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CASTCHEM

Chapter 3 Pre-foaming and Foam Molding

Preliminary Preparations for Lost Foam Casting

No casting process is universally applicable. When selecting a casting method, comprehensive considerations—including product quality, yield rate, and production efficiency—must be made to identify the most suitable process for each component. Lost Foam Casting (LFC) is no exception. Upon receiving a product drawing, the following key points should be evaluated:

1. Equipment Capability Assessment

Verify whether in-house equipment (e.g., molding machines, sand flasks, melting furnaces) meets the dimensional and weight requirements of the product.

2. Material and Technical Requirements

- Select the appropriate foam material (FD, STMMA, or EPMMA) based on the casting alloy and specifications.
- Coordinate with mold manufacturers to determine shrinkage rates, accounting for melting and pouring conditions.

3. Drawing Analysis

- Define machining allowances per drawing specifications. For critical or high-precision surfaces, a minimum allowance of **3 mm** is recommended.

4. Pattern and Mold Design

- Priority to monolithic patterns: Avoid segmented designs when possible, especially for components with airtightness requirements. Monolithic patterns (e.g., hand-molded) reduce post-processing of glue seams and improve cost efficiency.
- While automated glue applicators are widely available, monolithic molding often offers better aesthetics and lower overall costs for specialized demands.

5. Process and Tooling Preparation

After finalizing the mold, develop a preliminary trial-production plan and prepare all necessary tooling, auxiliary materials, and equipment to minimize trial cycles and accelerate mass production.

Selection of Foam Beads and Density

1. Recommendations for Foam Bead Selection

(1) Selection of Foam Bead Types

The selection of foam beads is generally determined once the casting material is confirmed. In actual production:

- Gray iron (HT) castings: FD or EPS beads are typically recommended. STMMA copolymer beads may be used when conditions permit or for products with special requirements.
- Ductile iron (QT) castings: Copolymer beads (STMMA) are preferred because the pouring temperature of ductile iron is limited by the nodularization process (higher temperatures cause severe alloy loss and significantly affect nodularization results). Additionally, the fluidity of ductile iron molten metal is inferior to gray iron. For thin-walled castings or those with severely uneven wall thicknesses, incomplete foam vaporization during mold filling can cause various defects. This explains why most manufacturers avoided producing ductile iron castings in the early development stages of lost foam casting.

Since STMMA copolymer beads were introduced to the market in 2000, large-scale production of ductile iron castings using lost foam casting has become possible and has grown rapidly in recent years, particularly in:

• Automotive components (differential housings, casings, wheel hubs, etc.)
• Ductile iron pipe, pump and valve industries
• Agricultural machinery parts

Currently, some major domestic lost foam casting manufacturers still use FD or EPS beads for thin-walled, large-diameter ductile iron water supply and drainage fittings (pipe joints, tees, elbows, flanges, sockets, etc.). The main reason is their operating environment - these fittings are mostly buried underground after coating treatment and have low pressure requirements, allowing FD and EPS beads to provide cost advantages.

For steel castings, opinions vary on whether to use EPS or STMMA beads due to stringent pattern requirements. We believe the choice should depend on product structure and technical specifications. Although STMMA offers advantages over EPS in addressing surface defects and carbon pickup in steel castings, it remains less than ideal. After three years of research, CASTCHEM has successfully developed modified copolymer resins and EPMMA, which with their superior properties represent a new breakthrough in pattern materials for steel castings.

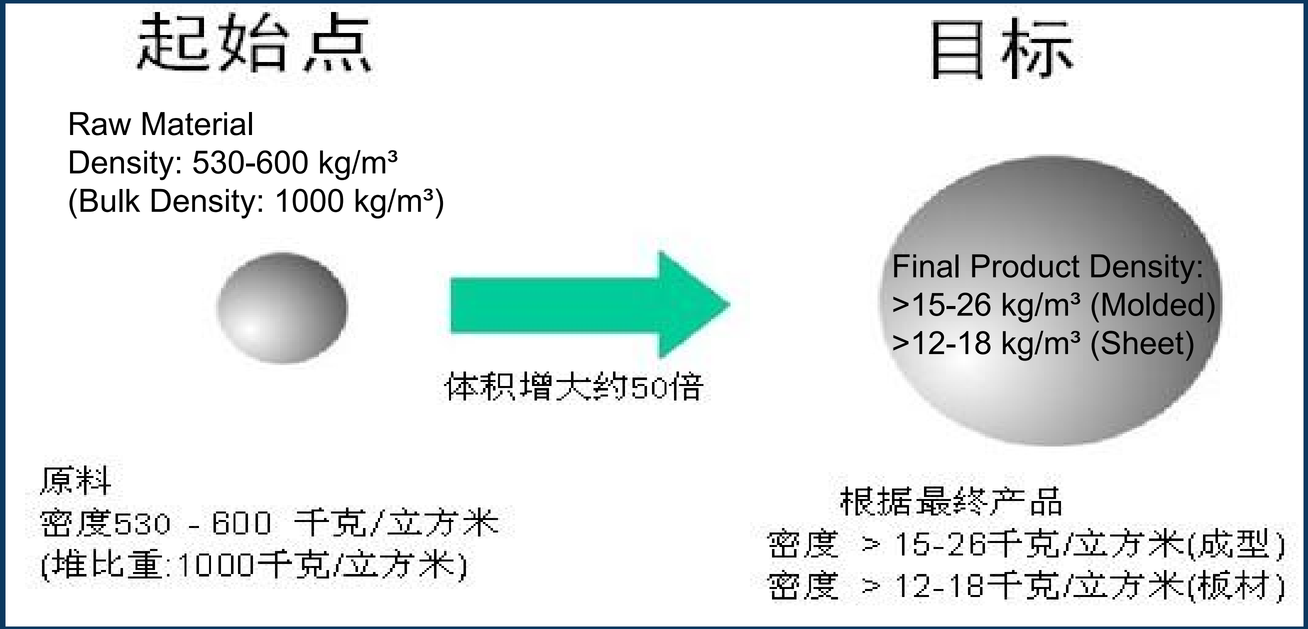
Selection of Foam Beads and Their Density

1. Recommendations for Foam Bead Selection

(2) Suggestions for Foam Bead Particle Size Selection

In lost foam casting, foam pattern production is extremely critical. The manufacturing of foam patterns must emphasize the selection of raw beads. First, appropriate beads for lost foam casting should be selected based on the casting material, performance requirements and process specifications. After determining whether to use STMMA, FD or EPS beads, suitable bead particle size should then be chosen.

During bead pre-expansion with an expansion ratio of 40-50 times, the bead diameter increases approximately threefold. As shown in the figure:



When the bead pre-expansion ratio is 40~50 times, the schematic diagram shows the increase in bead diameter.

[Diagram/Illustration of Bead Diameter Expansion]

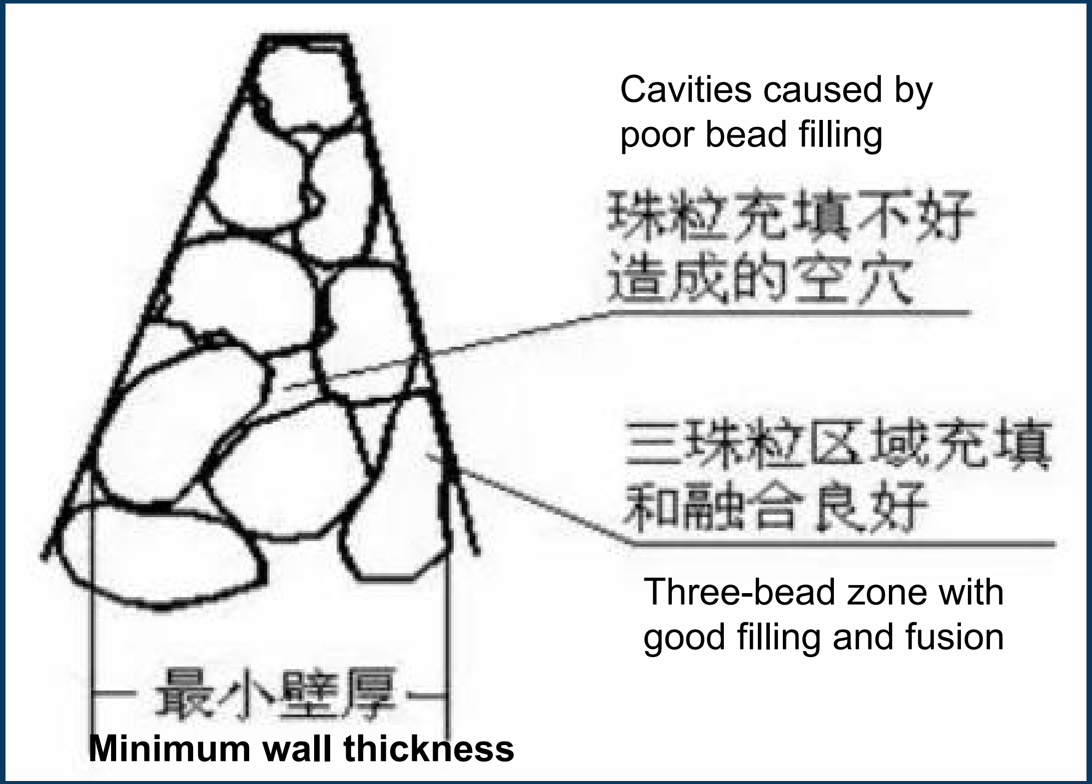
Selection of Foam Beads and Their Density

1. Recommendations for Foam Bead Selection

(2) Suggestions for Foam Bead Particle Size Selection

To achieve better surface quality of foam patterns, the minimum wall thickness of the pattern should accommodate at least 3 beads during secondary foaming (molding).

