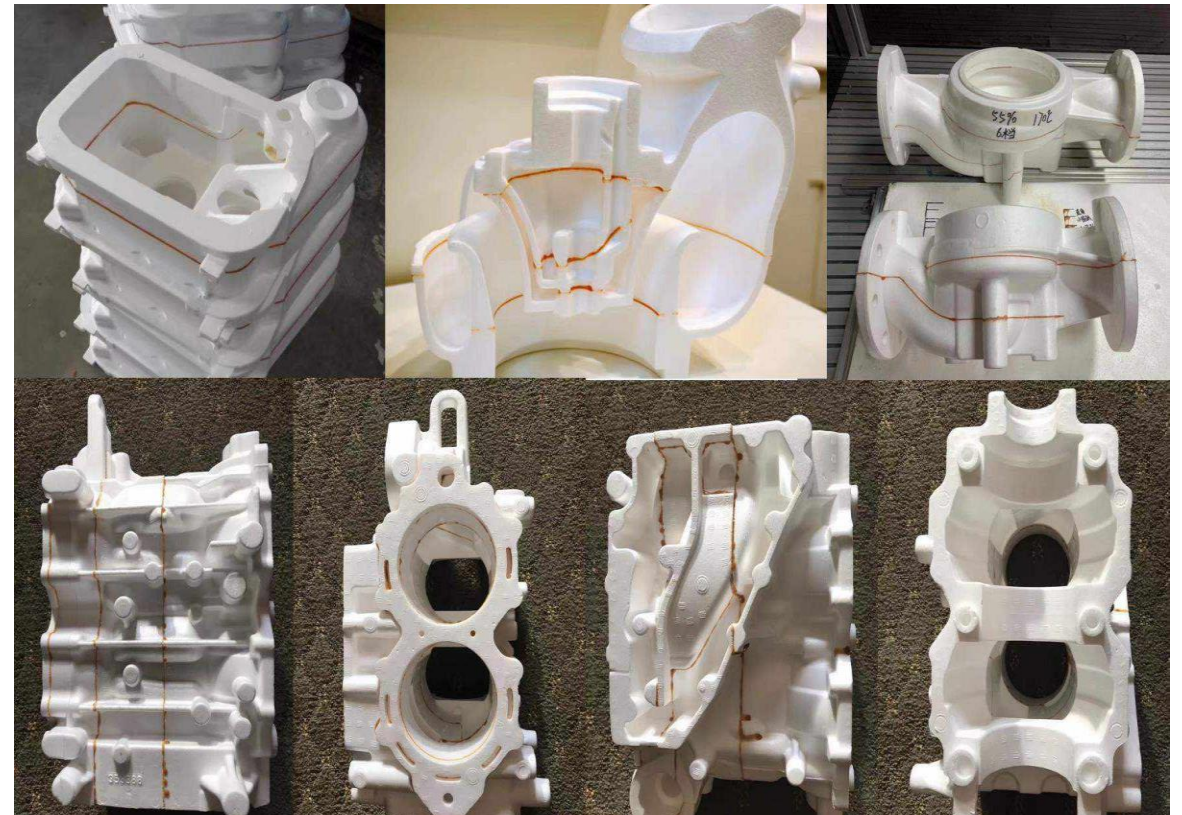
Bonding seam No
tape, paper, or
repair paste
required deal with



7. Bonding combination of model pieces and mold clusters

1. Three ways of bonding model pieces ✕ Third, hot glue automatic bonding machine: In some of the companies we visited, several of them use automatic bonding machines.

For example, a domestic manufacturer produces engine cylinder heads and uses special hot glue as an adhesive. This kind of operation process is highly efficient, cooling quickly after closing the mold, and no special treatment is required for the glue seam. However, it is necessary to make a special mold (similar to the mold opening). The cost is relatively high, and it is more troublesome to disassemble the mold. product. The above three operations are currently the more common foam model bonding methods used by domestic enterprises. You can choose the operation method that suits your own production reasonably according to the structure, quantity, and site conditions of the products produced.





2.7 Bonding combination of model pieces and mold clusters

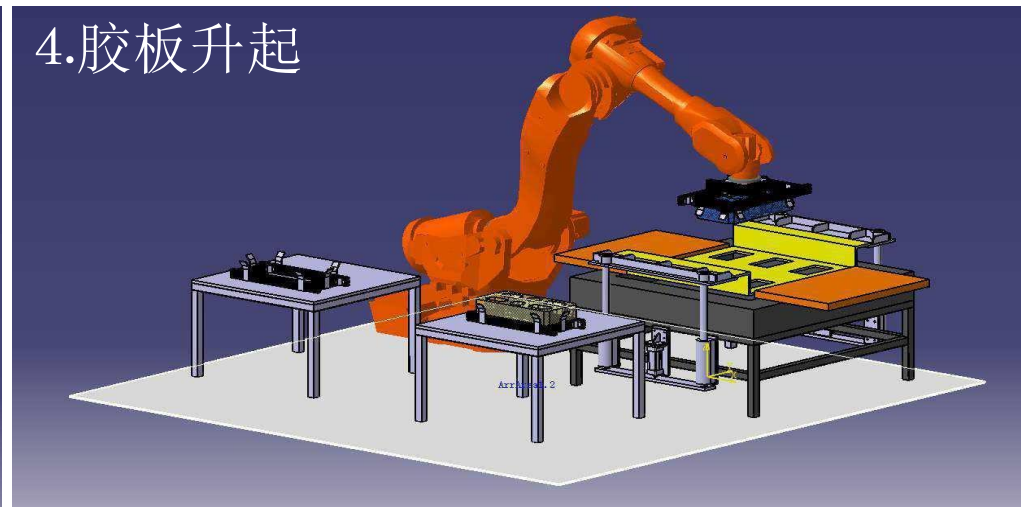
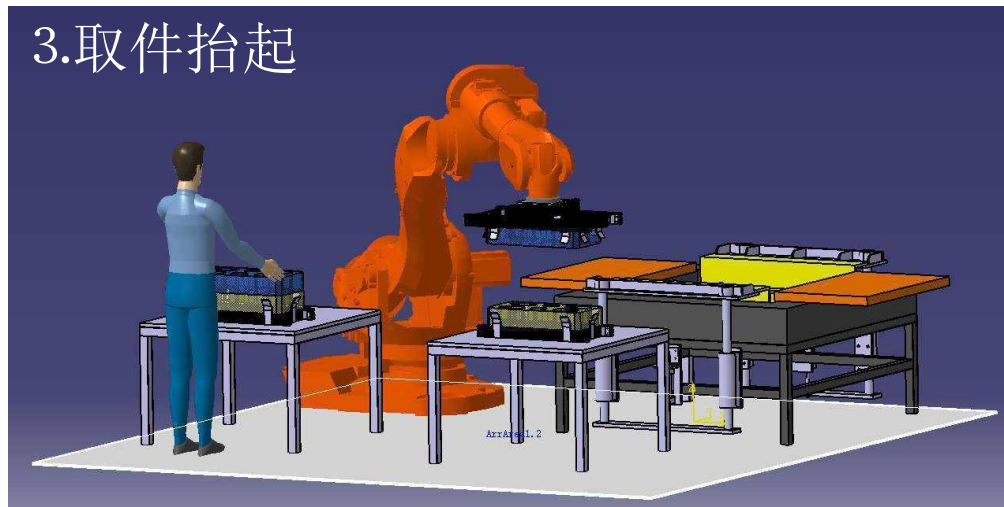
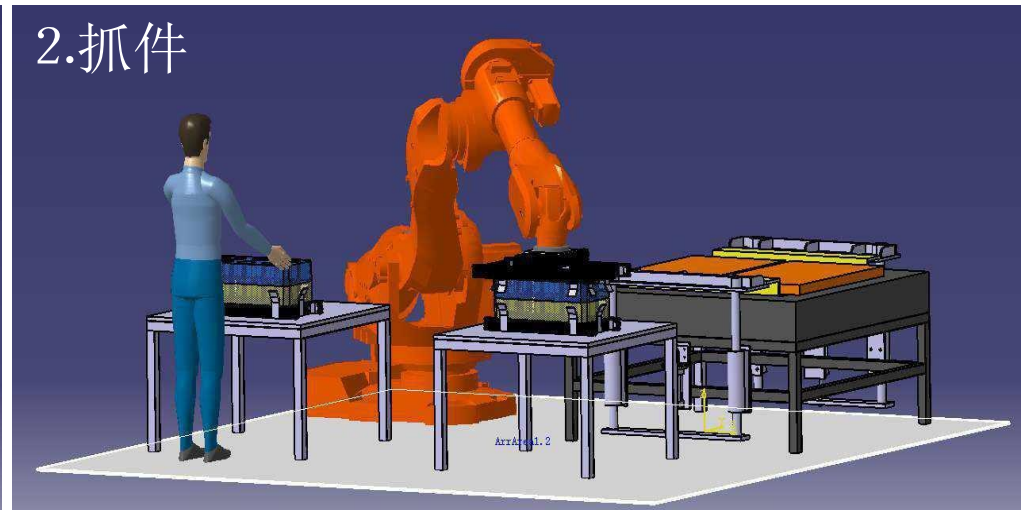
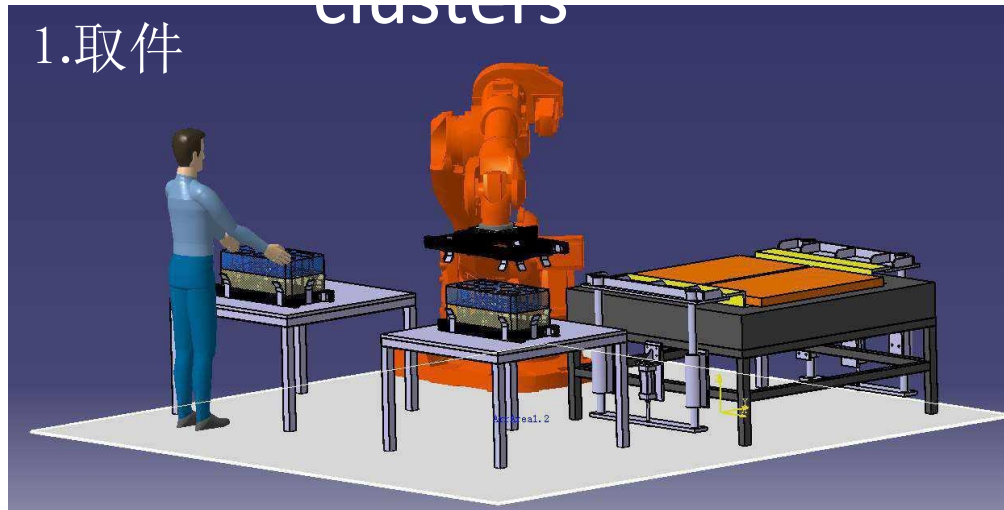
2.7.2 Precautions when bonding and grouping model pieces In the actual production process, major companies will choose the appropriate bonding method according to the existing hardware facilities and product structure. The specific operations should pay attention to the following issues:

- ① For some thin-walled parts and foam models that are prone to deformation after subsequent operations, they should be calibrated or used tooling, wood strips (or fiber rods) for anti-deformation treatment before closing the mold. The tooling can be made of aluminum alloy, insulating plates and other materials. Production to ensure accuracy.
- ② The integrity of the model should be checked after the die is glued, and the unqualified products cannot flow into the subsequent production process (many companies use paper tape and repair paste to repair, and the automatic gluing machine has uniform glue seam, which has obvious advantages).
- ③ The bonded foam model should be placed on a special drying mold frame, and should not be stacked randomly (most of the companies we visited are placed on the ground, and a special person should be arranged to check and repair before painting) to prevent degeneration and transportation. Breakage in.
- ④ The glue used for foam model bonding should be organic glue. During the filling process of molten metal, some physical and chemical changes will occur, which will bring hidden dangers to the quality of castings inside and outside. Therefore, under the condition that the die bonding quality is qualified, the glue should be used as little as possible to reduce the air volume of the entire model, thereby reducing the probability of casting defects (in some of the companies we visited, the glue joints were repainted with hot melt glue guns). Once again, especially at the bonding seams of the gating system , This kind of operation is quite harmful).

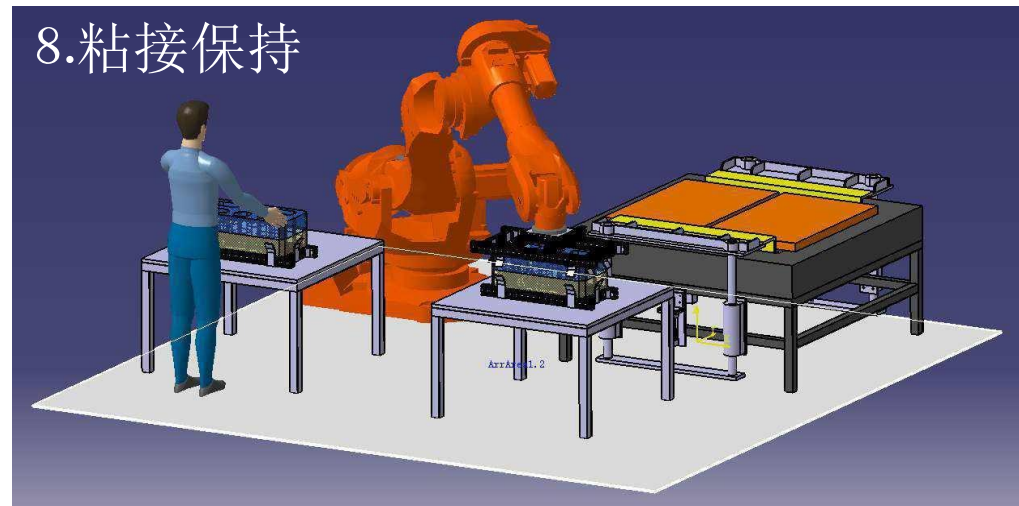
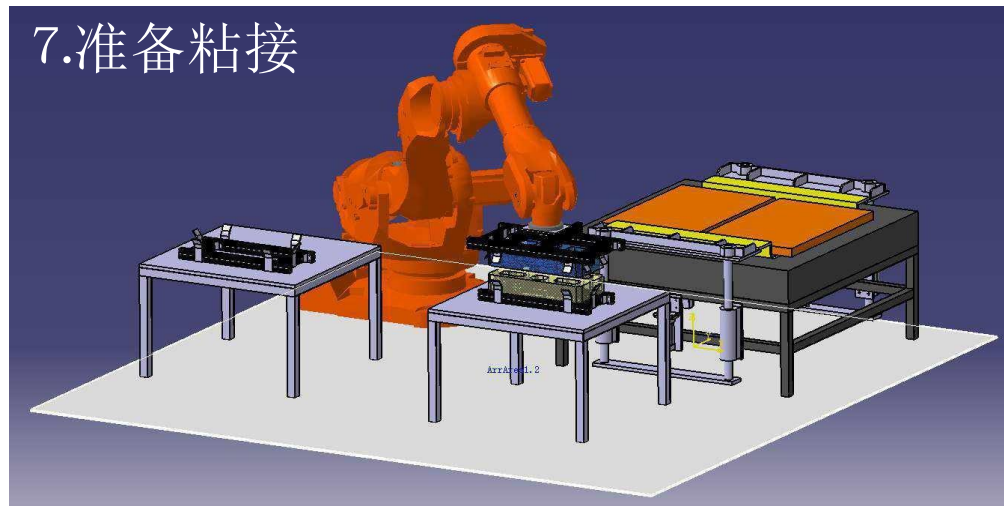
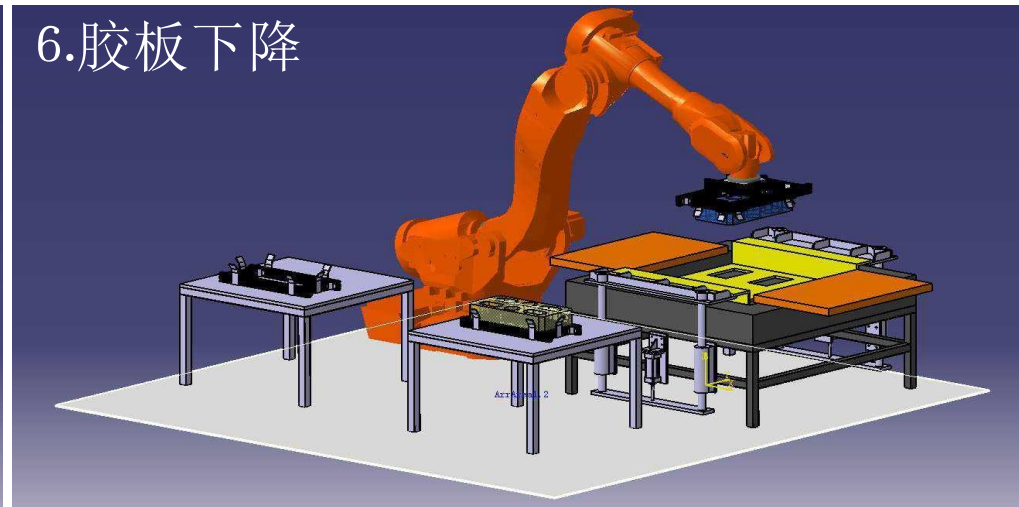
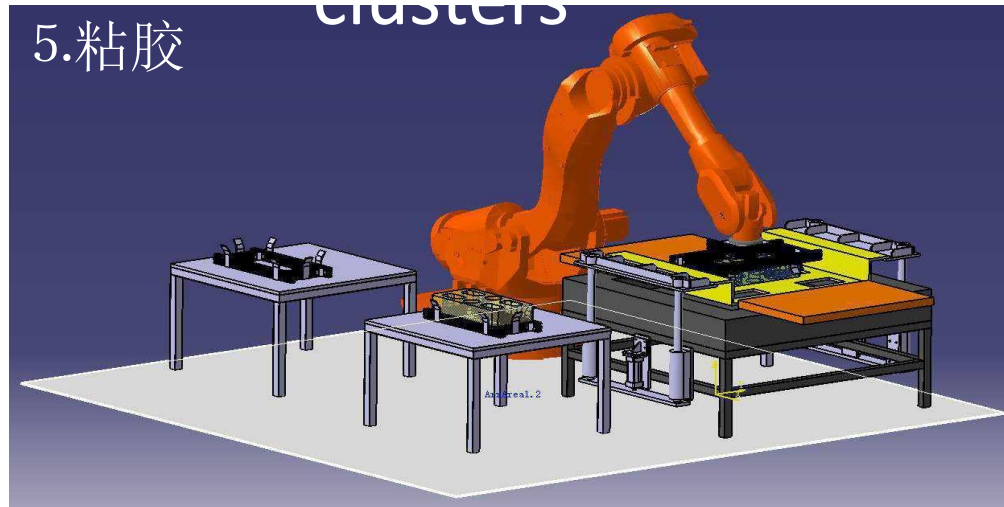
Chapter 2 The manufacture of foam models and the