As shown in the figure:



Schematic diagram of bead arrangement

Selection of Foam Beads and Their Density

1. Recommendations for Foam Bead Selection

(2) Suggestions for Foam Bead Particle Size Selection

Principles for selecting bead specifications (particle size):

When choosing the particle size of any type of bead, customers must first understand the dimensions, wall thickness, and surface quality requirements of the castings to be produced.

Under normal circumstances, we select the bead particle size (specification) according to 1/10 of the casting's minimum wall thickness, namely:

Foam bead particle size = Minimum wall thickness/10.

Then, based on the bead particle size vs. specification reference table provided by the raw material manufacturer, select the corresponding bead model that matches the foam particle size. If the casting has high surface requirements, smaller particle size beads can be chosen.

Selection of Foam Beads and Their Density

2. Foam Bead Selection Case Studies

Each bead manufacturer provides a recommended pre-expansion density based on their expansion ratio. We can select the appropriate pre-expansion density according to molding conditions and foam pattern appearance requirements. For foam patterns with high surface quality demands, smaller particle size beads can be chosen.

In general production, to facilitate subsequent casting, lower foam density reduces the probability of defects during pouring, provided that the foam pattern's strength and dimensional shrinkage meet requirements.

Practical Case of Bead Selection:
- **Product Name**: Ductile Iron Housing
- **Material**: Ductile Iron 450-10
- **Wall Thickness**: Minimum 6mm, Maximum 26mm
- **Rough Casting Weight**: 37kg
- **Machining Requirements**: No defects on machined end faces, no shrinkage porosity in drilled holes.

Selection Based on Above Criteria:
- **Bead Type**: STMMA copolymer beads
- **Specification**: STMMA-2#
- **For Higher Surface Quality Requirements**: Smaller particle size beads (STMMA-3A) are recommended, as shown in the right figure.

(Note: The actual figure should be inserted here as referenced in the original text.)

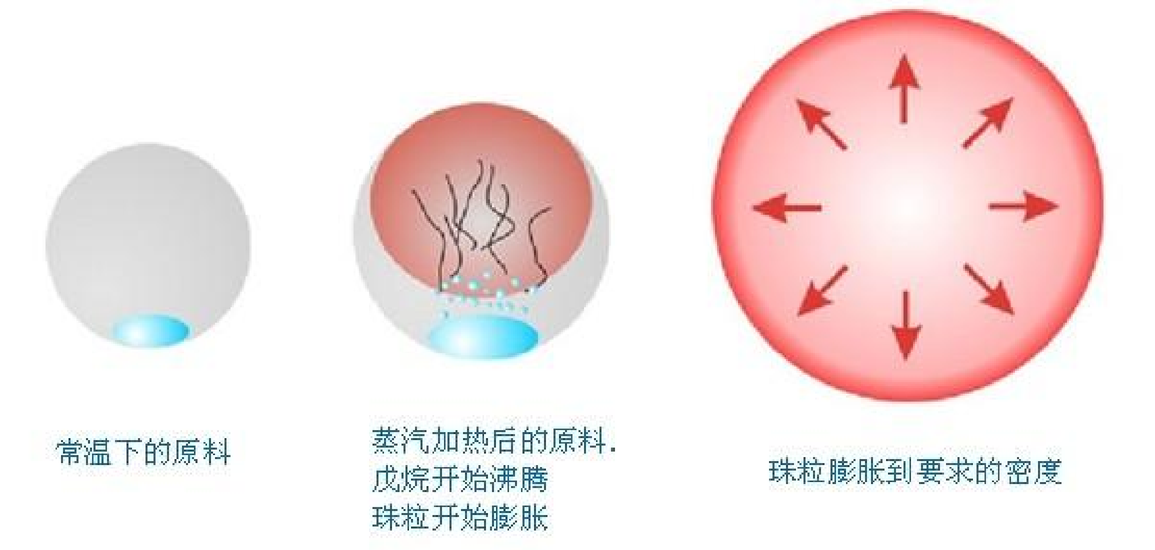
3.1 Purpose of Pre-foaming

Pre-expansion of foam beads is essential to obtain low-density foam patterns or foam boards with uniform cell structure. The resin beads must undergo pre-expansion before pattern molding. The quality of bead pre-expansion significantly impacts both the molding process and final product quality. While various methods exist depending on heating medium and approach, steam pre-expansion is currently the most commonly used method.

Principle of Steam Pre-expansion:

Before reaching their softening temperature when heated by steam, the resin beads do not expand but only experience foaming agent evaporation. As the temperature rises to the beads' softening point, they begin to soften and become plastic. The foaming agent inside the beads vaporizes under heat, generating pressure that causes bead expansion, ultimately forming an interconnected honeycomb structure.

Once the cellular structure forms, steam permeates into the cells, gradually increasing internal pressure and causing further cell expansion. During this expansion process, the foaming agent simultaneously diffuses outward until equilibrium is reached between internal and external pressures, at which point expansion ceases. Upon cooling, the expanded bead size becomes fixed. As shown in the diagram:



3.2 Pre-foaming Equipment and Foaming Process

In lost foam casting, the pre-expansion of foam beads is primarily conducted using batch-type steam pre-expansion equipment. This process involves quantitatively feeding raw beads and heating them through steam penetration to achieve the required expansion ratio or density.

1.Qualified bead pre-expansion must meet four essential requirements:

2.High-quality pattern material

3.Excellent pre-expansion equipment

4.Low-pressure, high-volume saturated slightly superheated steam

5.Effective process control

3.2 Pre-foaming Equipment and Foaming Process

1. Pre-expansion Process and Operating Parameter Control
The pre-expansion of beads is typically performed in batch-type steam expansion machines. While operating parameters vary across different pre-expansion equipment, the fundamental process remains consistent.

Process Steps:
Preheating → Loading → Heating/Expansion → Discharge → Drying → Cleaning

(1) Preheating:
Purpose: Reduce moisture in the expansion chamber and shorten pre-expansion time.

Procedure:

•Begin loading prepared beads once the target preheating temperature is reached.
•Preheating consists of two phases:
a. Steam injection preheating: Raises chamber temperature to 90–105° C.
b. Cyclic steam injection/exhaust preheating: Maintains stable temperature (minimal fluctuation) for 15–20 minutes.
•Manual blowdown is required during preheating.
(2) Loading:
Example: For a 450-type pre-expansion machine (e.g., Hangzhou Fuyang Bai Equipment), the loading quantity is typically ~0.6 kg (≈1000 mL).