Additional robot bonding for lost foam die



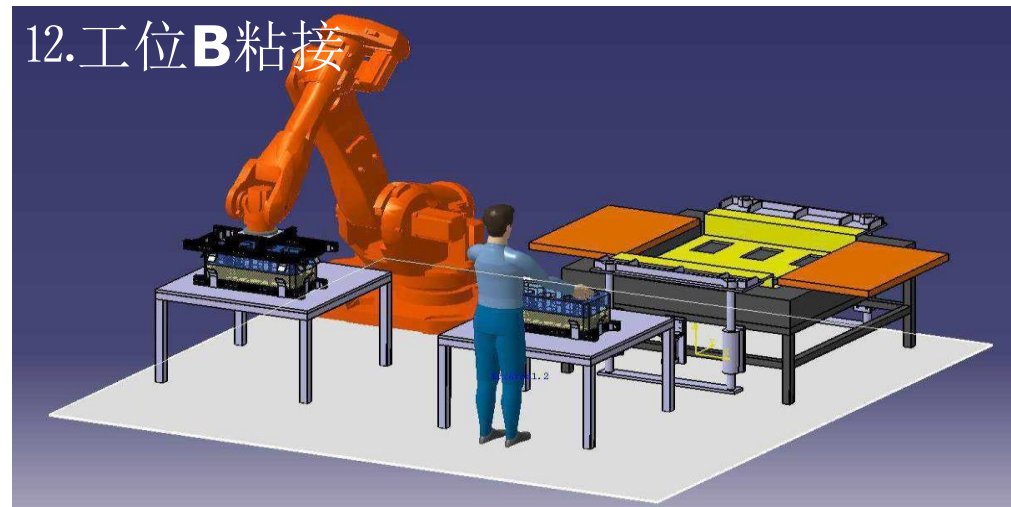
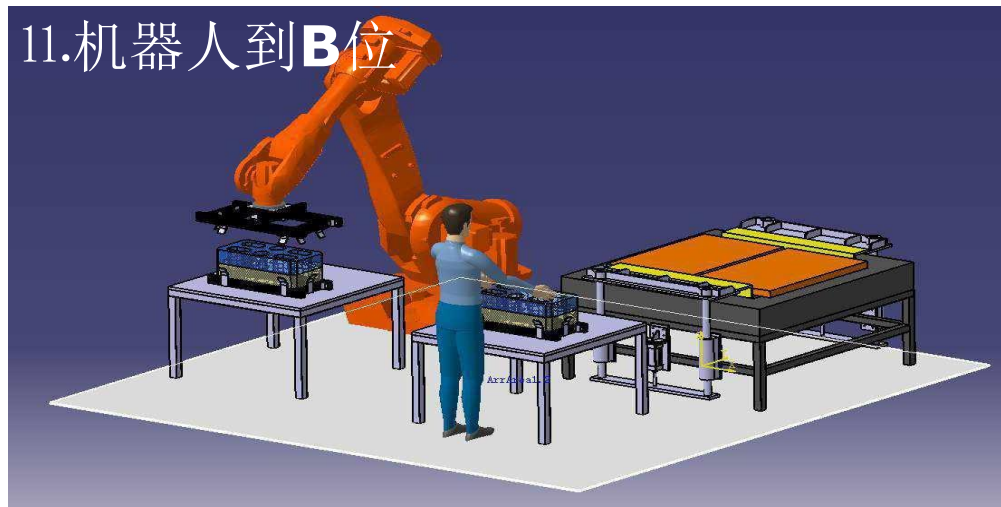
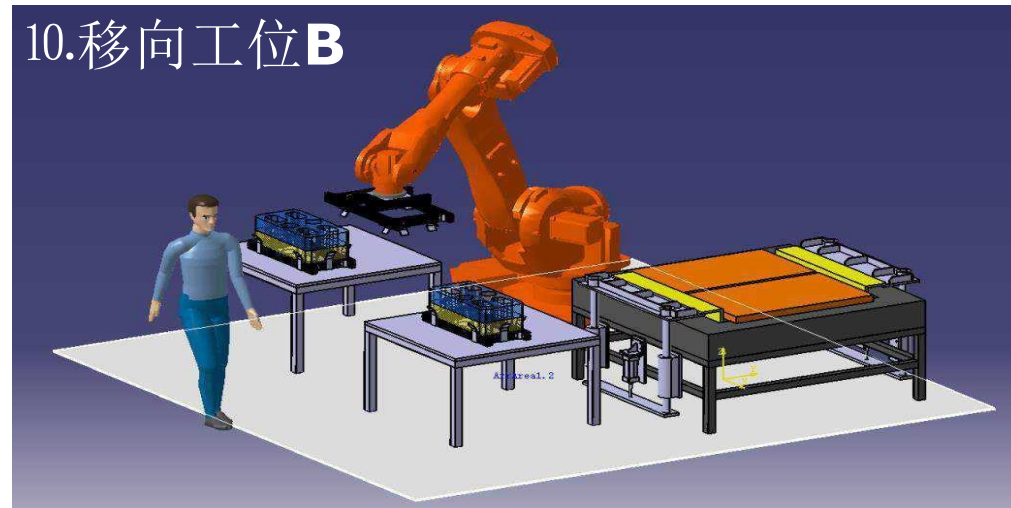
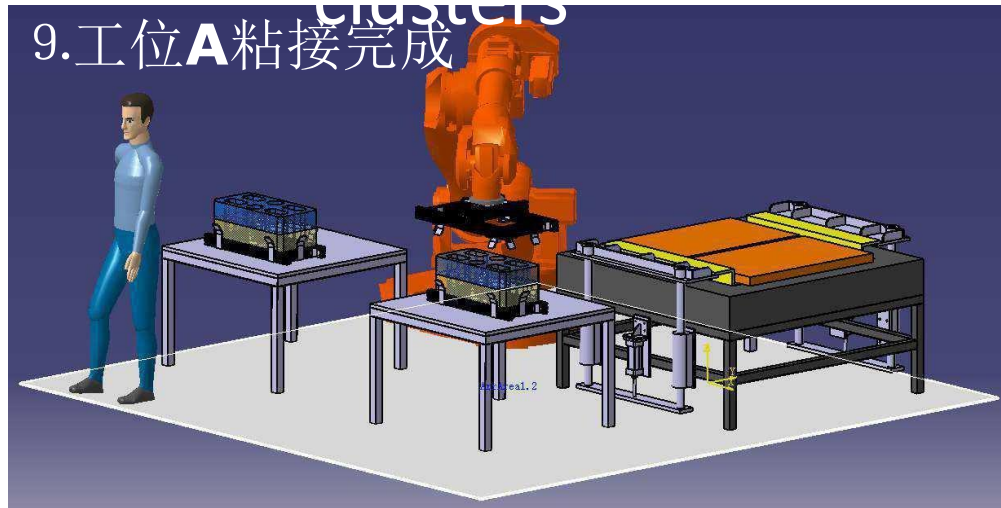
Additional robot bonding for lost foam die



Chapter 2 The manufacture of foam models and the



Additional robot bonding for lost foam die





8. Process design, pouring and riser system design and model cluster combination process

1. Design of pouring and riser system

When you get the product drawing and formulate the process card, you must first consider the casting process of the product. Compared with traditional casting, lost foam casting, as long as the principle of stable filling is satisfied, the process design of the gating system is more flexible and is basically not affected by other traditional castings. Due to theoretical constraints, the following chapters will specifically describe the components of the pouring system and the design principles of each component. Here are some key points of the pouring process design:

First, consider the placement of the foam model clusters in the negative pressure sand box.

Second, no matter which injection method is used (top injection, middle injection, bottom injection, step injection, or professional single-point cut-in, multi-point cut-in), it is necessary to ensure the molding of the casting (the integrity of the casting) and ensure that it is compatible with the existing equipment. Matching.

Third, set up a variety of processes, multiple trial production, to ensure simple operation, high process yield, continuous optimization, so as to ensure the highest yield and achieve the goal of reducing costs.

The design of the gating system should be convenient for the later buried box and casting cleaning process operations .

2.8 Process design, pouring and riser system design and model cluster combination process

2.8 Process design, pouring and riser system design and model cluster combination process

The focus is on training the operators, or after the new operators see the process, they can follow the steps required by the process. This is what we often say-fool process. Of course, it is also the simplest and most practical process.

箱体震动造型示意图

15-07-15

第三步：放砂到此位置（距浇口杯顶部约50mm），震动20秒。



第四步：放塑料布，确保顶砂厚度45-50mm；型砂顶部到浇口杯距离为8-10mm。

第二步：目测白模必须放平，放砂到此位置，保证白模内外腔型砂高度一致，震动20-25秒。

第一步：放底砂高约290mm（砂箱内标识），刮平。震动20-25秒。

编制：

审核：

批准：



2.8 Process design, pouring and riser system design and model cluster combination process

2.8.2 Combination process of model clusters

Compared with traditional casting, lost foam casting has a more obvious difference: in the process of molten metal shaping, foam decomposition and gasification will take away a lot of heat, which will cause the molten metal to cool down more seriously. Therefore, in order to ensure the temperature of the casting, generally Under the circumstances, a single pouring amount is reasonably prepared according to the product structure. For some small and medium-sized parts (castings less than 50 kg), we have to reduce the number of single ladle pouring (every ladle movement takes a lot of time for the ladle, we have done Design, 1 ton ladle is poured into 6 boxes, it takes 10 minutes, the real time for pouring is only 5 minutes and 25 seconds) So for some small and medium-sized pieces, we adopted the concept of "small pieces become big pieces". That is, model clusters, pouring products of the same tonnage reduces the number of buried boxes, shortens pouring time, improves production efficiency, and reduces overall costs.

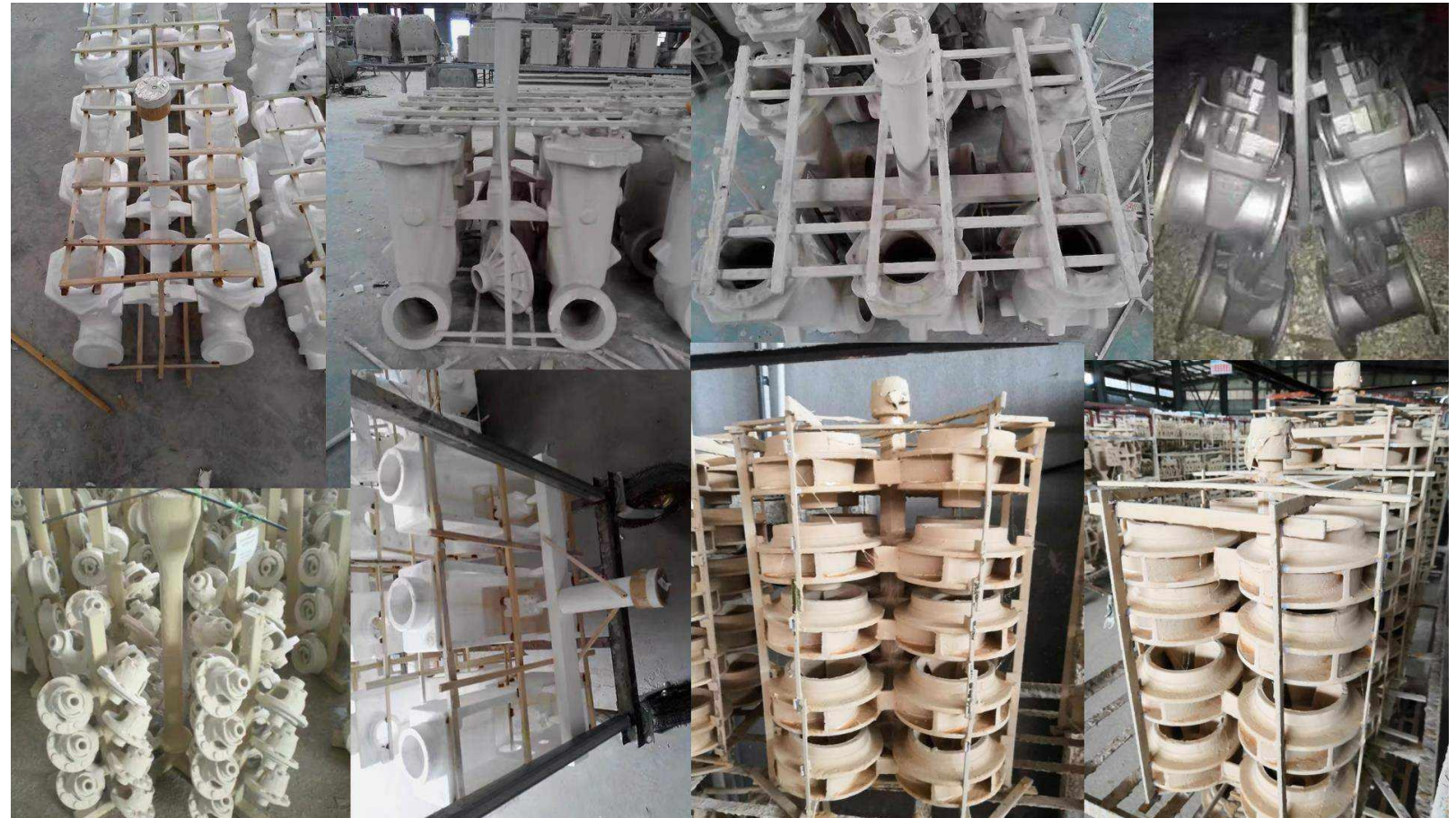
Many manufacturers have also tried the process of "small parts becoming larger" in the early stages of production. Most companies think that it is too troublesome to place the model in the buried box. What is more troublesome is the inconvenience of the later paint operation, so they abandon this operation process. In this chapter, we have taken a lot of pictures to illustrate the practicability of this process. Here we elaborate two points: first, we must develop corresponding tooling to improve operation efficiency (for standardization); second, build a model "Iron skeleton" is very convenient and practical for later operation and transportation.

Chapter 2 The manufacture of foam models and the



2.8 Process design, pouring and riser system design and model cluster combination process

2.8.2 Combination process of model clusters Manufacturers whose process of "small parts become large" are often blocked by lack of professional technical personnel. In addition, they cannot solve the new problems in time and effectively. We also encountered some problems when implementing this kind of operation process. Let's talk about it. For example, a lost-foam company in Guangxi used a single piece to produce crankcases. After discussing it together, we agreed to a two-piece process.