(3) Heating/Expansion:
•Steam supply pressure: 0.45 MPa (post-pressure reduction).
•Machine steam pressure: 0.14–0.18 MPa (regulated).
Expansion Parameters by Bead Type:

Bead Type	Chamber Pressure	Temperature	Time
Copolymer (STMMA)	0.02–0.05 MPa	95–105° C	30–70 sec
FD Beads	Atmospheric	83–93° C	15–45 sec

3.2 Pre-foaming Equipment and Foaming Process

1. Pre-expansion Process and Operating Parameter Control
(4) Drying:
Pre-expanded beads must be dried on a fluidized bed to reduce moisture content.
Note: Drying time should not be too long (excessive time increases static electricity). Fluidized bed temperature should preferably be 25~40° C.
(5) Cleaning:
After each pre-expansion, thoroughly clean the fluidized bed and expansion chamber to avoid material mixing in the next pre-expansion.
(6) Pattern Density:
Should be controlled at 18~26g/L.
- Density <18g/L: Patterns are prone to deformation
- Density >26g/L: Higher density patterns may generate excessive gas during pouring, potentially causing defects like back-spray

Bead density control depends on:
- Original bead particle size
- Model thickness dimensions

Generally, refer to the following table for selection:

STMMA beads type	1#	2#	3A	3#	4#
FD beads type	big1#	small1#	2#	3#	4#
recommend density range（g/L)	18~20	19~22	20~23	22~26	23~26

3.2 Pre-foaming Equipment and Foaming Process

2. Evaluation of Qualified Beads After Pre-expansion

(1) The pre-expanded beads should have low moisture content (considering steam quality and preheating of the expansion machine), with moisture content <5%;

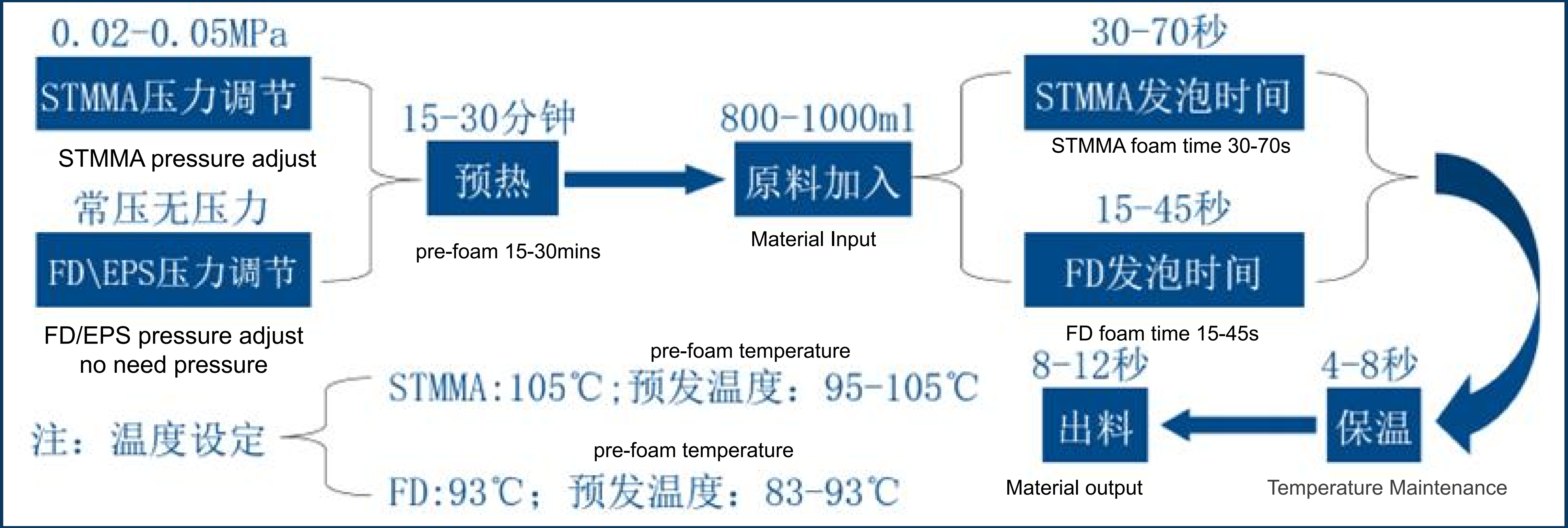
(2) The pre-expanded beads should be uniform (considering material loading quantity, preheating, scraper of expansion machine, steam quality, expansion time, and bead quality), with density fluctuation controlled within ±0.5g/L;

(3) The pre-expanded beads should have a glossy appearance (considering expansion time, expansion density, and expansion temperature);

(4) Reasonably control the pre-expansion density according to aging requirements (considering moisture content and volatile control of beads). The density difference between well-aged beads and properly pre-expanded beads should be 1~1.5g/L.

3.2 Pre-foaming Equipment and Foaming Process

3.Analysis of Pre-expansion Process Parameters



3.3 Aging Treatment of Pre-foamed Beads

After pre-expansion, the beads are cooled, causing the foaming agent and water vapor inside the foam cells to condense into liquid, thereby creating a vacuum within the cells. During the aging process, air gradually diffuses into the cells, helping to equalize the internal and external pressure of the beads.

The pre-expanded beads are stored in a conditioning silo—also known as an aging silo—for this aging process, as illustrated below.

For aging expanded polystyrene (EPS) beads used in the white area of the lost foam casting process, the typical capacity of the aging silo ranges from 1 to 3 m^3. These silos are usually made of plastic mesh or stainless steel mesh. To prevent static electricity buildup during bead conveying—which may cause bead loss or even pentane combustion—the use of plastic pipes is generally not recommended. If plastic pipes are used, grounding strips must be attached. Metal pipes with proper grounding are preferred for better safety and performance.

The aging silo should be placed in a well-ventilated area to ensure proper aging of the foam beads, thereby minimizing casting defects caused by inadequate bead aging.

3.3 Aging Treatment of Pre-foamed Beads

The pre-expanded beads are stored in a material silo for aging—referred to as an aging silo, as shown in the figure below:

3.3 Aging Treatment of Pre-foamed Beads

1. Requirements for the Aging Silo During the Aging Process

(1) The volume of the aging silo should not be too large. For EPS beads used in the white area of lost foam casting, the typical silo capacity ranges from 1 to 3 m^3.

(2) The mesh of the aging silo should not be too fine; the mesh opening should be larger than the diameter of the smallest pre-expanded bead.

(3) The aging silo should be made of anti-static materials, such as plastic mesh or stainless steel mesh.

To prevent static electricity buildup during bead conveying, which could lead to combustion, proper anti-static measures must be taken.

This straightforward yet efficient solution effectively addresses the issue of uneven bead

If the aging silo is too tall, it may lead to poor space utilization and inconsistencies in bead aging due to uneven air circulation.

3.3 Aging Treatment of Pre-foamed Beads

2. Environmental Requirements During the Aging Process

(1) Aging Silo: It should be placed in a well-ventilated area to ensure that the foam beads reach proper aging conditions, reducing defects in pattern molding caused by insufficient aging.

(2) Optimal Aging Conditions for Beads:
- Temperature: 25–40° C
- Humidity: <30%

(3) Recommended Aging Time:
- Copolymer beads: ≥24 hours
- FD/EPS beads: 8–48 hours

(Note: These values should be adjusted according to the user's equipment and specific environmental conditions.)

Note: If the aging environment lacks proper ventilation, compressed air or a blower should be used every 2–3 hours to stir the beads or to transfer them to another silo.

Purpose: To switch the positions of beads on the surface and inside the silo, ensuring uniform aging throughout the entire batch.

3.3 Aging Treatment of Pre-foamed Beads

3. Recommended Aging Time

The optimal aging temperature for beads is 25–40° C. The required aging time depends on factors such as the bead's moisture content, density, and the surrounding temperature and humidity.

For example, the relationship between the density of FD beads and their aging time is shown in the figure below:

beads density（g/L）	18	20	23	26
Optimal Aging Time (h)	20~48	12~30	10~24	8~12

FD beads, after pre-expansion, are dried and aged using a hot air drying bed (fluidized bed). A minimum aging time of 8 hours is sufficient for molding.

STMMA copolymer beads, after pre-expansion, typically require an aging time of at least 24 hours. Proper aging after pre-expansion is a critical step in producing high-quality patterns.

3.3 Aging Treatment of Pre-foamed Beads

4. Criteria for Determining Properly Aged Beads

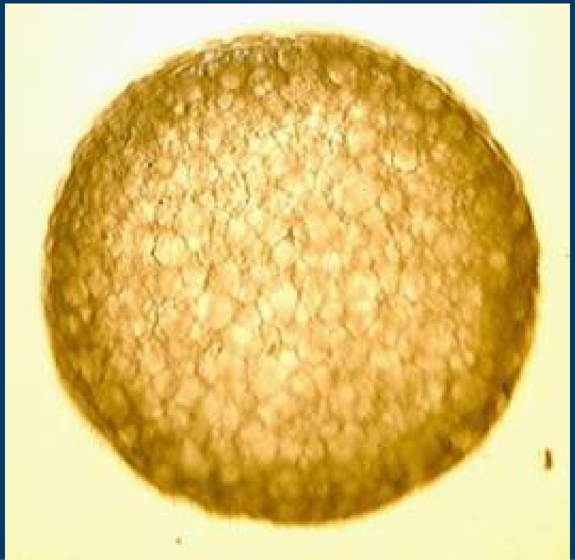
Well-aged beads typically have a glossy, smooth surface and a rounded shape, with good resilience when gently squeezed by hand. In contrast, poorly pre-expanded beads may exhibit surface blistering, irregular oval shapes, lack of elasticity, and rapid loss of volatiles.

In this aging process, the optimal volatile content should be controlled as follows:

- Copolymer beads: 7–7.5%
- Conventional (FD/EPS) beads: ≥5%

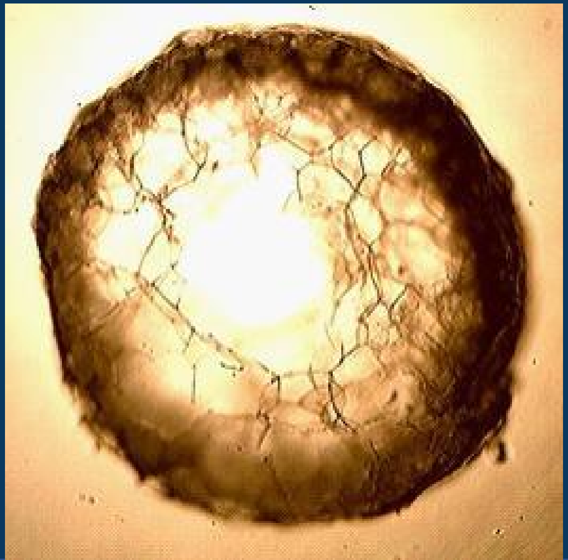
Proper volatile content helps reduce the risk of secondary foaming or poor fusion during final molding.

Examples of properly aged and defective beads after aging are shown in the figure below:



Analysis of Properly Pre-Expanded and Aged Beads

Damaged Beads After Pre-Expansion and Aging

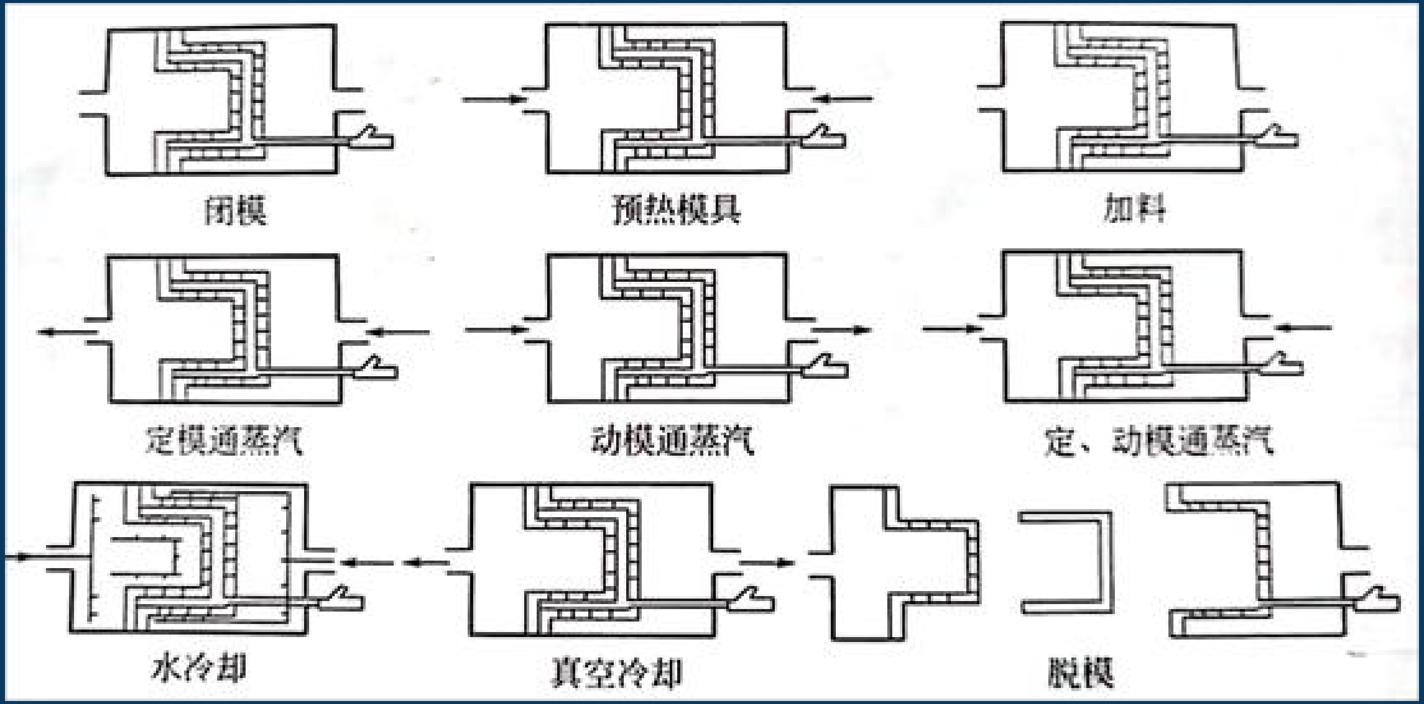


3.4 Purpose and Process of Foam Molding

The purpose of the molding foaming process is to fill the loosely pre-expanded beads into a mold of specific shape and dimensions, then apply heat again for secondary expansion. This results in a unified pattern that conforms precisely to the shape and size of the mold.

Steam enters through air vents and penetrates the gaps between the pre-expanded beads, displacing the air and moisture while heating the bead surfaces to their thermo-softening temperature. The residual foaming agent inside the beads is then preheated and expands, increasing internal pressure. This causes the beads to undergo secondary expansion and fuse at the interfaces, forming a single, cohesive structure.

The process is illustrated in the figure below:



3.5 Foam Molding Equipment

There are various methods for pattern foam molding depending on the heating approach, with the main ones being the **steam chamber (steam box) molding method** and the **pressurized air chamber molding method**.

Equipment and Molds for Steam Chamber Molding

Molding Equipment and Molds for Pressurized Air Chamber Forming

3.5 Foam Molding Equipment

1. Steam Chamber (Steam Box) Molding

Steam chamber (or steam box) molding, commonly referred to as **manual molding**, is typically used for patterns with complex mold structures that require multiple loose blocks (either on the sides or top and bottom) to be manually assembled and disassembled. When there is a high demand for white patterns, this method eliminates the need for bonding during the entire production process.

The process begins by filling the mold cavity with properly aged beads using a filling gun. The mold is then placed into the steam chamber (or steam box), where steam is introduced with controlled pressure, temperature, and time. After foaming and forming, the mold is removed, cooled, and demolded.

During steam chamber molding, the secondary expansion of the beads occurs as steam penetrates through vent holes into the gaps between the beads. Since both steam and residual air and condensate coexist within the cavity, sufficient time is required for air and condensate to be expelled through the vents. This results in a slower expansion rate and longer processing time.

For example, when molding patterns with thicknesses ranging from 7 to 30 mm, the typical heating time is approximately 3 to 5 minutes.

The steam pressure used during steam chamber molding is shown in the table below:

material pattern	FD/EPS	STMMA
steam pressure（MPa）	0.08~0.10	0.10~0.14

3.5 Foam Molding Equipment

1. Steam Chamber (Steam Box) Molding

The assembly and disassembly of the steam chamber (or steam box) molding mold are done manually, resulting in lower production efficiency. This method is not suitable for large-scale production. The steam chamber molding process is illustrated in the figure below:：

3.5 Foam Molding Equipment

2. Pressurized Air Chamber Molding Method

Pressurized air chamber molding, commonly known as **machine mold molding**, involves filling the mold cavity, which contains an air chamber, with pre-expanded and aged beads using a filling gun. The mold is horizontally split into an upper and lower steam cabinet: the upper steam cabinet is fixed to the movable platen of the molding machine, while the lower steam cabinet is fixed to the stationary platen. The movable platen rises and falls to complete the opening and closing of the mold for molding.