1. The role of paint
2. Performance requirements of lost foam coatings
3. The basic composition and requirements of lost foam coatings
4. Preparation methods and requirements of coatings
5. Mold cluster coating drying and control



3.1 The role of paint

a. Function 1: Improve the rigidity and strength of the foam model, and prevent the model from being damaged or deformed during transportation and sand filling and compaction. This function is mainly guaranteed by the dry strength of the coating. In the actual production process, There are many defects in the appearance of castings that have a lot to do with the dry strength of the coating.

In response to this problem, we have taken the following measures: First, adjust the coating formula to increase the dry strength of the coating; Second, after the rain and sand are added, workers are required to scrape and then operate the vibrating table; Third, reduce the tapping time while ensuring the sand tapping. After this operation, the appearance size of the casting is basically stable. After visiting many companies, we also found that many company technicians are also aware that the dry strength of the coating is not good or too good will cause a series of problems, but in the actual production, it is only adjusted by the thickness of the coating, which is just a kind of A temporary solution is not a permanent cure, because changes in the thickness of the coating will cause new problems. For example, if the coating is too thin, it will stick to sand, and if the coating is too thick, it will affect the permeability of the coating.



3.1 The role of paint

b. Function 2: During pouring, the coating layer is an important isolation medium between the liquid metal and the dry sand. The coating layer separates the liquid metal from the molding sand and prevents the molten metal from penetrating into the dry sand, so as to obtain non-sticky sand and smooth surface castings. ; At the same time, prevent the molten metal from flowing into the gap between the molten metal and the foam model, causing the mold to collapse. When talking about collapsed boxes, I would like to mention one thing. Among the companies we visited, there is a company in Jiamusi that makes motor shells. When making 280 and 315 products, there are often some models that will collapse about half of the pouring, and then we The company found that the thickness of the coating was only 0.8-1mm. Later, we found out that the reason why the coating thickness of the 280 and 315 motor shells of the company did so is because the coating layer is too thick and there will be "sawtooth" defects. On-site tracking found that the particle size of the modeling sand is uneven, which affects the air permeability. The local paint finished paint has poor air permeability. The most important thing is that the factory is smelted with a cupola and an electric furnace. However, the electric furnace has little effect. The maximum discharge temperature is about 1550°C. When analyzing the defects of lost foam castings, we must find the most critical factors, and we must not care about one and the other.



3.1 The role of paint

c. Function 3: The coating layer is the channel through which the thermal decomposition products (a large amount of liquid or gas) of the foam model are discharged. The effective discharge of the pyrolysis products is an effective way to solve the defects of casting pores and carbon inclusions.

Due to the different casting temperatures of different alloys, the decomposition products of the foam model are very different. When ferrous metals are cast, gaseous products are the main products, and the coating must have higher high temperature gas permeability; while the pyrolysis products of cast aluminum alloys are mainly liquid, It is required that the liquid decomposition product can be wetted with the coating, enter the coating smoothly, and exit the cavity; when casting aluminum castings, due to the low temperature of the molten metal and poor fluidity, in order to avoid the temperature drop of the molten aluminum due to excessive heat transfer of the mold Too much will cause defects such as insufficient pouring, and it is required that the coating used for aluminum alloy lost foam casting should also have good thermal insulation.



3.2 Performance requirements of lost foam coatings

Lost foam coating should meet the following requirements :

① It has high refractoriness and chemical stability, and will not be melted by high-temperature metal or chemically react with metal oxides during pouring to form chemical sticky sand. When it comes to refractoriness, many technical personnel in enterprises blindly attribute refractoriness to refractory materials and ignore the influence of the inorganic high-temperature adhesive in the binder.

We went to a company in Guangxi that mainly produced gray cast iron castings. The paint was added with 20% zircon powder. This is undoubtedly a big cost waste. After all, we are studying the overall performance of the paint. Muscovite powder is added to the paint prepared by ourselves. The refractoriness of the muscovite powder is lower than 1500, but it quickly produces melt when it comes into contact with molten iron. Filling the coating gap makes the coating layer sinter quickly and improves the erosion resistance of the coating. The principle of our special coating for runners is to use some low-refractory materials to reduce the sintering temperature of the coating, thereby increasing the sintering time of the coating, and ensuring better erosion resistance during the limited time of the pouring system. Some manufacturers use graphite powder, but the paint does not work well.



3.2 Performance requirements of lost foam coatings

Lost foam coating should meet the following requirements:

② It has good coating and adhesion, and can be evenly and densely coated on the surface of the foam model. In many companies we visited, we found that the paint hangability is a big problem faced by domestic paint manufacturers. Most of the company's workshops are arranged in white and black areas very close to each other. Foams will appear during drying and placement. A large amount of dust (electrostatic adsorption) is attached to the surface of the foam model; in addition, most of the foam will have some flash burrs due to the existence of live pieces. When the foam model is polished, a large amount of foam debris will be adsorbed on the local area due to static electricity. The polished parts look like "grassland" under a magnifying glass, which seriously affects the coating and adhesion of the paint; bulging, cracking, and shedding may occur in the later drying process of the paint. In recent years, some people have proposed to improve the wettability of coatings, so as to ensure good coating and adhesion of the coatings, and the effect is remarkable.

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



3.2 Performance requirements of lost foam coatings

Painted
Coating and
adhesion not
good

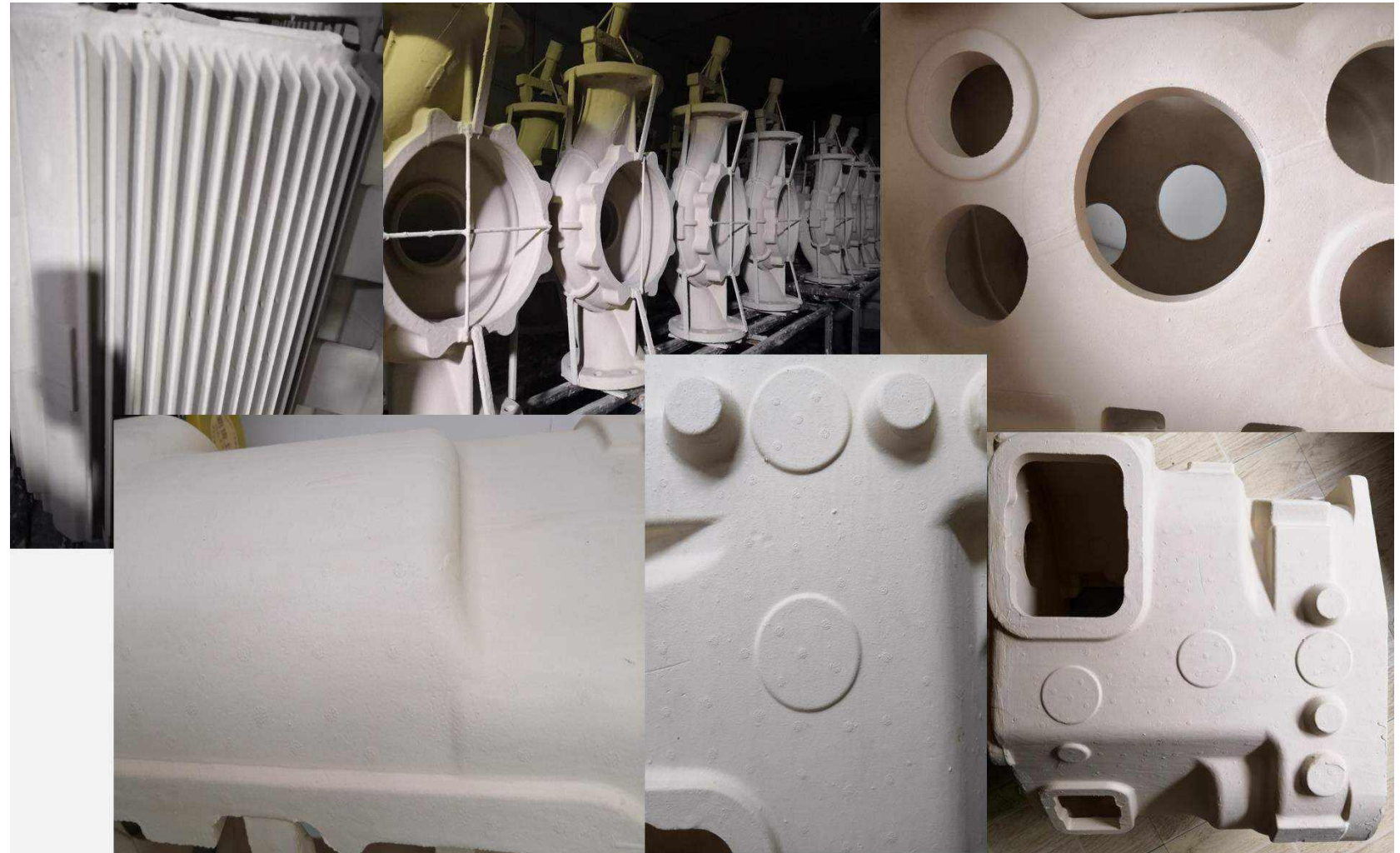


Chapter 3 Preparation of coatings and treatment of mold cluster coatings



3.2 Performance requirements of lost foam coatings

Uniformly dense
Painted on Foam model
surface





3.2 Performance requirements of lost foam coatings

Lost foam coating should meet the following requirements:

③ It has good strength and rigidity. It will not be damaged during the process of model transportation and tapping the buried box; after drying, the model will not be deformed; it can withstand the back pressure of the molding sand due to the gasification of the hot mold during pouring. It will not collapse the box due to the imbalance of internal and external pressure.

④ The coating should have good high-temperature gas permeability. With the advancement of the high-temperature metal surface, the gas generated by the gasification of the model and the air in the cavity can be eliminated, and it can be smoothly discharged from the coating through the sand mold wall to the outside of the mold. In actual production, we cannot blindly pursue air permeability. For example, in enterprises in Jiangsu, Zhejiang and coastal areas, the air humidity is relatively high, and reverse spray occurs. The air permeability of the coating has a great relationship with the "moisture absorption" of the coating.

Some enterprise technicians attributed the reason to the air permeability of the coating when the pouring occurred, which is actually wrong. In addition, the air permeability of the coating is too good, and the "wall effect" will be more obvious, so we are designing the casting process. It is necessary to fully consider how to ensure the smooth filling of molten metal and the disappearance of pyrolysis products without traces.



3.3 The basic composition and requirements of lost foam coatings

Lost foam coatings are generally composed of refractory materials, binders, carriers (solvents), suspending agents, thixotropic agents and other additives. 3.3.1 Refractories Refractory materials, also known as refractory fillers or refractory aggregates. The requirements for refractory powder are high refractoriness, moderate sintering point and fineness, good high temperature chemical stability, not being wetted by molten metal and its oxides, not having adverse reactions with molding sand, and not damaging the castings. Chemical composition and performance, low coefficient of thermal expansion, good thermal conductivity, large heat capacity, small air volume, a wide range of sources, and harmless to human health.

- | | |
|--------------------|-------------------|
| ① Graphite powder | ⑥ Bauxite clinker |
| ② Quartz powder | ⑦ Mullite |
| ③ Zircon powder | ⑧ Corundum powder |
| ④ Magnesite powder | ⑨ Mica powder |
| ⑤ Olivine powder | ⑩ Spodumene |



3.3 The basic composition and requirements of lost foam coatings

3.3.2 Carrier liquid

The carrier liquid is the dispersion medium of the refractory powder, and it is also the solvent of some finely divided paints. The paints with water as the carrier are called water-based paints, and the paints with various alcohols as the carrier are called alcohol-based paints. In lost foam casting, considering the requirements of environmental protection, application, drying, gas generation, cost and other aspects, water is often used as the carrier liquid. For the solid casting of lost foam resin sand, alcohol solvents can also be used as carrier liquid. Too much calcium and magnesium salts in the water will destroy the stability of colloids or other suspensions in the paint. Therefore, the hardness of the water in the coating should not be too high (1 liter containing 10mg of calcium oxide is called 1 degree), and the water can be distilled or chemical modifiers can be added to solve the problem. Generally, tap water can meet the requirements without treatment.



3.3 The basic composition and requirements of lost foam coatings

3.3.3 Suspending agent

The function of the suspending agent is to use solid materials to disperse and suspend in the carrier liquid to prevent excessive penetration of the carrier liquid into the mold and core. The suspending agent can also give the coating the required rheological properties. The commonly used suspending agent for water-based coatings is bentonite , Attapulgit clay, sodium carboxymethyl cellulose (CMC), sodium alginate, polyacrylamide, xanthan gum, etc.; commonly used suspending agents for alcohol-based coatings are: organic bentonite, sodium bentonite, lithium bentonite, attapulgit Clay, rectorite, sepiolite, polyvinyl butyral (PVB), SN suspension agent, etc.

① Bentonite

② Attapulgit (also known as palygorsk)

③ Rectorite clay

④ Sodium carboxymethyl cellulose (CMC)

⑤ Sodium alginate

⑥ Polyacrylamide



3.3 The basic composition and requirements of lost foam coatings

3.3.4 Binder

The role of the binder is to bond the refractory powder particles together, make the coating have a certain strength, and make the coating adhere to the surface of the model to prevent the coating from falling off or cracking from the surface of the foam model (reinforced coating Adhesion). The above-mentioned suspending agent also has a certain bonding ability, but the addition amount of suspending agent cannot be too high, so the coating strength is not enough, and a binder needs to be added. The binder for coatings can be divided into inorganic binder and organic binder. Agent. The former can also be called high-temperature adhesives, and the latter can be called low-temperature adhesives. Each type of binder can be divided into two types: hydrophilic type and hydrophobic type. The hydrophilic type is used for water-based coatings, and the hydrophobic type is used for alcohol-based coatings. Commonly used binders and properties of coatings are as follows:

- ① Clay
- ② Water glass
- ③ Silica sol
- ④ Phosphate

- ⑤ Sulfate
- ⑥ Dextrin
- ⑦ Polyvinyl alcohol (PVA)
- ⑧ Polyvinyl acetate emulsion
- ⑨ VAE emulsion (vinyl acetate-ethylene copolymer emulsion)



3.3 The basic composition and requirements of lost foam coatings

3.3.5 Additives

The additives in the lost foam coating mainly include surfactants, defoamers and preservatives.

(1) Surfactant Surfactants refer to substances that can reduce the surface tension and liquid/liquid interfacial tension of solvents (usually water) and have certain properties and structure. Surfactants have hydrophilic and lipophilic properties, and can play a series of functions such as emulsification, dispersion, solubilization, and wetting. Surfactants generally consist of a non-polar lipophilic group and a polar hydrophilic group. These two groups are located at the two ends of the molecule, forming an asymmetric structure. When the surfactant is dissolved in water, the strong force between water molecules (dispersion force, hydrogen bond, etc.) produces a strong tendency to push the hydrophobic end of the surfactant out of the water phase. On the one hand, water molecules form a new structure around the surfactant molecules, on the other hand, the hydrophobic groups of the surfactant molecules attract each other, self-associate and form micelles under certain conditions.

The HLB value is often used as the basis for selecting surfactants. This value refers to the hydrophilic and hydrophobic balance values in the molecular structure of the emulsifier. It can be used to measure the contribution of the hydrophilic part and the lipophilic part of the surfactant to the total emulsification properties. The larger the HLB value, the higher the hydrophilicity, and vice versa, the higher the lipophilicity. According to the nature of the hydrophilic group of the surfactant, the surfactant can be divided into anionic, cationic, nonionic and amphoteric surfactants.



3.3 The basic composition and requirements of lost foam coatings

3.3.5 Additives

The additives in the lost foam coating mainly include surfactants, defoamers and preservatives.

(2) Defoamer In the production process of water-based paint, as the stirring progresses, the air entering the liquid medium cannot leave at a fast enough speed to form bubbles. The presence of surface-active substances such as emulsifiers and wetting agents in water-based coatings promotes the formation of stable foam. The foam system is not in the lowest free energy state, so it is an unstable state, which means that the foam itself is about to burst. The collapse of the foam goes through three stages, namely the redistribution of bubbles, the thinning of the membrane wall and the rupture of the membrane. For a generally stable foam system, it takes a long time to go through these three stages, so defoamers should be added in the production of coatings. When the defoamer is added to the water-based coating, it will diffuse into the water film around the bubbles and penetrate into the foam system as fine particles. After contacting the foam, it will capture the hydrophobic chain ends on the foam surface, and then pass It spreads quickly and forms a very thin double film layer, and then further penetrates into the foam system. The defoamer with low surface tension always drives some liquid to flow into the foam system with high surface tension, which promotes the gradual thinning of the film wall, which eventually leads to The bubble burst. According to the above mechanism, the defoamer should have the following characteristics:

- ① Its surface tension is lower than that of the bubbling medium;
- ② There is a certain degree of incompatibility between the defoamer and the medium;
- ③ The density of the defoamer should be less than the density of the medium so that it can be effective on the surface of the medium.