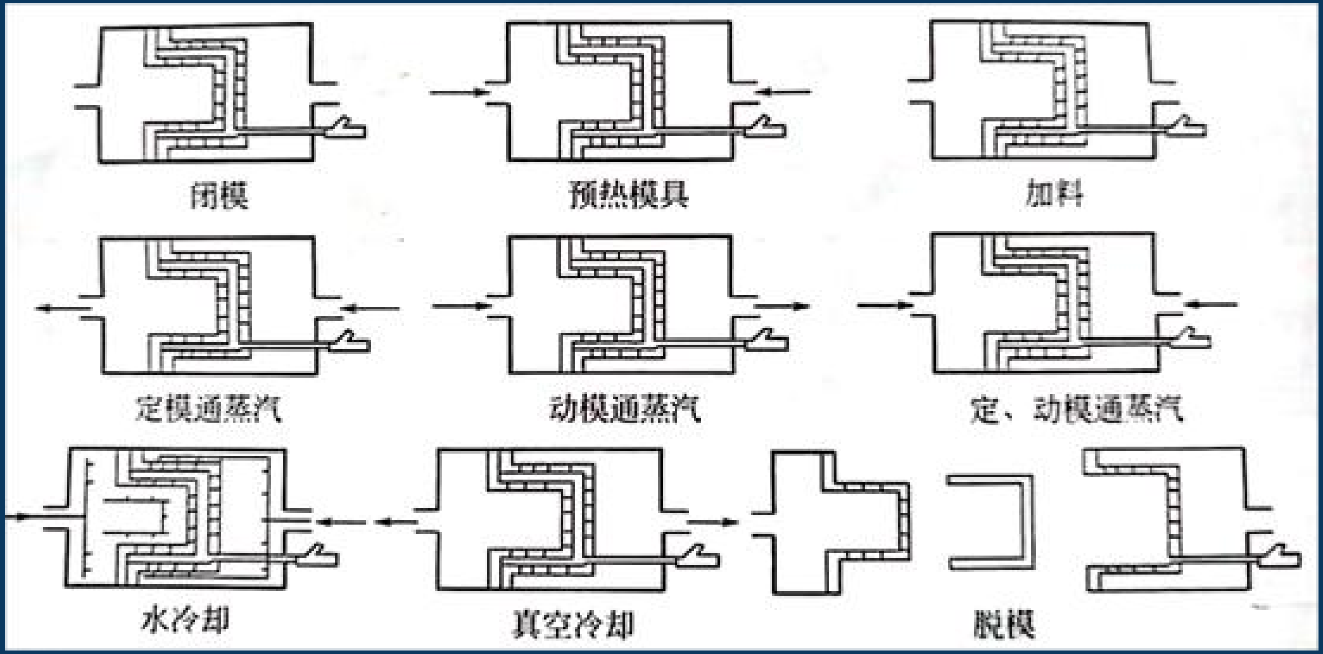
Superheated steam enters the mold cavity through vent holes in the mold walls. The steam then passes through the gaps between the beads, displacing the air and condensate, quickly filling the gaps and infiltrating the foam cells.

When the pressure inside the foam cells—comprising the foaming agent’s vapor pressure, the saturation steam pressure at the molding temperature, and the air pressure due to expansion—greatly exceeds the external pressure on the beads, and the beads soften due to heat, they expand and foam to form the desired shape. Afterward, cooling water is introduced into the air chamber to cool the mold and the molded pattern, and the pattern is then demolded to obtain the required foam shape or mold sheet.

3.5 Foam Molding Equipment

2. Pressurized Air Chamber Molding Method

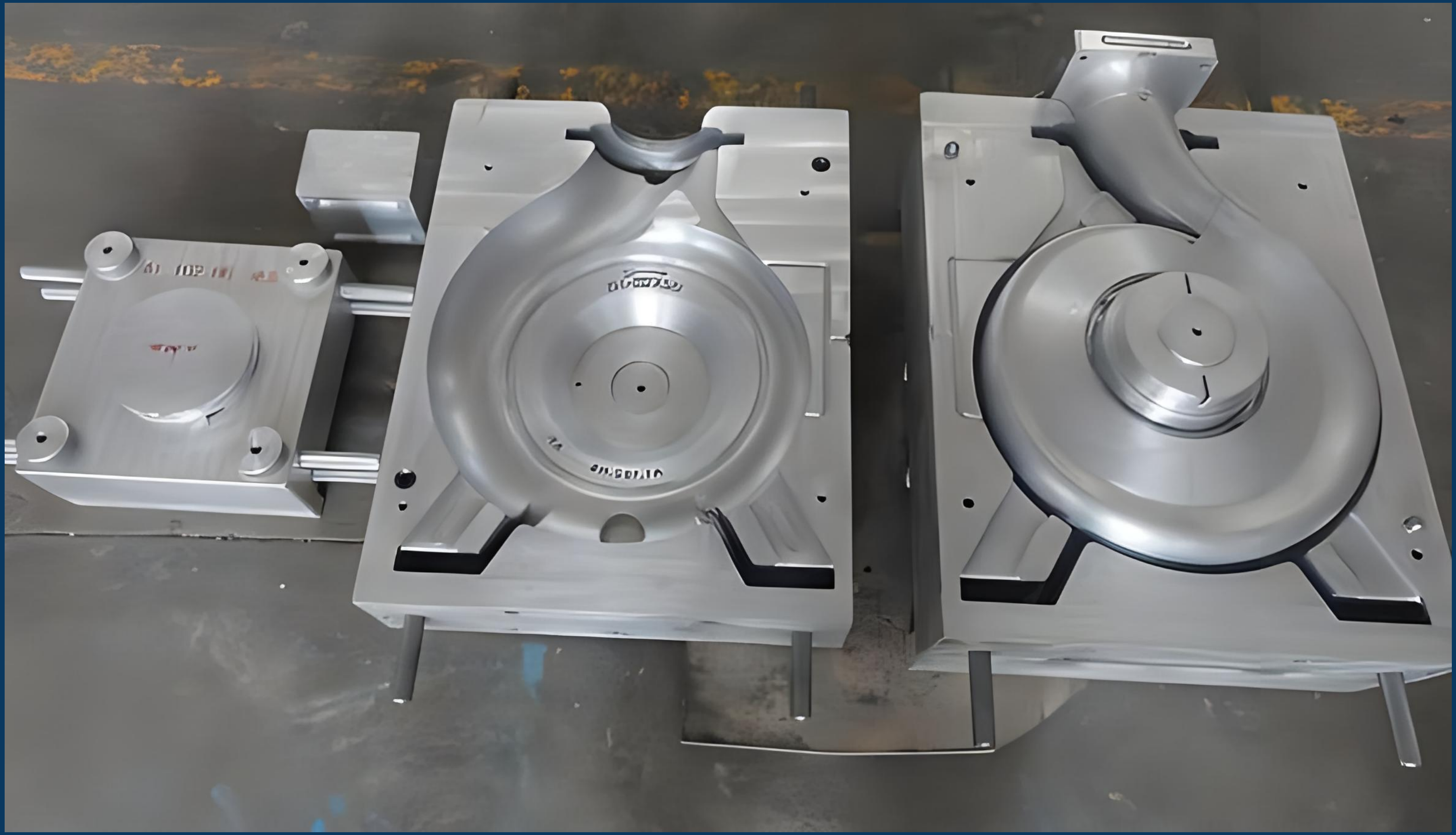
The pressurized air chamber molding method allows for the production of low-density foam patterns, with a short molding time, stable process, and good pattern quality. This method is the primary molding technique for producing foam patterns for lost foam casting, as shown in the figure below:



Pressurized Air Chamber Molding Equipment and Molds

Process of Pressurized Air Chamber Molding

3.6 Foam Molds



3.6 Foam Molds

The foam mold is the most critical and direct factor in determining the quality of the pattern. A poorly made mold will never produce a high-quality pattern. At the same time, the mold's manufacturing cost, ease of operation, and efficiency in pattern production also play significant roles in the overall efficiency and cost of casting.

1. Basic Requirements for Molds

(1) The dimensional accuracy of the mold must ensure that the resulting casting meets the required precision range of the pattern. The surface roughness of the mold working face should be controlled below R6.3μm.

(2) To ensure uniform and rapid heating and cooling of the pattern, the mold material should have good thermal conductivity. The mold cavity is generally made with a thin-shell, conformal structure.

(3) The injection nozzle in the mold should be designed to guarantee smooth material flow, ensuring that the pre-expanded beads can fill all parts of the mold without obstruction.

(4) Proper placement of the exhaust valve and determination of exhaust area size are essential for ensuring the pattern is compact and that heating and cooling are uniform.

(5) The mold must be reliably connected to the molding machine, with accurate installation and positioning.

(6) The mold should have sufficient strength and rigidity, excellent resistance to corrosion from water, steam, and other media, and a long service life.

(7) The mold should be easy to manufacture and operate.