3.3 The basic composition and requirements of lost foam coatings

3.3.5 Additives

The additives in the lost foam coating mainly include surfactants, defoamers and preservatives.

(3) Anti-mold fungicide Water-based coatings often contain resins, adhesives, additives and other substances. These substances are often nutrient sources for various microorganisms, and the carrier liquid water is a life element, which constitutes the conditions for microbial production. A series of operations from the time the water-based paint is manufactured may cause the water-based paint to be contaminated by microorganisms. When the contaminated paint reaches a certain humidity, temperature, PH value and other conditions, if there is no substance that inhibits its growth, and microorganisms begin to grow frequently, the paint will be mildewed, deteriorated, and lose its viscosity. Sterilization, anti-mildew, and preservatives are auxiliaries that water-based coatings cannot lack, and are called anti-mildew agents for short. The requirements for the anti-mold and fungicides of the coatings for lost foam casting are:

- ① Comprehensive sterilization line, resistance to various microorganisms, long action time, low concentration required to inhibit mold growth; good sterilization effect for most molds and bacteria that breed in a weak alkaline environment.
- ② It has good compatibility with various components in the coating, and does not have chemical interaction with other components.
- ③ Stable storage in the range of PH value of 6-10 (at least 7-9.5).
- ④ It has good water solubility, because microorganisms grow in the water phase, which can ensure better contact with them and faster sterilization.
- ⑤ Low volatility in paint, UV resistance, oxidation resistance, and temperature change resistance.
- ⑥ It is non-toxic or low-toxic to human body and has good biodegradability and low environmental toxicity, so as to minimize the irritation to operators.



3.3 The basic composition and requirements of lost foam coatings

3.3.6 Suggestions for the selection of coating raw materials

① The choice of refractory powder The refractory powder is determined according to the type of casting alloy. The casting temperature of steel castings is high, and refractory powders with high refractoriness should be selected. For thick carbon steel and alloy steel castings, zircon powder and white corundum powder can be used as refractory powders. For small and medium-sized steel castings Brown corundum powder, bauxite and quartz powder can be selected, or zircon powder is mainly used, and a part of mullite powder is added. For manganese steel castings, magnesia powder or forsterite powder should be selected to avoid the formation of MnOSiO_2 chemical sand; For large iron castings, refractory powders such as zircon powder and flake graphite should be used. For small and medium iron castings, earthy graphite, bauxite, quartz powder, magnesia powder and other refractory powders can be selected, and a certain amount can be added. Mica. Wollastonite and obsidian to improve the high temperature air permeability of the coating. For aluminum alloy castings, talc powder, mica powder, and vermiculite powder can be used. In order to ensure the high temperature air permeability of the coating, the selected refractory powder should have a reasonable particle size gradation. For example, particles with about 100 mesh should account for about 12%, and particles with less than 270 mesh should account for 25-28%.



3.3 The basic composition and requirements of lost foam coatings

3.3.6 Suggestions for the selection of coating raw materials

- ② Selection of carrier fluid For lost foam coatings, considering the requirements of environmental protection, application, drying, gas generation, cost, etc., water is generally used as the carrier liquid, that is, water-based coatings.
- ③ Binder and water-based paint can choose white latex (polyvinyl acetate emulsion), water-soluble phenolic resin, styrene-acrylic emulsion (styrene-acrylic emulsion), ethylene-vinyl acetate emulsion, and a small amount of yellow can be added to improve the viscosity. Raw rubber, in order to increase the high temperature strength can add a small amount of clay.
- ④ Suspension agent, water-based lost foam coating, sodium bentonite or lithium bentonite can be used CMC and HPMC are used as suspending agents.
- ⑤ Additives, water-based lost foam coatings can choose Pingpingjia, JFC or Tritonx-100 Used as wetting and dispersing agent. Use SPA-202 as defoaming agent and thymol or sodium pentachlorophenate and formaldehyde as preservatives. According to the author's experience, sodium benzoate has a poor anti-mold effect, it cannot kill fungi, and the smell of formaldehyde is large, which is not good for the health of operators.

4. Preparation methods and requirements of coatings

1. Selection of equipment

The paint mixer pulverizes, disperses, emulsifies, and mixes the paint. It is a new type of high-efficiency mixing equipment that runs at a high speed through the upper and lower serrations of the dispersing disc.

High-speed and strong shearing, impact, crushing and dispersion of materials are carried out to achieve the functions of rapid mixing, dissolution, dispersion and refinement. It is an efficient equipment for mixing, dispersing and dissolving paint and other solids. Some of the companies we visited also use grinders. The particle size of the paint produced by this equipment is uniform, and the coating performance and adhesion of the powder after high temperature modification The focus is good, but the raw material particle size is relatively coarse and the grinding time is longer, and it is inconvenient to use. At present, most of the coatings produced abroad use the grinding method.





4. Preparation methods and requirements of coatings

2. Coating mixing and coating preparation
 1. The mixing process of the paint (the method of using the paint is as follows:)
 1. Keep the paint mixer clean. ...
 2. The ratio of dry powder paint and water is controlled at about 1:0.68~0.75, which can be appropriately controlled according to different castings.
 3. Start the mixer and control the speed at 400-600 rpm. First add the weighed water into the mixing tank, and then slowly add the dry powder paint. When most of the dry powder is added, the paint in the mixing tank will become very viscous. At this time, it is not allowed to add water. You should stop adding the dry powder paint, stir for about ten minutes, stir evenly, and then add the dry powder until all is added.
 4. After stirring for 2-3 hours, adjust the rotation speed to 200 rpm and continue stirring for 30 minutes to detect the Baume degree.
 5. The coating thickness is controlled to be 1.2-2mm, the upper limit is taken for large pieces, and the lower limit is taken for small pieces. The coating thickness of the gating system is controlled at 1.5-2.5mm.
 6. Some tooling (cooling mold frame) should be properly designed to avoid cracks due to the accumulation of paint in dead corners. After the first drying, repair it before doing the second paint.
 7. The coating drying should be divided into two parts, one is room temperature drying, the drying temperature is 20-25 degrees, ventilated and dry, and let it cool for 3-4 hours. There is no obvious wet trace on the surface of the coating. The second is to control the temperature of the drying room at 40-45 degrees, requiring circulating air to be placed for 4-6 hours.
 8. Pay attention to the shelf life of the paint. The stirred paint should be used up within the specified time. The expired paint cannot be used. Please be sure to pay attention to the surface quality of the first coating, and the whitening phenomenon should be handled before the second coating.

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



3.4 Preparation methods and requirements of coatings

3.4.2 Coating mixing and coating preparation

3.4.2.2 Coating preparation

(1) Dip coating



In manual dip coating, the pattern floats in the paint and then rolls.



Take the pattern out of the mixing dipping bucket, and pour out the inner cavity paint.



Change the angle of the shape to make the surface coating uniform.



Coating process

Manual operation process

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



3.4 Preparation methods and requirements of coatings

(3) Spraying

3.4.2 Coating mixing and coating preparation

3.4.2.2 Coating preparation (2) Flow coating



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Additional paint automatic leveling machine design

✓ Introduction to the topic:

With the development of lost foam casting, customers have higher requirements for the quality of castings. As a lost foam casting enterprise: improving product qualification rate and product quality, and reducing production costs are still our tasks. At present, the two factors that have the greatest impact on the quality of lost foam castings are: consistency and traceability in the production process of lost foam casting; traceability can be achieved through the quality management system of each section and each process, if it is done. The consistency of the qualified quality of each process is best met by automated equipment (to reduce the influence of human factors). This topic introduces the use of lost foam technology to produce transmission housings, by designing and manufacturing simple mechanical devices to replace manual operations, reducing the labor intensity of the model coating leveling operation in the dip coating process and the excessive human factors of pure manual operations, and Improve production efficiency.



Additional paint automatic leveling machine design

✓ statement of problem:

An lost foam casting company in Shaanxi uses the lost foam process to produce aluminum alloy transmission housings. In order to improve the strength and rigidity of the foam pattern, prevent sand sticking and improve the surface quality, it is necessary to evenly coat the refractory coating on the surface of the model during the coating process . In the dipping process, the operator needs to hold the dipped paint pattern to pour the excess paint out of the cavity, and then continuously change the angle to make the surface paint of the pattern evenly coated and the excess dripping clean. It takes about 10 minutes for the pattern to leave the paint stirring dipping barrel after the dipping of the pattern is completed, and until the paint on the surface of the model no longer drips. This process is called the leveling of the paint. The paint leveling process is time-consuming, labor-intensive and labor-intensive. In order to complete 180 tasks per shift, six operators are required.

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

Manual operation process of coating process

Dip coating



In manual dip coating, the pattern floats in the paint and then rolls.



Change the angle of the shape to make the surface coating uniform.



Take the pattern out of the mixing dipping bucket, and pour out the inner cavity paint.





Additional paint automatic leveling machine design

Solution 1: Robot automatic dip coating

The use of robot dip coating has been successfully applied abroad. Its advantage is that it saves manpower. The dip coating and leveling are completed by the robot at one time, and the dip coating leveling action can be adjusted at any time through teaching programming according to the actual situation. Figure 1 shows the robot dip coating solution designed for the transmission housing. The system consists of a robot with a load of 300kg and a quick-change tooling interface, two paint mixing cylinders with a diameter of 2500mm and a depth of 1500mm, two conveying slides, two grippers designed for this pattern, paint supply system, detection control System composition.

Specific process flow: First, the operator loads the pattern to be dipped into the gripper, and then slides it into the working range of the robot through the sliding table to wait for the robot to grab; at the same time, the robot will pass the model that was first sent by another sliding table After dipping and leveling in the paint tank, put it back on the original sliding table together with the gripper; the robot that puts down the gripper will immediately grab the waiting gripper on the next sliding table to dip the pattern, and The painted pattern that has just been put down is sent out of the robot's working area by the sliding table.

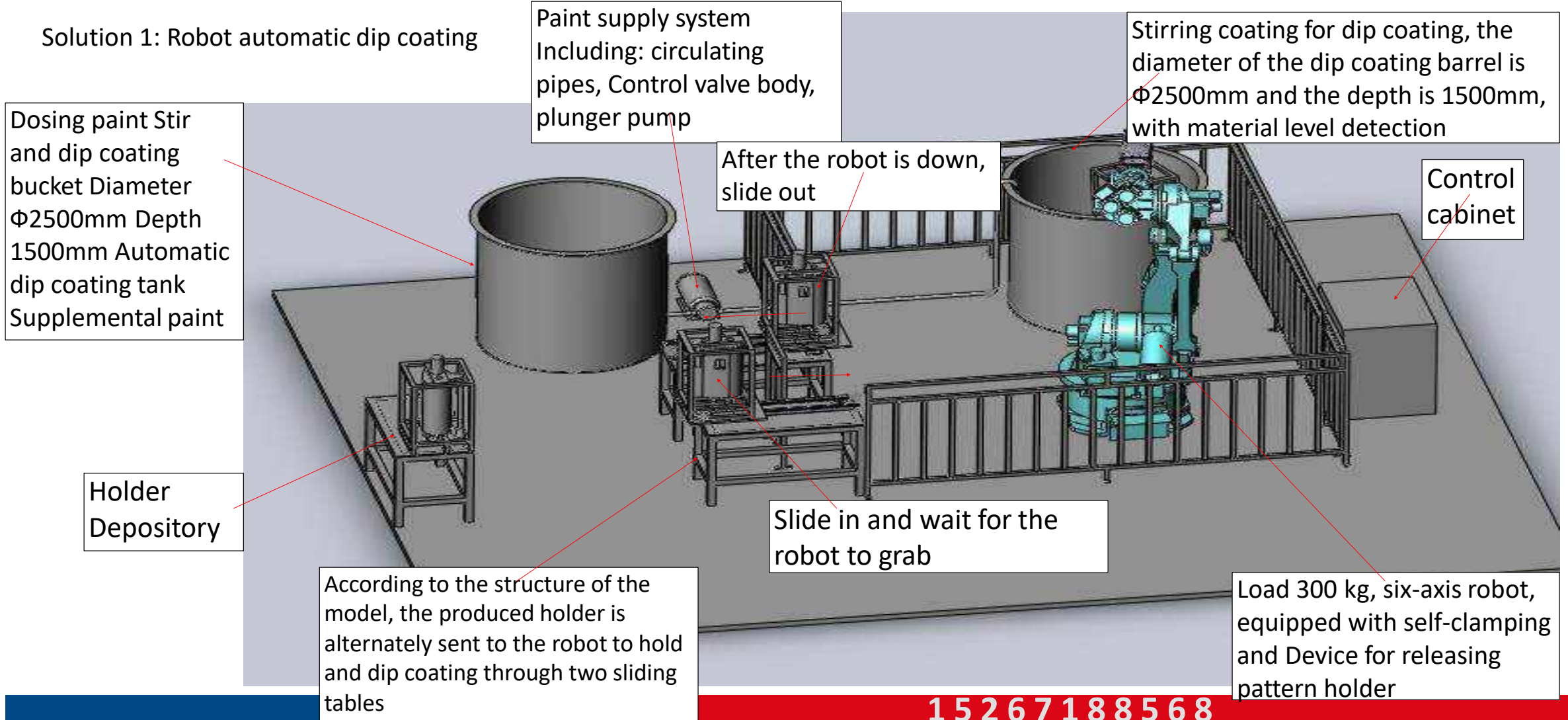
The operator takes out the pattern, loads it into the undipped pattern, and sends it back to the robot's working area to wait for dipping, and so on.

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

Solution 1: Robot automatic dip coating





Additional paint automatic leveling machine design

Solution 1: Robot automatic dip coating (problems with this system)

- 1) The equipment is huge, heavy, and inconvenient to install: it cannot bear the weight of a 2.5-ton robot and a paint mixing tank that is close to 8 tons after being filled with paint.
- 2) Difficulty design of the holder: When the robot is dipping, generally the entire model is slowly pressed into the paint tank until the pattern is completely submerged. Because the density of the foamed plastic mold is small, the pattern is a thin-walled shell. When immersed in the paint, it will receive a buoyancy of about 240N. In order to prevent the pattern from deforming or even breaking, while selecting a reasonable immersion angle, it is necessary to set enough support points and clamping points on the holder, and there are stiffeners on the outer surface. How to set the soft surface of the flat round barrel shape and how many support points and clamping points are set has become the first problem to be solved in the design. After the support and clamping points are determined, how to solve the problem that the clamping mechanism works reliably in the paint. It has become an unsolvable problem.
- 3) High cost and high post-maintenance cost: The supplier's quotation for the robot dip coating system manufactured according to the above scheme is about 1.5 million yuan. Because the system uses a large number of imported high-end components, the maintenance costs for later use are too high. For example, the plunger pump imported from Germany used in the paint supply system, because the paint contains hard particles such as quartz powder, can only guarantee a one-year service life and needs to be replaced frequently.
- 4) The labor intensity is reduced, but the production efficiency is not improved, and the cost performance is not high: After the dip coating is completed, the robot will slowly lift the model to make the model and the holder separate from the paint in the cylinder, and rotate the holder to make the inner cavity. The excess paint is poured out, and then the robot will continue to rotate the holder and stay at a specific angle to make the paint on the surface of the pattern evenly coated without dripping. This process is the same as manual operation and takes about 10 minutes. , Plus the time for dipping and picking and putting down the holder, the time for the robot to coat a pattern is about 12 minutes, which is similar to the production efficiency of a person, and it does not improve the production efficiency. There is also a lot of waste of paint after cleaning up the gripper, sliding table and other devices, labor and time.