3.7 Process Control in Foam Molding

1. Control of Molding Process Conditions

A. Closing the Mold:

The foam mold is closed. When using larger diameter beads, small gaps, smaller than the radius of the pre-expanded beads, are often left at the mold parting line. This allows compressed air to simultaneously escape from both the vent holes and the gap during the filling process, helping the beads quickly fill the mold cavity. During steam heating, the air and condensate between the beads can also escape through the vent holes and gaps. However, when using materials specifically for lost foam casting, the bead size is smaller, so gaps are generally not left when closing the mold. The air and condensate between the beads can only escape through the vent holes. It should be noted that leaving gaps often causes flash at the mold parting line.

B. Preheating the Mold:

Preheating the mold before filling helps to reduce steam condensation during the foaming process and shortens the molding time.

C. Filling:

The exhaust vents of the stationary and movable mold chambers are opened, and pre-expanded beads are blown into the mold cavity through the filling port using compressed air. Once the mold cavity is completely filled with beads, the filling port is sealed with a stopper. Filling is the foundation of the foaming process. If the filling method is improper, resulting in uneven or incomplete filling of the cavity, defects will occur in the pattern, even if the mold and beads are of high quality. Therefore, the filling method is one of the most critical steps in the foaming molding process.

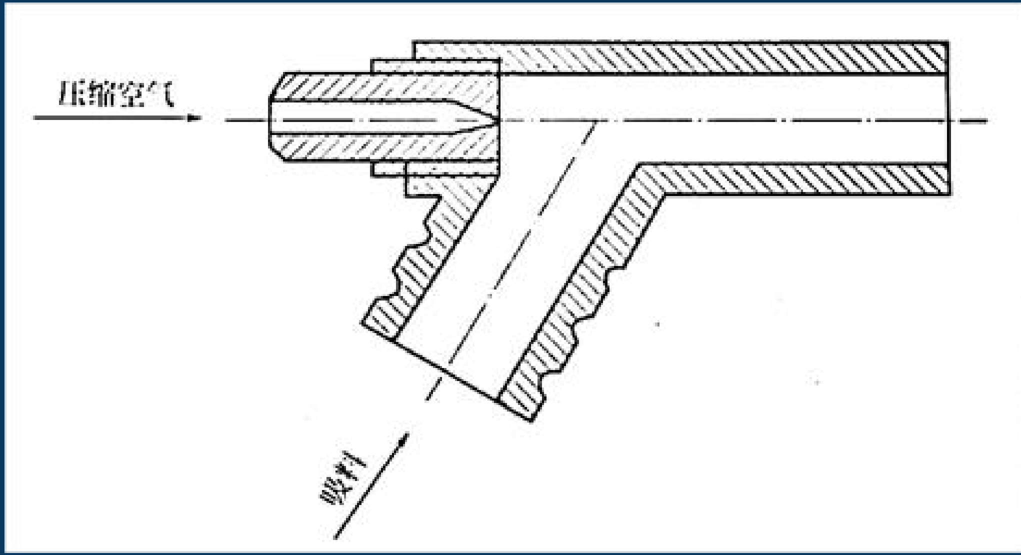
3.7 Process Control in Foam Molding

1. Control of Molding Process Conditions

Currently, three common feeding methods are used in production: suction filling, pressure-assisted suction filling, and negative pressure suction filling.

① Suction Filling

This is the most commonly used feeding method by manufacturers in China. This method uses a standard material gun — the Venturi (Vonturi) gun — which utilizes compressed air to suck the beads into the mold cavity. For molds with simple cavity structures, this method works well. However, for molds with more complex cavity structures, this method cannot fully fill the cavity with beads, leading to insufficient filling in the pattern. A schematic diagram of a standard material gun is shown below:



3.7 Process Control in Foam Molding

1. Control of Molding Process Conditions

② Pressure-Assisted Suction Filling

This method involves applying positive pressure on the beads during filling, ensuring that the beads completely fill the mold cavity and achieve a certain level of compaction. See the diagram below:

3.7 Process Control in Foam Molding

1. Control of Molding Process Conditions

③ Negative Pressure Suction Filling

This method applies negative pressure on the back of the mold while using suction filling. The combined effect of the negative pressure pull and compressed air suction ensures that the beads fill the mold cavity.

To address the feeding issue for complex, thin-walled patterns, multiple material guns can be used simultaneously. For all the above feeding methods, using multiple material guns at the same time yields the best results.

3.7 Process Control in Foam Molding

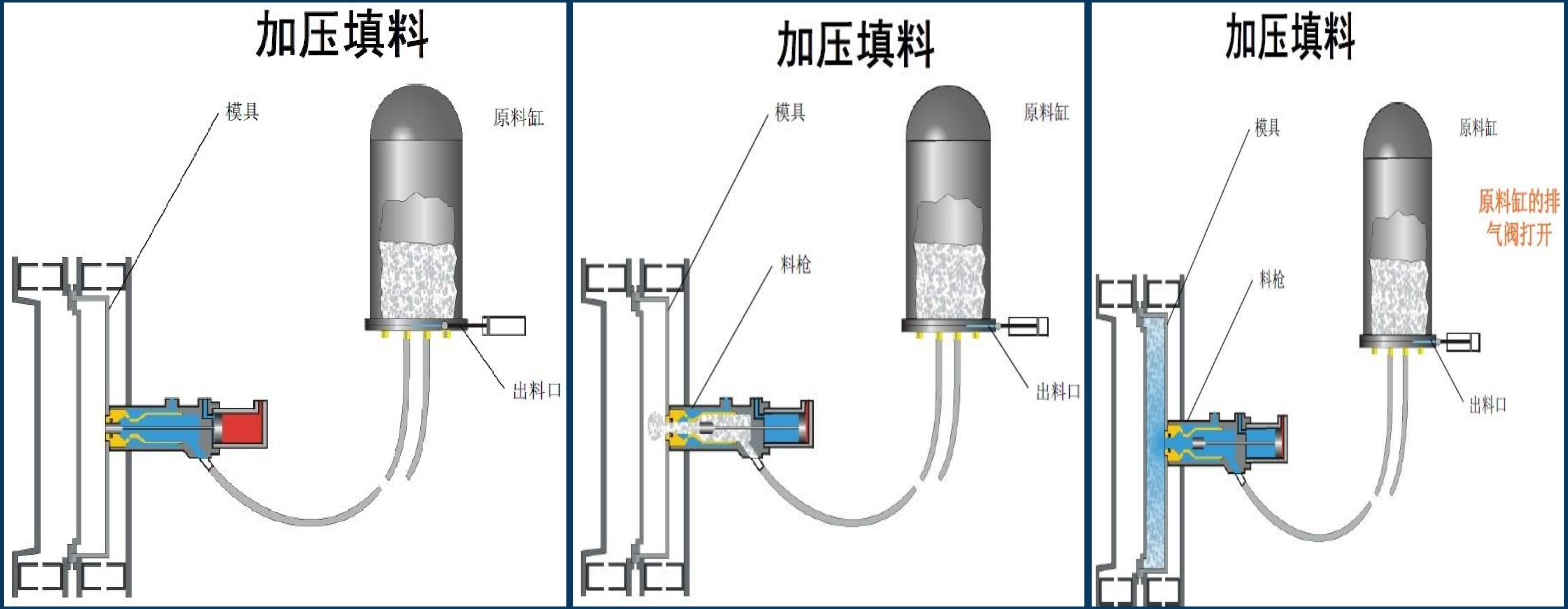
2. Filling of Beads During Molding

To produce high-quality patterns, a well-designed filling system and complete process control are essential. Perfect filling of the mold is crucial for creating good castings! Ensuring that the qualified, cured beads are perfectly filled into the mold cavity is a key step in pattern production, and it is a very important issue. Poor filling can result in missing material in the pattern and density gradients in the final mold. Fully automated molding machines in foreign countries can solve this problem quite well. In China, most manufacturers use hydraulic press molding, and the pressure filling system (feeding tank) is widely used. This system requires a low pressure when feeding from the hopper to the mold cavity, with uniform pressure matching to ensure that the beads flow smoothly and avoid back-spraying into the hopper or clogging of the filling pipeline. Using filling hoses with a smaller diameter than usual is a reliable method, but filling defects still often occur in the patterns.

3.7 Process Control in Foam Molding

2. Filling of Beads During Molding

I. Pressurized Feeding Process (See Diagram):



3.7 Process Control in Foam Molding

2. Filling of Beads During Molding

II. Analysis of Pattern Filling:

It is known that when the beads flow in, a large amount of compressed air is introduced into the mold cavity. It is very difficult for the compressed air to escape from the mold through the vents. Therefore, the internal pressure of the mold cavity will increase, and molds with insufficient ventilation will fill with high pressure, leading to uneven bead density, particularly at the nozzle area of the material gun where the density increases.