Additional paint automatic leveling machine design

problem analysis

- The robot system is used abroad to complete the two processes of dipping and leveling of the model. Such a system is not only large, complicated and expensive, and is not suitable for our company to adopt.
- Through the analysis of the process, we can find that the leveling process takes most of the time, which is also the main reason for the high labor intensity.
- If the existing manual dip coating method is retained, and an automatic system is designed to replace manual work, the leveling of the appearance is completed, which not only reduces labor intensity, but also ensures the coating quality, and is simple and economical.
- From this we designed the second set of solutions: after manual dip coating, machine leveling is used



Additional paint automatic leveling machine design

Option 2: After manual dip coating, use machine leveling

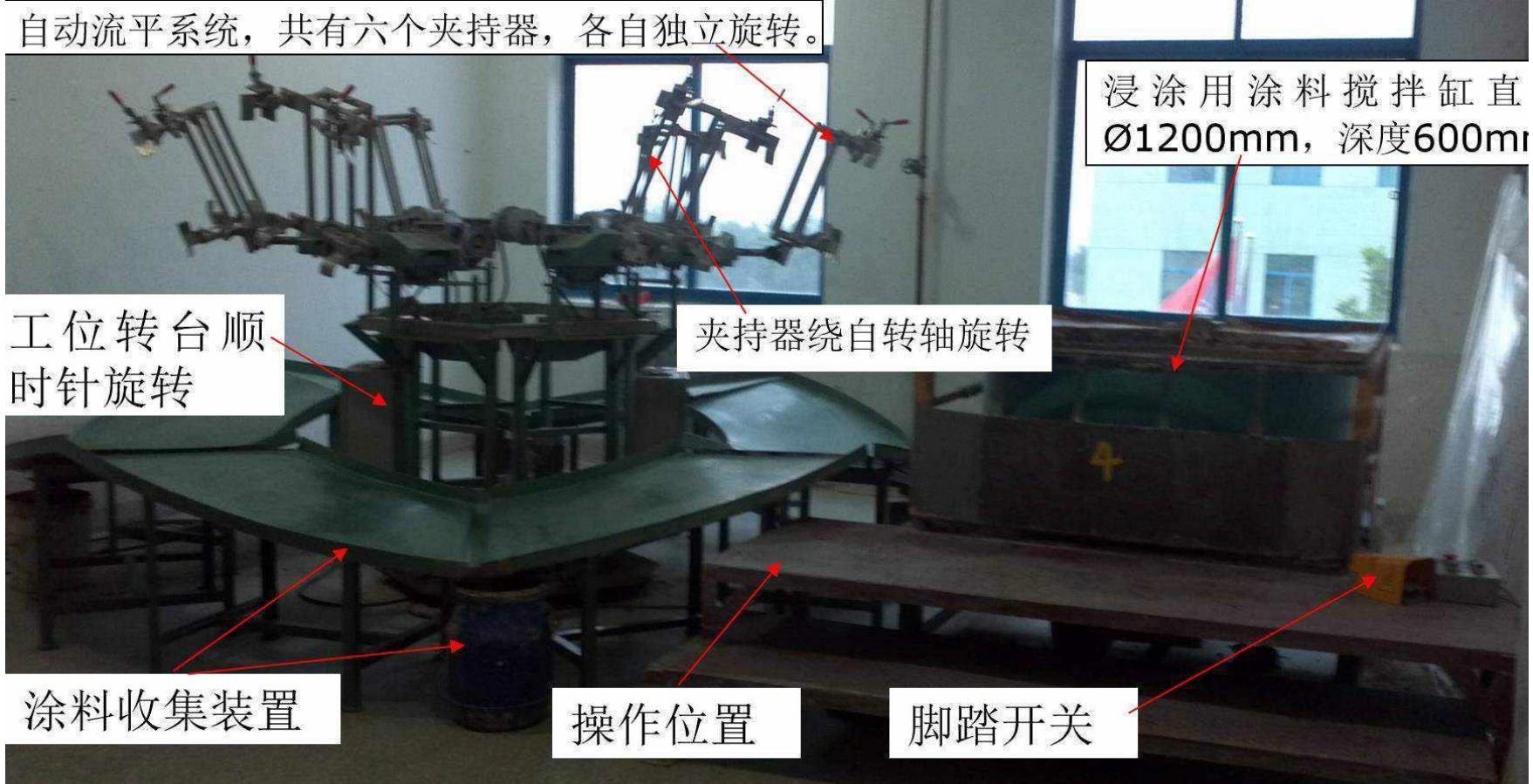
This solution uses manual dip coating. When dip coating, the pattern does not need to be pressed into the paint, but floats on the surface and rolls twice. The whole process only takes 25 seconds. Then the pattern is lifted out and clamped on the holder. Step on the foot switch, and then the gripper will start to rotate according to the preset program, and stay at a specific angle, pour out the inner cavity paint to make the paint flow evenly; at the same time, the station turntable rotates 60 degrees clockwise to make The newly installed pattern leaves the upper part position, and the leveled pattern is transferred to the operator. The operator removes the pattern, then dips the new pattern and clamps it on the holder to start leveling.

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

Option 2: After manual dip coating, use machine leveling



Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

Option 2: After manual dip coating, use machine leveling

The automatic leveling system is composed of a six-station turntable, six rotating grippers and a paint collection system. It is controlled by a small PLC. The operator only needs to participate in the operation of the system through a foot switch. The gripper is driven by a motor to rotate to a set angle under the control of the program according to the requirements of the leveling process and continues to rotate to the next angle after waiting for the specified time. The production cycle of the whole system is 120 seconds.

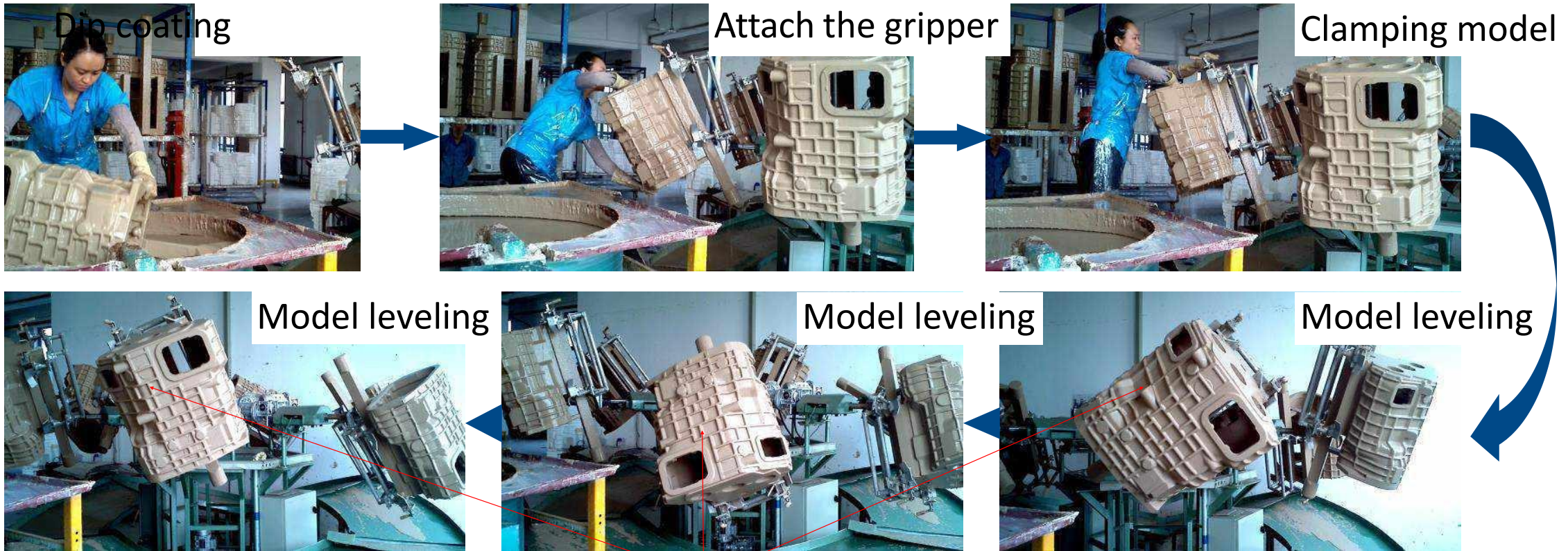


Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

- ✓ Option 2: After manual dip coating, use machine leveling



The model starts to rotate according to the program setting

Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

✓ Option 2: After manual dip coating, use machine leveling

After the dip coating is completed, the operator clamps the model on the holder, step on the foot switch, and then the holder will start to rotate according to the preset program to make the paint flow evenly; at the same time, the station turntable rotates 60 degrees to make The newly installed pattern leaves the upper work station, and the leveled pattern is transferred to the operator. The operator removes the pattern, then dips the new pattern and clamps it on the holder to



start leveling



Additional paint automatic leveling machine design

✓ Option 2: After manual dip coating, use machine leveling

Compared with robot dip coating, this solution has the following advantages:

1. The original equipment is utilized to the greatest extent, and only a set of leveling device is added beside the existing dip coating barrel instead of manual leveling, which can reduce labor intensity and improve production efficiency.
2. During the dipping process of the model, most of the time is spent on the leveling of the paint. By increasing the leveling station, the production cycle of the leveling process can reach 100 seconds, which can meet the production cycle requirement of 120 seconds.
3. The system is simple and compact in structure, light in weight, small in area, and easy to arrange.
4. Low labor intensity and high production efficiency: Fast company originally required six people to complete 180 production tasks per shift, but after using the automatic leveling system, only one person per shift is needed, and the production efficiency has been increased by 6 times.
5. Low price: The whole set of leveling system is about 300,000 yuan, and the price of a set of robot dip coating leveling system is about 1.5 million.
6. Superior coating quality: The system ensures the consistency of the leveling process and the coating thickness is uniform.

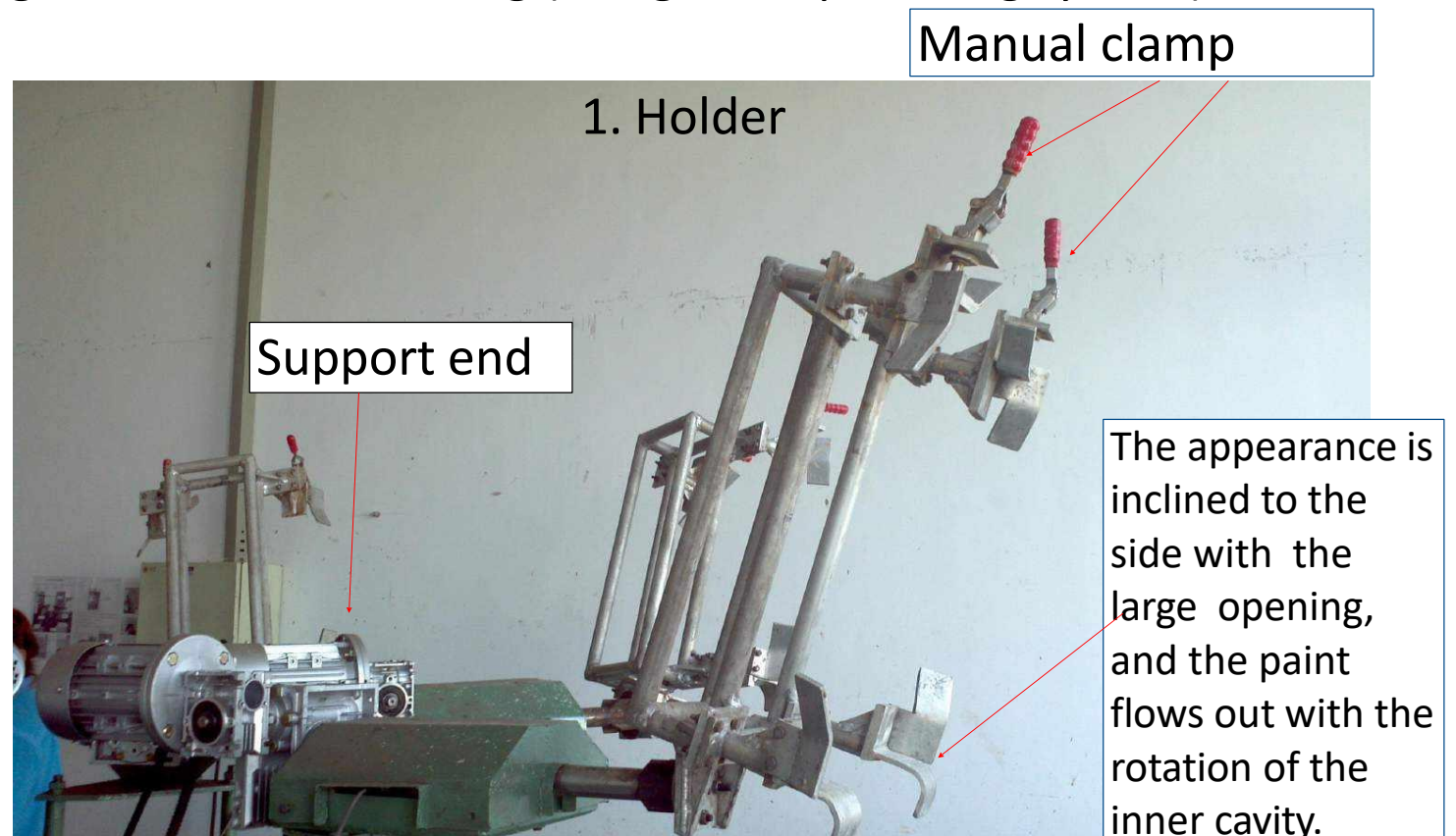
Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

✓ Option 2: After manual dip coating, use machine leveling (design of dip coating system)

The pattern holder of the leveling system does not need to design a support and clamping structure on the pattern, but only needs to fix the square runner part to make the pattern of about 3 kilograms dipped and coated with paint can be reliably rotated; in order to reduce the weight of the system and Easy to clean, the holder is made of aluminum alloy; the clamping device is a standard manual clamp made of stainless steel, which is reliable in clamping and has strong anti-pollution ability.

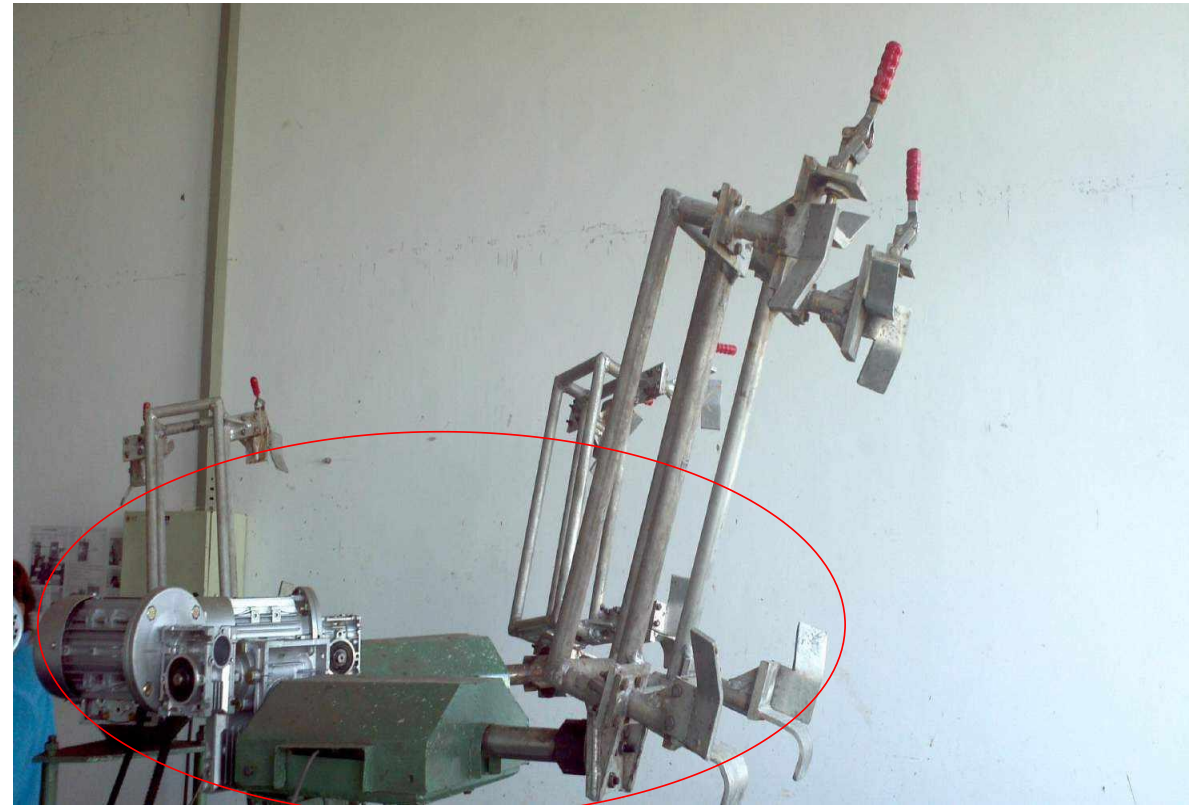


Additional paint automatic leveling machine design

- ✓ Option 2: After manual dip coating, use machine leveling (design of dip coating system) 2.

Gripper rotating device:

The gripper is driven by a 120W three-phase asynchronous motor through a two-stage worm gear reducer and the speed is 3r/min. Through the pre-programmed program, the PLC controls the contactor to close and disconnect to realize the automatic rotation of the holder and wait.