Due to the inconsistency in the density of the pattern, this phenomenon can cause casting issues. Filling patterns with thin walls and complex shapes is even more difficult. We do not recommend using mold lifting during filling; dry molds can achieve better filling results.

3.7 Process Control in Foam Molding

2. Filling of Beads During Molding

III. How to Effectively Reduce Filling Defects in Patterns

① Control During Pre-expansion: Ensure that the pre-expanded beads are glossy, uniformly sized, and have low moisture content. During fluidized bed drying, avoid excessive dwell time to reduce static electricity generation.

② Control During Curing: During curing, ensure that all beads reach the curing standard and that the cured beads exhibit good resilience.

③ Control During Molding: Before filling, preheat the mold and dry the condensed water inside the mold cavity using compressed air. When filling with suction, ensure the feeding tube is not too long (to avoid increased resistance). The pressure inside the feeding tank should generally be 0.2 MPa (adjustable based on specific conditions). During filling, control the compressed air flow to prevent vortex formation inside the cavity. For beads with lower density (<18 g/L), consider using mold lifting during filling.

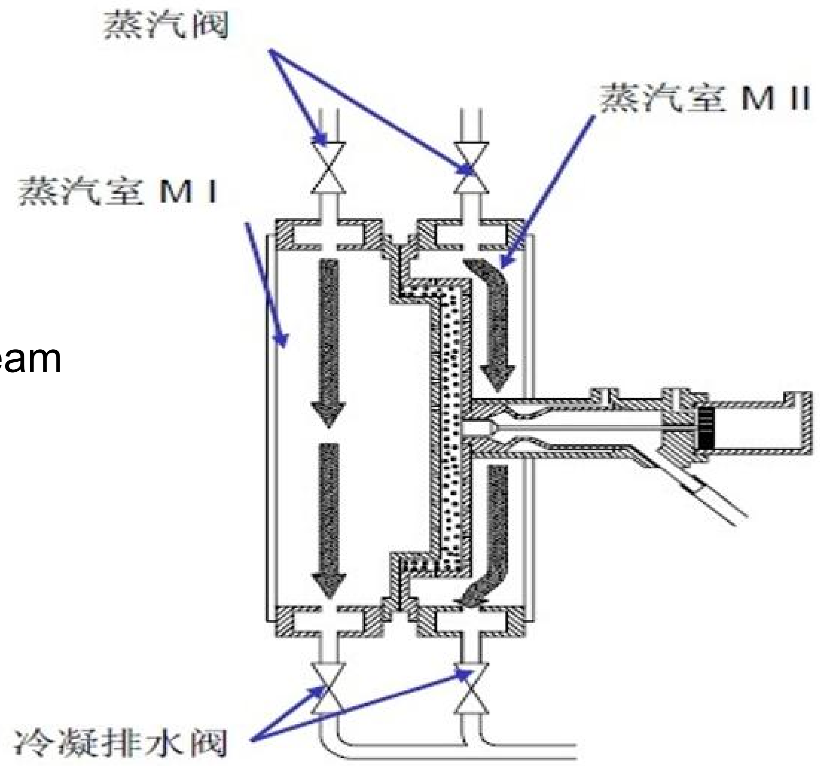
④Control of the Mold: Depending on the mold cavity, choose the appropriate feed port location and gas vent specifications (size of vent holes). Regularly clean the mold vents to prevent blockage from beads and impurities in water.

3.7 Process Control in Foam Molding

It looks like you're explaining how to control the molding process, specifically focusing on the preheating of the mold. However, there isn't an image or diagram included in the message.

- 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

Preheating the Mold Expel the cold air from the steam chamber, as air has poor thermal conductivity.



3.7 Process Control in Foam Molding

3. Control of Molding Process Conditions

② Steam Delay

Allow the beads inside the mold to remain for a short time to stabilize within the mold. This method is used for relatively complex products.

③ Steam through Fixed Mold

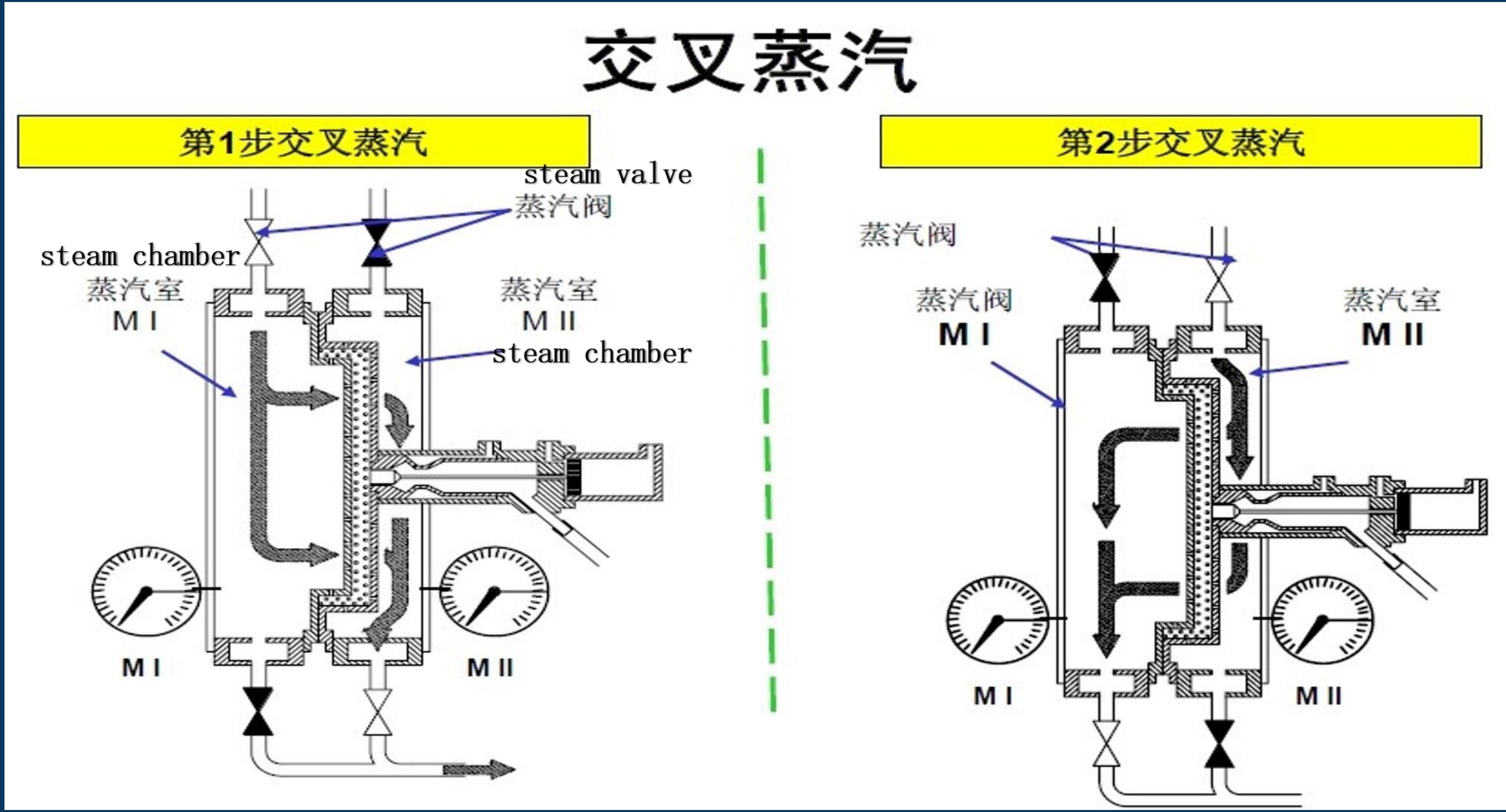
Steam enters the moving mold's steam chamber and then flows through vent holes in the mold wall into the mold cavity. It displaces the air and condensed water between the beads, which are expelled through vent holes on the moving mold side.

④ Steam through Moving Mold

Steam enters the moving mold's steam chamber and then flows through vent holes in the mold wall into the mold cavity. It displaces the air and condensed water between the beads, which are expelled through vent holes on the fixed mold side, as shown in the diagram below.