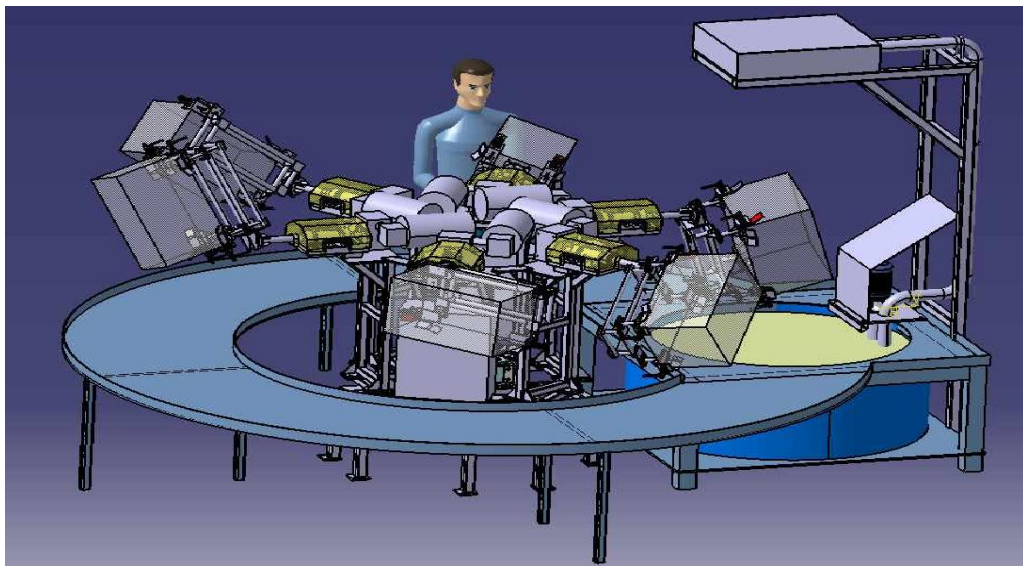


Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

- ✓ Option 2: After manual dip coating, use machine leveling (design of dip coating system)
- ✓ 3. Six-station turntable: In order to meet the production cycle of 120 seconds, six leveling stations need to be arranged in a circle and installed on the simple turntable as shown in the figure, so that the area of the system is only a circle with a diameter of 3 meters. Easy to arrange.



Chapter 3 Preparation of coatings and treatment of mold cluster coatings

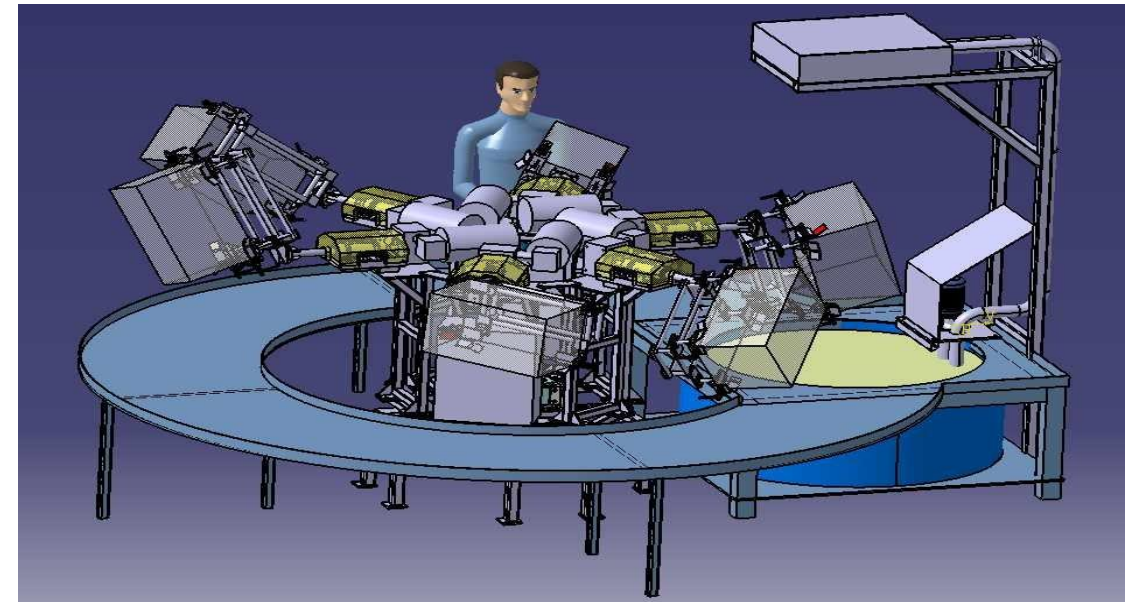


Additional paint automatic leveling machine design

✓ Option 3: Automatic coating and leveling

The low-speed mixer is used for spraying and automatic leveling. Its advantage is that it saves manpower. The spraying and leveling are completed by the machine at one time, and the spraying and leveling action can be adjusted at any time through teaching programming according to the actual situation.

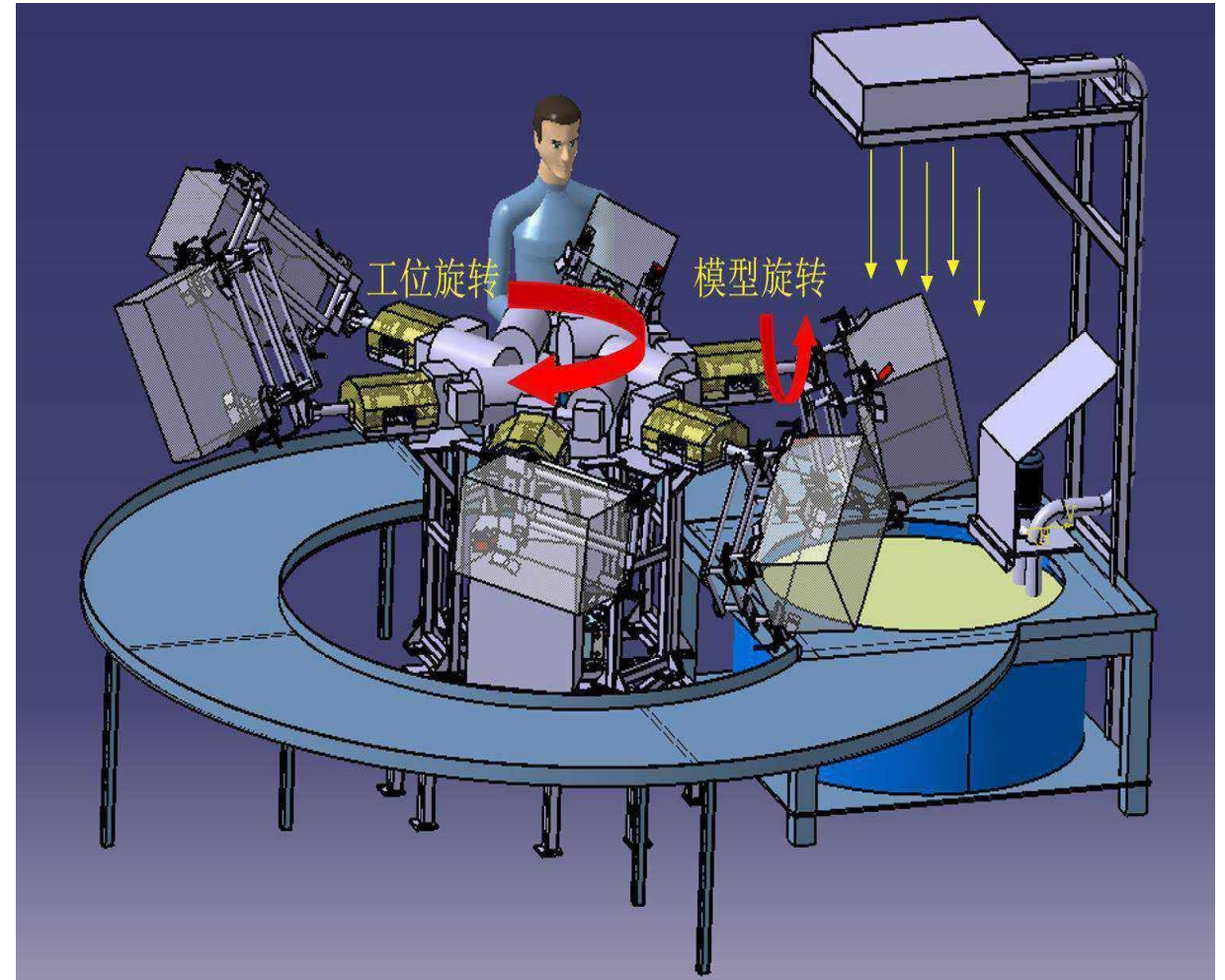
A paint mixing tank with a diameter of 1200mm and a depth of 550mm, the paint supply system, sprays the white mold through the nozzle system. Specific process: First, the operator loads the pattern to be sprayed into the holder, and then sprays it on the white mold through the sprinkler system; at the same time, the machine will transfer the spray-coated model out of the paint bucket for 5 directions. The paint is leveled, the operator takes out the model in the 6th station, loads the undipped pattern, and sends it back to the working area of the machine to wait for the coating leveling, and so on.



Additional paint automatic leveling machine design

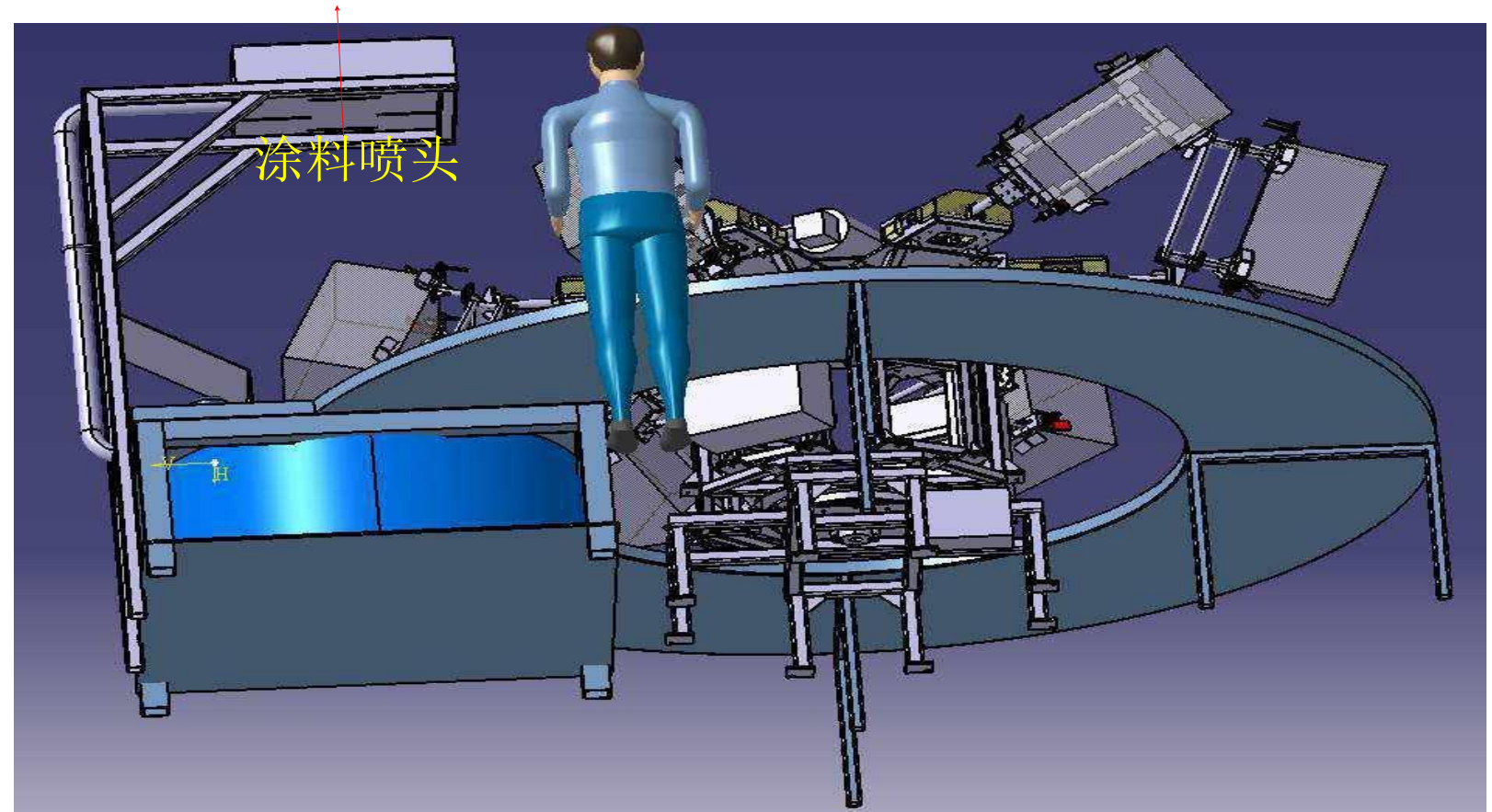
✓ Option 3: Automatic coating and leveling

The model rotates under the paint nozzle and starts to rotate, and the paint is evenly poured on the surface of the model. The model can be stopped at a specific position so that the paint can enter the cavity of the model. After the coating is completed, the station rotates, and the model turns out of the coating station, and continues to rotate to level the paint.



Additional paint automatic leveling machine design

- ✓ Option 3: Automatic coating and leveling

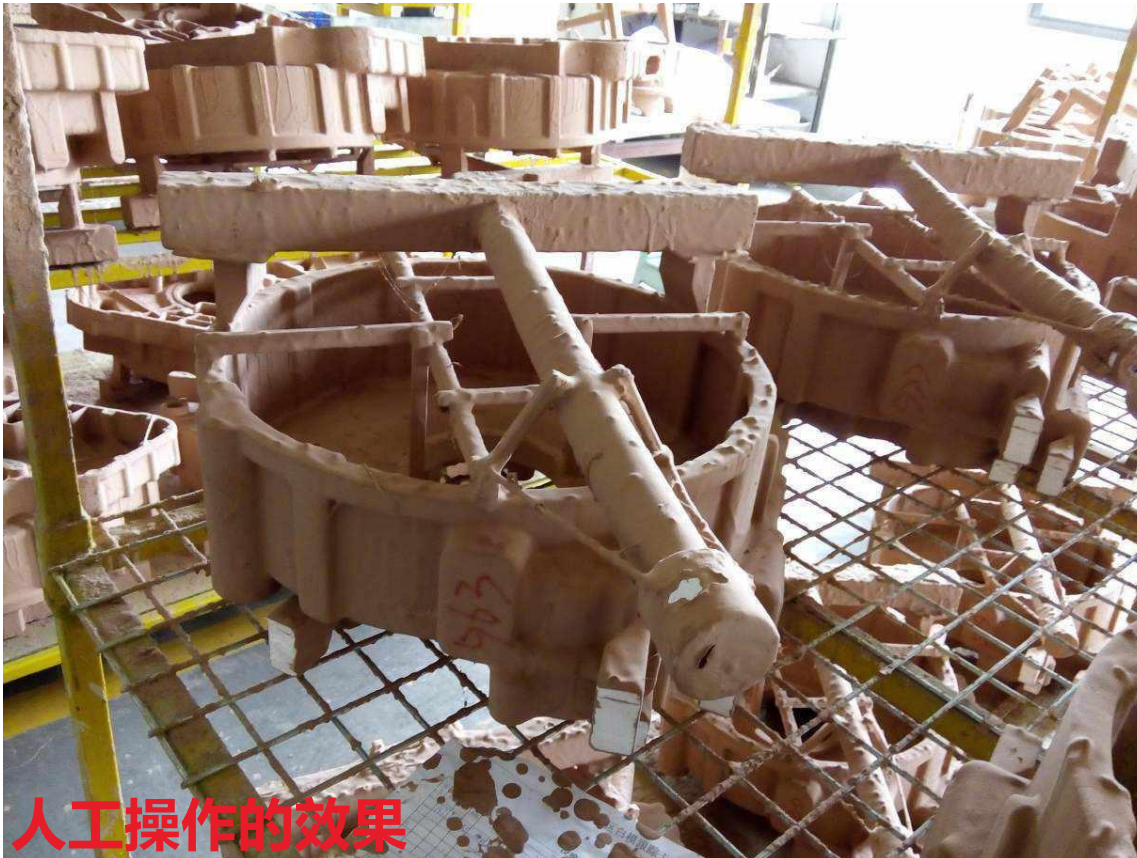


Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine design

- ✓ Comparison of paint leveling machine and artificial effect

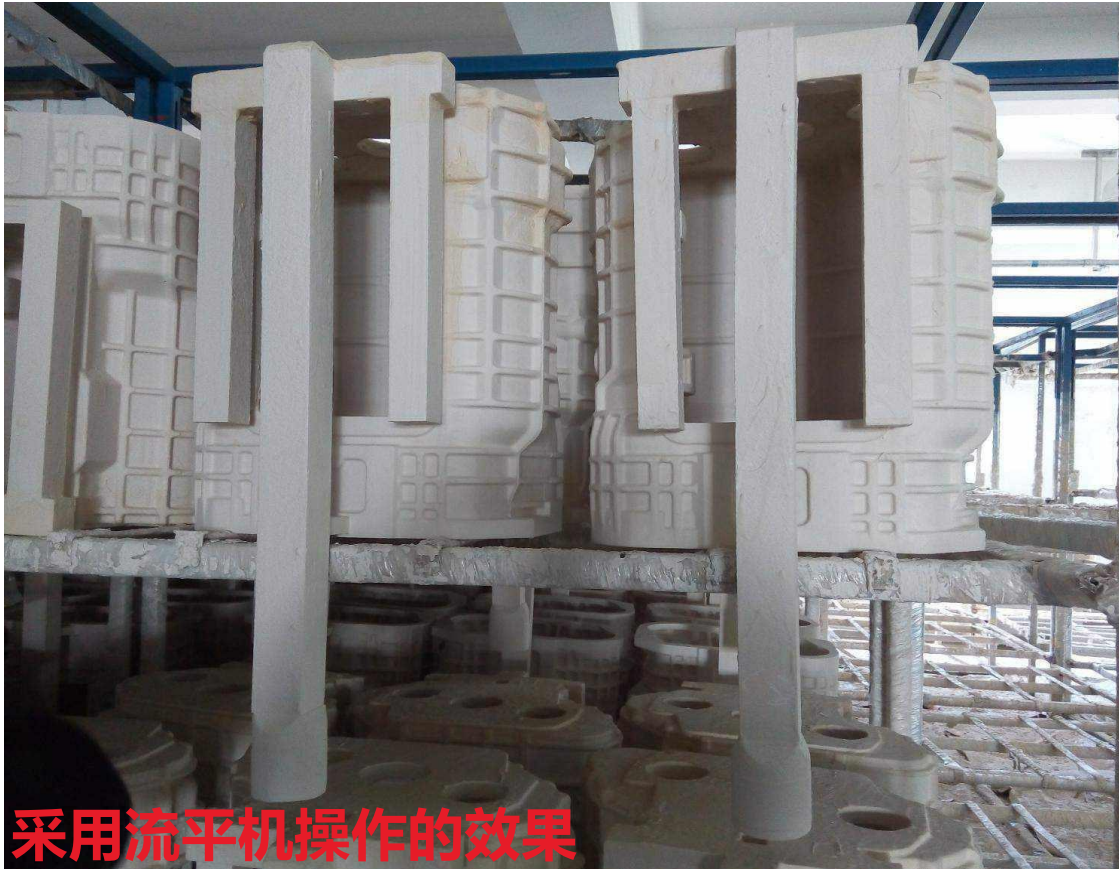


Chapter 3 Preparation of coatings and treatment of mold cluster coatings



Additional paint automatic leveling machine

- ✓ Comparison of paint leveling machine and artificial effect



采用流平机操作的效果



人工操作的效果

Chapter 3 Preparation of coatings and treatment of mold cluster coatings

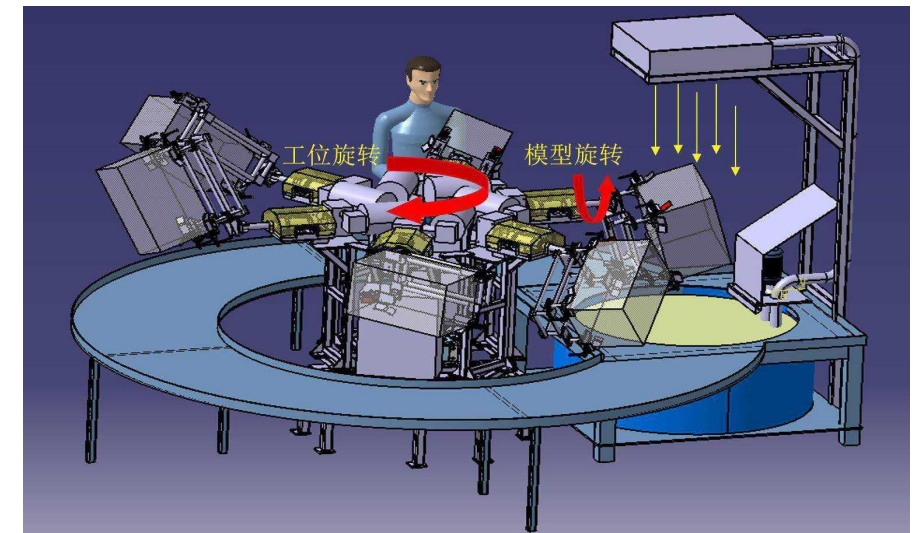


Additional paint automatic leveling machine design

✓ in conclusion

After manual dip coating, the machine leveling program and the automatic leveling program are adopted, based on the principle of simplicity and practicality, to give full play to the flexibility of manual operation and the labor-saving and high consistency of machine operation, while reducing the labor intensity of workers and improving production efficiency. , To achieve the consistency of coating quality, reduce the purchase (operation) cost of equipment.

The system has been put into operation for two years with good results.





3.5 Mold cluster coating drying and control

Studies have shown that water molecules exist in the coating layer in three forms, namely the free water state, the bound water state, and the combined water state. Free water and bound water are the water added to the coating. The free water molecules account for about 60% of the moisture discharged per drying. The water molecules in this state exist on the surface of the coating layer and only need to absorb a little heat and a certain amount of moisture. The wind speed can escape from the paint layer. In summer, the water molecules can be dried in the workshop for 2-3 hours; the bound state water molecules refer to the part of the water molecules fused with the paint molecules, and this part of the water molecules needs to absorb more heat energy to obtain Enough energy is separated from the paint molecules; the water of hydration refers to the water molecules in the paint, and the general water content is about 5-9%. This part of the water molecules needs to absorb more heat energy and enough time to separate from the paint. The "three-temperature section low-temperature drying process" developed by a company in Hubei is a drying process with three temperature and humidity conditions designed corresponding to the three forms of water molecules in the coating layer. The temperature in the drying room initially passes through a low temperature of 30°C and a certain wind speed to quickly separate the free water in the coating layer. Then the temperature of the drying room is increased to 40°C, and the moisture removal rate is reduced by 30% until the coating layer has a certain degree of hardness. The temperature continues to rise to 50°C, and the paint layer is baked for 1-2 hours to evaporate the water of the paint layer.

3.5 Mold cluster coating drying and control

Among the companies we visited, the recommendations we made to many companies particularly emphasized the low-temperature (25°C) ventilation and drying of the paint, generally at least 4 hours or more, and then enter the drying room for 4-6 hours, and the drying temperature should be controlled at 40-45°C,

The coating layer has no obvious surface defects, the coating has good rigidity and good air permeability. Many manufacturers require the finished coating to quickly enter the drying room for high-temperature drying, which causes the combined water molecules to rapidly expand after absorbing a large amount of heat energy, forming air pockets in the coating, and forming raised succulents or spores on the surface of the casting after casting 状 defect. In addition, due to the poor effect of the dehumidification equipment, the drying room is like a "sauna", which seriously affects the coating The effect of material drying can even lead to casting defects.





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1. Modeling (buried box)

1. Selection of modeling sand and subsequent control Lost foam casting dry sand is the main molding material, which has an important impact on the quality of castings. At present, there are three main types of dry sand commonly used by domestic enterprises: quartz sand, pearl sand, forsterite sand; The requirements mainly include: chemical composition, particle size, grain shape, mud content, water content, ignition loss, etc. In the companies we visited, we found that the current companies that use quartz sand are divided into three categories:
The first type is crushed sand. Because quartz sand is distributed all over the country, in line with the principle of local materials, there are plate sand production bases in various places, so some of our companies use it directly for convenience; this kind of sand is polygonal. The sand has poor fluidity. After a period of use, the sand is transported under high temperature and vibration. The abrasion between the sand and the sand and between the sand and the conveying equipment is more serious. The raw sand particles are becoming more and more uneven, and the dust content is getting higher and higher. The air permeability is getting worse, and the load of sand treatment is getting heavier. This is also the reason why some manufacturers start to produce castings with good quality, and suddenly batches are scrapped after two months. .
The second type is natural air-dried sand, mainly desert sand in the Weichang area of Gansu and Hebei. The dry sand is produced through the processes of excavation, washing, drying, and screening. The grain shape of the sand is square, and the sharp corners have been passivated. , The fluidity is much better than that of crushed sand. At present, about 40% of enterprises using quartz sand choose this kind of sand, and the wear of sand is smaller than that of crushed sand, and the overall cost is also reduced a lot.
The third type is sea sand. Like desert sand, this kind of sand has a rounder grain shape, and the later use cost is much lower than that of crushed sand. At present, it is mainly used in Shandong and Fujian coastal areas. In the lost foam casting process, the SiO_2 content of quartz sand generally requires 90%-95%, which is sufficient. The commonly used dry sand AFS has a fineness of 25-45, the grain shape has no sharp corners, the round sand has the best fluidity and compactness, and it has better air permeability after tapping.

Chapter 4 The disappearance of the bubble model and black zone control



1. Modeling (buried box)

1. Selection of modeling sand and subsequent control The following three aspects should be paid attention to in the quality control of dry sand:
First, the moisture content of the raw sand, the moisture in the raw sand is the source of many casting defects. For lost foam casting, the use of dry sand without moisture also means that it can reduce the amount of heat required for vaporization. This is beneficial to improve the gasification conditions of the foam pattern and ensure the quality of the castings. The moisture of the dry sand should be less than 1%. In actual production, we generally recommend companies that use quartz sand not to add too much sand for the first time. As the production continues, it is better to add raw sand in batches from the falling sand. In the past, there have been batches of sand sticking in castings. The defect is related to the addition of too much new sand at one time. Adding a small amount of sand in multiple batches is to use the residual temperature of the old sand (200-600°C) after founding the sand to "hot" the new sand to let the water overflow, And close to the temperature of the old sand, thereby improving the quality of castings.
Second, the mud content of dry sand. At present, among domestic enterprises that use quartz sand, natural desert sand and sea sand account for the majority. Due to the thermal action of the high-temperature molten metal, some components in the dry sand and mud gasify to produce a large amount of gas, and at the same time form a higher pressure, these gases must escape the mold through the molding sand; in addition, the foam model is also heated and gasified to produce a large amount of gas. Gas must be discharged out of the mold through the sand mold. Dry sand contains a large amount of dust, which will reduce the gas permeability of the molding sand and hinder the discharge of gas during pouring. It is like the molding sand for lost foam casting, which should have higher air permeability than general casting sand. And low air generation, and the excessive mud content in dry sand will reduce the air permeability of compacted sand. Therefore, the mud content of dry sand should be controlled at 2%, and it is best to use washed and dried sand.
Third, it is necessary to determine the ignition loss of dry sand (). The ignition loss is an important parameter of dry sand performance. During the pouring process, the temperature of the molding sand closest to the pattern and coating layer can reach above 1200°C (premature sand casting). It is red). Dry sand has a high impurity content. After a long-term high temperature, the sand is fragile and pulverized, which seriously affects the air permeability of the sand. Generally, the ignition loss of sand is controlled within 0.5%.



1. Modeling (buried box)

1. Selection of modeling sand and subsequent control In order to solve a series of problems caused by the quartz sand molding process, as early as 2005, some foundry material companies began to develop electric fused sand, also known as "baozhu sand"; using high-quality bauxite as the raw material, it was calcined, fused and granulated. , Sieving and other processes. Its characteristics have the following advantages:

① The coefficient of thermal expansion is small, and the performance is comparable to that of zirconium gold sand. When used as molding sand, the casting will not produce expansion defects. ② Sand particles are spherical, with good fluidity, easy to tap dead corners, and good air permeability. ③ Smooth surface, compact structure, neutral material, both acid and alkali materials can be used. ④ High refractoriness, high thermal conductivity, good stability without cracking, good recycling performance, low wear, and high cost performance. It is a one-time investment. The advantages of Baozhu sand are obvious, especially for castings with complex structures such as the deceleration shell series in auto parts. It has good air permeability and simple modeling operation, avoiding many casting defects.

Chapter 4 The disappearance of the bubble model and black zone control



4.1 Modeling (buried box)

4.1.2 Placement requirements of the model in the sand box In recent years, with the promotion of lost foam technology and the continuous exploration and innovation of first-line technicians, the applicable range of lost foam casting technology has become wider and wider. From the weight of castings to dozens of grams to dozens of tons, the wall thickness varies from The sand box varies from 4mm to 200mm. The size and shape of the sand box are different. According to the actual production needs, the placement of the model in the sand box should be considered reasonably.

Under normal circumstances, we follow the following principles:

First, the principle of being able to stand without lying down. As the name implies, the model can be placed standing, not flat. When the foam model is placed upright, the projected area is the smallest. After the liquid metal enters the cavity, the heat loss is relatively slow, and the liquid metal fluidity will be better. The conditioning will be better, the punching will be more stable, and the later castings will have relatively fewer defects such as wrinkles, heavy skins, and pores.

Second, the principle that important areas and thick parts are on the bottom. The thick part is mainly considered from the solidification sequence, especially for cast iron castings. The molten iron enters the thick part first, and solidifies first, which is conducive to solidification at the same time as the thin-walled part; for steel castings, the molten steel enters the thick hot zone first. During the solidification process, the molten steel in the upper cavity replenishes the lower cavity due to gravity, and the riser replenishes the upper cavity. While avoiding tropical overlap, it enhances the replenishment effect and improves the utilization rate of molten steel. Third, the principle of convenient operation. If necessary, self-hardening sand should be treated in advance. For some thin-walled parts with more complex structures, some manufacturers use sand-filling methods. Conveniently, the method of placing in the sand box: "various" and "staggered", which brings some casting defects. For how to place it, we must first consider the principles of easy operation, easy standardization, and easy efficiency. In fact, in the local position of the model, the dead corners are filled with resin sand to remove the sand-filled dead corners. The entire placement will be very simple. Many manufacturers think that the resin sand is very troublesome, but they ignore the standardized operation of this process, which will affect the filling of the later castings. advantage.

4.1 Modeling (buried box)

4.1.3 Standardized operation of buried box 1. Place the bottom sand. The bottom sand is the interval between the sand box and the model bundle, which plays a great role. Generally, the thickness is required to be $> 150\text{mm}$, and the bottom sand should be flattened and vibrated. In addition, the actual situation should be determined according to the height of the model bundle and the sand box. The height of the bottom sand, supplemented by related tools (), standardized operation, convenient for later pouring.

2. The number of times of sanding and tapping. In actual production, the lost foam process has a greater advantage to produce complex structure castings. Therefore, the general model bundle must be sanded and tapped several times after being placed in the sand box. Generally, we recommend the number of sanding times. According to the position of the dead angle of the model beam, put the sand about 2cm above the dead angle each time, hang it flat and tap it, and if necessary, artificially assist the sand filling to ensure that it can be filled tightly. For each product, it is necessary to formulate an operation process card according to the actual production situation after repeated verification to facilitate standardized operation.

箱体震动造型示意图

15-07-15



4.1 Modeling (buried box)

4.1.3 Standardized operation of buried box 3. Pouring cup treatment At present, there are two types of pouring cups mainly used in the companies we visited: The first type: foam sprue cup, also called cup in box

Most manufacturers have developed special molds for the sprue cups, and used the molding method to make the sprue cups. The sprue cup has obvious advantages. Firstly, it is light in weight and can be used for coating with the sprue, or it can be separately hanged and glued with the model bundle in the later stage, and then buried in the box; second, when the molten metal is poured, the sprue cup The foam burns first, and the combustion releases a lot of heat, which reduces the cooling of the molten metal poured in the initial stage. Finally, because the sprue cup and the sprue are integrated, it is not easy to move the sprue cup during the pouring process.



泡沫浇口杯

Chapter 4 The disappearance of the bubble model and black zone control



4.1 Modeling (buried box)

4.1.3 Standardized operation of buried box (treatment of sprue cup) However, there are several issues that should be paid attention to when using foam sprue cups:

- a. The thickness of the foam sprue cup coating should be controlled to be greater than 2mm. If possible, it can be reinforced by sticking asbestos net, or use special coating for the sprue cup.
- b. When packing and discharging sand, it is better to take certain protective measures in the area of the sprue cup to prevent damage to the sprue cup.
- c. The contact point between the molten metal and the sprue cup should be below the plastic cloth (the area where there is negative pressure).



Chapter 4 The disappearance of the bubble model and black zone control



4.1 Modeling (buried box)

4.1.3 Standardized operation of buried box Pouring cup handling Schematic diagram of sprue cup buried box



Chapter 4 The disappearance of the bubble model and black zone control



4.1 Modeling (buried box)

4.1.3 Standardized operation of buried box

3. Pouring cup treatment

At present, there are two types of pouring cups mainly used in the companies we visited: The second type: common sprue cups are called cups outside the box, such as artificial sand sleeves, paper sprue cups, and ceramic sprue cups. As the name suggests, they are the sprue cups placed on the periphery of the plastic cloth in the later stage of the box; The cup should be closely matched with the bonding part of the runner to prevent the cup from floating or moving during pouring.



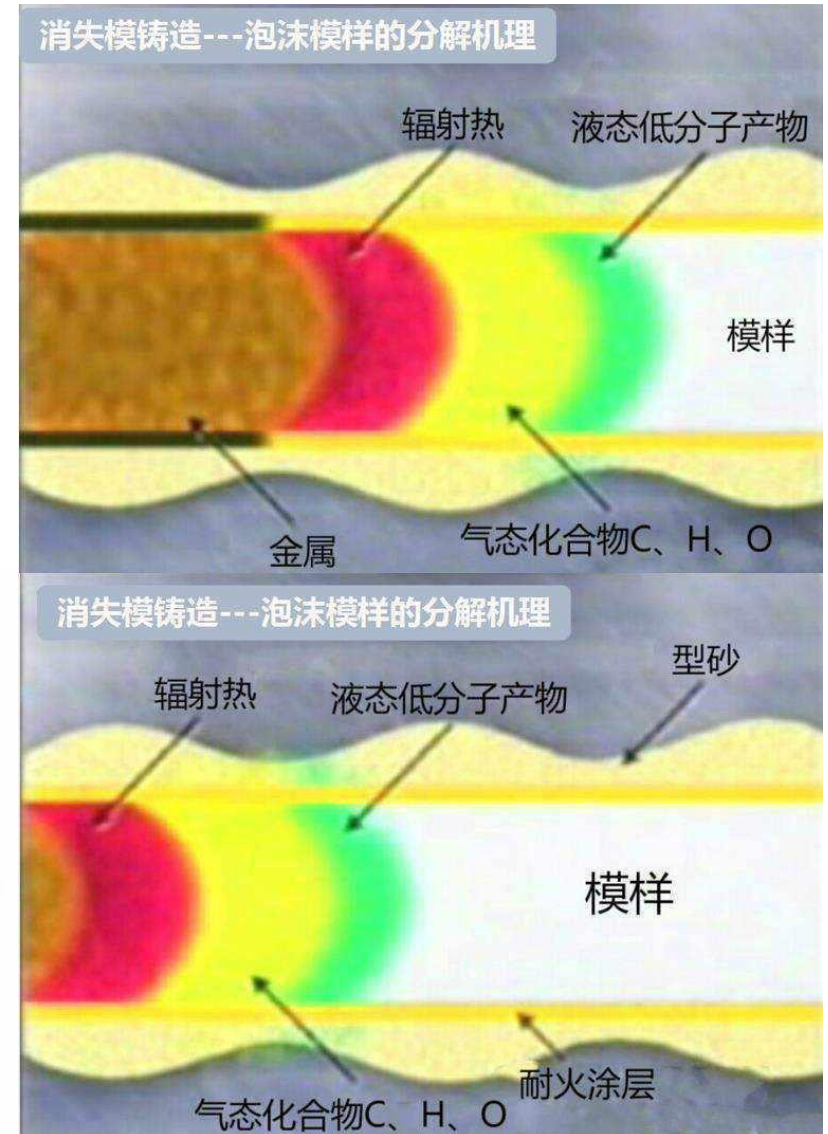
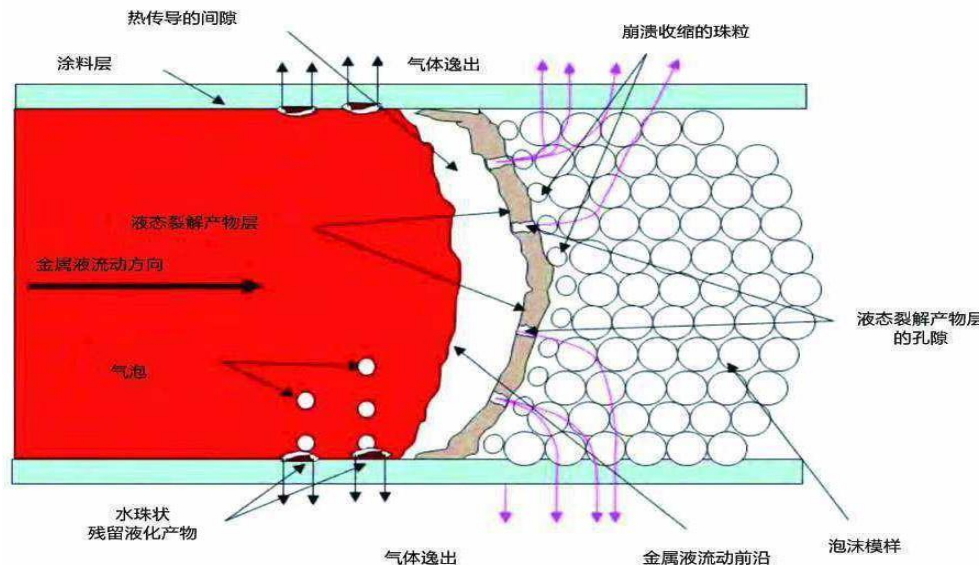
Chapter 4 The disappearance of the bubble model and black zone control



2. Negative pressure pouring

1. Quality control of molten metal Controlling the quality of molten metal is mainly controlled: the composition of molten iron, the purity of molten iron, and the temperature of molten iron; in lost foam casting, molten metal "disappears" the foam pattern.

The molten metal replaces the original space to form a casting. At the forefront of molten metal flow, there are complex physical and chemical reactions, heat and mass transfer phenomena.





2. Negative pressure pouring

1. Quality control of molten metal These include:

- ① In the gas at the front of the liquid metal, there are conduction, convection and radiation heat transfer between high-temperature liquid metal, coated dry sand, and unvaporized foam patterns.
- ② There are physical and chemical reactions between the pyrolysis products (liquid or gaseous) of the lost foam and the molten metal, coatings, and dry sand, and mass transfer occurs.
- ③ Due to the increase of the air pressure in the thermal conduction gap between the molten metal and the foam and the decomposing endothermic reaction of the pattern, the temperature of the flow front of the molten metal is continuously reduced, resulting in momentum transfer to the flow of the molten metal. Therefore, the quality control of the molten metal is not only related to the success or failure of the casting, but also has an important impact on the internal quality of the casting. For example, common in production: carburization, wrinkles, slag pores, cold barriers, etc., are often in the casting molding process Formed in.



2. Negative pressure pouring XX company freight train cast steel bracket: material requirements

1. Quality control of molten metal

1. The composition of molten metal: After receiving the product drawing, the first consideration is whether there are special requirements for the material of the casting. At the same time, the molten metal composition required by the casting is a factor that must be considered in the cost quotation. The product use requirements are different, the composition is also different, and the alloy melting process used is also Different, generally in accordance with the national standard requirements of the corresponding material of the casting, alloy elements with special requirements should consider the absorption of alloy elements and related testing methods.

2 材质:

所要求的材质按下列表格的标准执行:

化学成分 (百分比%)

质量标准	C	Mn	Si (最高)	P (最高)	S (最高)	Cr (最高)	Ni (最高)	Mo (最高)	V (最高)	Cu (最高)
E230-400MS	0.14-0.20	0.50-0.80	0.45	0.030	0.025	0.25	0.30	0.10	0.03	0.30
E260-450MS	0.19-0.25	0.50-0.80	同上	同上	同上	同上	同上	同上	同上	同上

机械性能

	抗拉强度 (N/mm ²)	屈服极限 (N/mm ²)	延伸率 (%)	断面收缩率 (%)	冲击韧性 (KV,+20°C)	硬度(**) (HB)
E230-400 MS	≥400	≥230	≥25	≥40	≥35	≤30
E260-450 MS	≥450	≥260	≥22	≥31	≥27	≤30

(*) – 做拉伸试验的试棒按 $L_0 = 5 \times D_0$

(**) – 同一批热处理出来的工件的布氏硬度会出现不一样



2. Negative pressure pouring

1. Quality control of molten metal

4.2.1.2 Purity of molten metal:

Now the purity of molten metal is no longer simply the purity of the smelting furnace, but the purity of the molten metal flowing into the sprue cup. Take the production of iron castings as an example. Among the companies we visited, most of the manufacturers have slag hole defects in their castings, some are external slag holes, and some are subcutaneous slag holes; the main source of slag holes is the molten iron, and some are not carefully slagging in the furnace. Some are sintered slag with poor lining material in the ladle, which will be melted into slurry by high-temperature molten iron during the next pouring. The slurry is different from the slag. The slurry is fluid and floats on top of the molten iron and can be filled into the cavity together with the molten iron. There is also slag caused during the spheroidization of molten iron. Therefore, in order to ensure the purity of the molten iron, high requirements are placed on the molten iron treatment employees: First, use a good slag accumulator to quickly slag slag; Secondly, the lining material of the ladle should be made of higher refractoriness; In the third pouring, slag blocking technology is appropriately adopted, such as slag blocking cotton, or a filter screen is set on the pouring system.

Chapter 4 The disappearance of the bubble model and black zone control



4.2 Negative pressure pouring

4.2.1 Quality control of molten metal

4.2.1.2 Purity of molten metal:





2. Negative pressure pouring

1. Quality control of molten metal

4.2.1.3 Temperature of molten metal:

Lost foam casting is different from traditional casting. A series of physical and chemical changes will occur during the replacement of molten metal and foam patterns. Since the vaporization of the pattern requires heat, the temperature of the molten metal flow front will drop, and the pouring temperature will be increased. On the one hand, It can change the fluidity of the molten metal, on the other hand, it can speed up the pyrolysis rate of the pattern, which is conducive to the escape of pyrolysis products.

Therefore, the pouring temperature in lost foam casting is 30-50°C higher than that of ordinary sand casting, (some companies that produce motor shells control the pouring temperature above 1600°C), and aluminum castings are even higher than 50-80°C; for ductile iron parts , Because there is a temperature drop of 80-100 °C during the spheroidization process, it is necessary to cooperate in many aspects such as casting materials, technology, pouring, etc., to reduce the furnace temperature as much as possible to reduce the alloy burning loss and ensure the mechanical properties.

Chapter 4 The disappearance of the bubble model and black zone control



4.2 Negative pressure pouring

4.2.2 Negative pressure selection Negative pressure is one of the three key points of lost foam casting research (foam model, dry sand, negative pressure). There are two main functions of negative pressure:

- The first fastening molding sand, in the lost foam casting, there is no negative pressure called "a pan of loose sand", it is precisely because of the existence of negative pressure that the molding sand is fastened quickly. Taking ductile iron castings as an example, there will be a process of graphitization and expansion after the pouring process is completed. If the molding sand is not strong enough, there will be a "mold wall movement" similar to traditional casting. First, the size of the casting changes greatly, and second, it will achieve the performance of the ductile iron. Feeding technology without riser becomes a bubble.
- The second important function is to ensure that the gas generated by the foam gasification is quickly discharged out of the flask through the gap between the coating layer and the molding sand, which is also a necessary condition for ensuring the filling of the molten metal. Under normal circumstances, the negative pressure is $-0.025 \sim -0.06\text{mpa}$. The selection of negative pressure should be based on the wall thickness of the casting, the design structure of the sand box, the air permeability of the coating, the air permeability of the molding sand and other reasons. Test to determine the final degree of negative pressure.

Here we emphasize the air permeability of coatings and molding sand. The air permeability we are talking about is high temperature air permeability. During the filling process of the molten metal, the principle of minimum energy is strictly followed. The turbulence and the wall effect field are related to the high temperature air permeability. Theoretically, it is necessary to balance the difference between the effective time and the foam vaporization speed and the discharge speed in the space. ". Many manufacturers test whether the air permeability of the coating is good or not based on whether the pouring is reversed or not. This is not comprehensive. The high temperature air permeability is too good, and the wall effect is more obvious. The air permeability of the coating depends on the pouring process, the temperature of the molten iron, and the degree of negative pressure. Cooperate with consideration.



4.2 Negative pressure pouring

4.2.3 Filling with molten metal (pouring)

① Transformation of ladle: Traditional casting has "three-part modeling, seven-part casting", and lost foam casting has higher requirements for casting. As a pouring tool, the ease of operation of the ladle is very important. In order to achieve accurate pouring, it is necessary to modify the ladle. Here we mainly promote the "duckbill ladle". In general, the height of the ladle is $1/2 \sim 2/3$ higher than the upper edge of the sand box. The position of the sprue cup in the sand box determines the length of the mouth of the sand box. The height of most sand boxes in the companies we visited is no more than 1200mm, the opening size of the sprue cup is generally about 140mm, and the position of the sprue cup generally does not exceed the center line, so the length of the ladle nozzle can be controlled at 400-500mm. Here we emphasize two points. If it is an open pouring line, it is recommended to set up a special pouring pit. The pouring pit is more convenient and safer than the pouring platform. If it is a closed pouring line, the height of the pouring platform is very important. As mentioned above, the pouring ladle is completely When it is located above the sand box, pouring is like a "seller", which is difficult to pack. It is difficult to ensure the smooth filling of the molten iron during the pouring process, and the probability of pouring cut-off is quite high. In addition, under normal circumstances, we do not advocate sand boxes. Pouring on both sides, especially in closed production lines, so the small part to large part process illustrated in the previous chapter is worth studying.

Chapter 4 The disappearance of the bubble model and black zone control



4.2 Negative pressure pouring

4.2.3 Filling with molten metal

(pouring) Many companies now also transform the pouring ladle into a "teapot type". Such a pouring ladle has a very obvious effect on solving the defects of the slag hole. It is more troublesome to pack and repair the bag every time, and the slag in the teapot mouth should be cleaned frequently, Otherwise the effect is counterproductive.



(It is better to control the distance between the sprue cup and the bag mouth at 200-300, The filling point should always be inside 1/2 of the sprue cup)



4.2 Negative pressure pouring

4.2.3 Filling with molten metal (pouring)

② Pouring method and speed control: Regarding the pouring method and speed control, this is still different from traditional casting. We have been to the site many times to train operators. In fact, it is very simple in theory. We have realized the three words "slow, fast and accurate", namely: At the beginning of pouring, because the foam of the sprue cup, sprue, and runner must first vaporize or burn under the contact of high-temperature molten metal (the burning part is greater than the vaporization part), and the negative pressure at the beginning of the pouring The flue gas produced does not work, most of the flue gas produced by gasification or combustion is discharged from the sprue cup. Once the pouring speed is too fast, the sprue cup fills up quickly and the gas discharge channel is blocked, and back spray will occur. This is also a situation that often occurs in the lost foam casting process.



4.2 Negative pressure pouring

4.2.3 Filling with molten metal (pouring)

② Pouring method and speed control: Many manufacturers use hollow sprue cups and hollow sprues to slow down the back spray phenomenon caused by the difficulty of controlling the early pouring speed as soon as possible. Therefore, the flow should be tricky. When you hear the sound of "whooping", it proves that the channels through which the molten metal enters are all opened up, and the pouring speed should be increased to seal the sprue cup without spilling. The word "fast" is easy for everyone to understand, and it is also very clear about the casting defects caused by pouring cut-off. In the later stage, the "whoop" becomes smaller and smaller, and the drop rate of the molten metal in the sprue cup becomes slower and slower. , It proves that the filling is about to end. At this time, the package should be collected slowly. This is "stable". In the companies we visited, the control of "stable" is not very satisfactory, or the package is received too late and the molten metal overflows the sprue cup. The loose sand flowing into the sand box even scalds the plastic cloth, causing the negative pressure to drop rapidly; or the bag is collected too quickly, and the sprue cup is "falsely filled", and then the metal liquid in the sprue cup sinks and the second pouring; in addition; The ladle is received too quickly, and the slag at the ladle nozzle will be drawn into the ladle along with the molten metal flow. When pouring the next time, it will directly enter the pouring cup. It can be used freely. It also requires the cooperating of the pouring worker and the driver to practice many times. , Flexible processing.



4.2 Negative pressure pouring

4.2.4 Holding pressure time control

The pressure holding time is determined according to the casting material and wall thickness. Generally, 5-20 minutes for small and medium-sized parts. Because of the long solidification time of thick and large parts, the pressure holding time is slightly longer, which can be determined according to the site conditions.