3.7 Process Control in Foam Molding

Cross Steam Injection



3.7 Process Control in Foam Molding

⑤ Steam Injection from Both Fixed and Moving Mold Halves

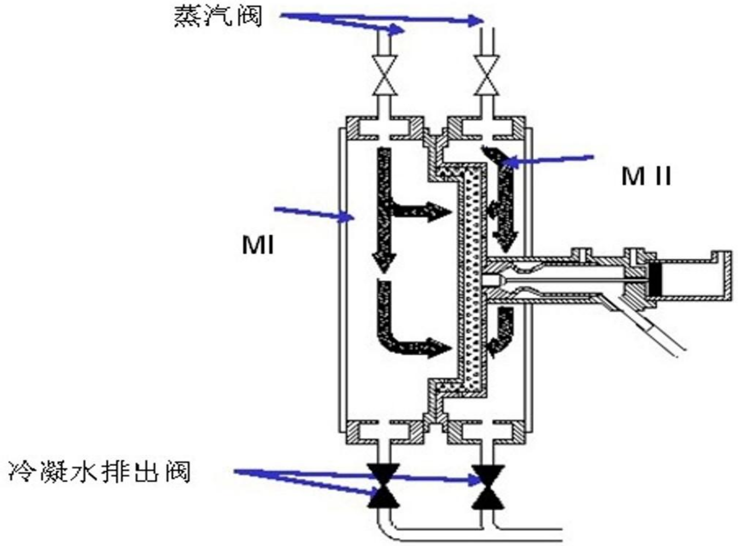
Steam is simultaneously injected into both the fixed and moving mold chambers and maintained at a set pressure for several seconds. The bead particles are softened by the heat and expand further to completely fill the mold cavity. This causes all the gaps between the beads to fuse together, forming a single, cohesive foam structure.

双面蒸汽
Double-Sided Steam

- 真正的膨胀过程开始。
- 达到熔结温度，珠粒熔结在一起。

The actual expansion process begins.

Once the fusion temperature is reached, the bead particles fuse together.



3.7 Process Control in Foam Molding

3. Molding Process Condition Control

⑥ Water Cooling

Shut off the steam and introduce cooling water into both the fixed and moving mold chambers to solidify the foam pattern and cool the mold to the demolding temperature, typically below 70° C.

⑦ Vacuum Cooling

After draining the cooling water, activate the vacuum system to further cool the foam pattern and reduce the moisture content within the pattern.

⑧ Mold Opening and Demolding

Open the mold on the press and select an appropriate demolding method, such as steam-water combination, mechanical ejector pins, or vacuum suction devices, to remove the foam pattern.

3.7 Process Control in Foam Molding

4. Fusion Stability of the Pattern During Molding

Ensure that the edges and corners of the product, as well as areas without steam vents, can still fuse properly through the residual heat of the mold — this is commonly referred to as "heat retention". This technique is especially used for more complex products.

Molding Process: If the surface fusion is not dense, extend the heat retention time.

Operational Procedure: Introduce a delay between the end of steam input and the start of venting and water cooling (heat retention time varies depending on the molding equipment and the pattern. Generally, a heat retention time of 8–12 seconds is recommended).

3.7 Process Control in Foam Molding

5. Cooling of the Pattern During Molding

① Traditional Water Cooling:

The water inlet valve remains open throughout the process. Cooling water flows through the mold, carrying away heat until the mold reaches the required demolding temperature. The cooling water is sprayed onto the pattern through the steam vents.

Generally, traditional water cooling is used for slow molding processes.

Key Considerations: Pay attention to the cooling speed and water inflow of both the fixed mold and the moving mold.

② Combined Water and Vacuum Cooling:

Heating 1 kg of water from 20° C to 100° C requires 335 kJ of energy, while turning 1 kg of water at 100° C into steam requires 2256 kJ.

Atomized water is sprayed onto the mold surface to absorb a large amount of heat through vaporization, thereby initially cooling the mold. Then, a vacuum is created inside the steam chamber to promote evaporation. The steam is extracted, carrying away the heat.

This method is mainly used for fast molding processes.

3.7 Process Control in Foam Molding

6. Precautions for Molding with Press Machine Air Chambers

When using a press machine air chamber for molding, the selection of heating steam pressure should take into account the type of raw beads, bead specifications, mold structure, and the method of introducing steam into the mold. Additionally, to produce qualified patterns, attention should be paid to the following four points during production:

① Select an appropriate feeding method based on the structural characteristics of the mold to ensure the beads are evenly filled into the mold cavity.

Insufficient filling may lead to molding defects, while excessive filling can increase the density gradient of the pattern.

② Control the steam heating conditions carefully.

Foaming molds are heated using steam as the heat transfer medium. When superheated steam is used for bead foaming and molding, it enters the mold cavity through the steam vent holes.

In this case, the beads near the vents expand rapidly, overheat, or stick together, which hinders further steam diffusion inward and causes poor fusion of beads in the cavity center.

Moist steam forms condensation on the bead surfaces, which also prevents the beads from fusing properly.

Therefore, mildly superheated and relatively dry steam is recommended, as it better penetrates into the beads.

③ Control the steam duration appropriately so that the beads in the mold can fully expand and fuse together.

If the steam is applied for too long, the pattern may shrink during the cooling process.

3.7 Process Control in Foam Molding

④ Cool the pattern immediately after molding.

At the beginning of cooling, the mold walls that come into contact with the pattern cool rapidly and evenly to a certain temperature. As a result, the pattern itself also cools down and becomes reinforced when the temperature drops below its glass transition point.

Due to the poor thermal conductivity of foam patterns, only the surface of the pattern cools and hardens quickly, while the interior remains hot. The expansion pressure within the still-hot inner part of the pattern is borne by the hardened surface shell.

As the surface temperature continues to drop, the internal expansion pressure decreases rapidly. Demolding should only be carried out once the pattern has reached sufficient stability.

If demolding occurs before the internal temperature has dropped low enough, the residual expansion pressure inside the pattern may lead to pattern deformation or bulging.

3.7 Process Control in Foam Molding

7. Some Requirements for Foam Molding Process

For many manufacturers, due to improper planning when installing equipment in the early stages, the steam storage tank is located far from the pre-expansion machine and the molding machine. Moreover, inadequate insulation of the steam pipeline results in issues during the pre-expansion process, such as excessive condensation in the steam, leading to uneven foam bead size, severe clumping, and significant waste. Therefore, it is recommended to install a steam-water separator at the pipeline inlet to the pre-expansion machine.

Through visits to various enterprises over the years, we have also found that although many companies have installed steam-water separators, many of them are merely for show. The main problem is that the installed steam traps are either manual or lack proper maintenance, causing the separators to stop working continuously. Some manufacturers use manual valves to drain the water, and operators only drain the water before their shift begins. This practice not only wastes a large amount of steam but also leads to excessive condensation in the steam pipeline during production, severely affecting the normal operation of the pre-expansion process.

3.7 Process Control in Foam Molding

7. Some Requirements for Foam Molding Process

The foam molding process also faces similar issues. Generally, we recommend installing automatic steam traps at the end of the steam pipeline and conducting regular maintenance. Additionally, water droplets adhering to the surface of the mold cavity can severely affect the filling of foam beads (molding) and the smoothness (flatness) of the foam model surface.

We suggest that during actual production, molds should have a good water cooling system. The spray pipe water cooling method designed by most mold manufacturers works well for cooling during the molding of complex and high-density foam models. Therefore, it is advisable to customize molds from professional manufacturers. Lastly, setting reasonable molding parameters is crucial. Currently, most manufacturers use semi-automatic molding machines produced by domestic equipment manufacturers. To produce high-quality foam models with good quantity and quality, it is particularly important to optimize the molding parameters.

Regarding the filling method, whether using an automatic or manual filling gun, the position of the feeding port is extremely important. Ensuring that foam beads face the least resistance when filling the mold cavity is a key issue that should be rigorously considered during mold design. Once again, it is recommended to choose a professional manufacturer.

3.7 Process Control in Foam Molding

8. Foam Molding Process Procedures

(1) Preheating the Mold

Preheating the mold before filling helps to reduce condensation during the bead foaming process and shortens the molding time. The recommended mold preheating temperature is 50–70° C (adjust according to the season). Before filling, it is essential to blow out any residual water inside the mold to prevent surface defects on the foam model.

(2) Precautions During Filling

When using large particle size beads (density <18g/L), a gap smaller than the radius of the pre-expanded beads is often left at the mold parting line to facilitate the filling of beads. When using a filling tank for bead addition or beads with a density ≥18g/L, it is generally not recommended to raise the mold during filling.

When using a filling tank, do not overfill the tank with beads (generally, fill about 2/3 of the tank's total volume).

When using a filling tank, the pressure in the tank should generally be around 0.18MPa (this can be adjusted based on the mold structure and the thickness of the foam model).

When using a Venturi gun, carefully control the amount of compressed air entering the mold to avoid insufficient filling, which could lead to incomplete foam models.

3.7 Process Control in Foam Molding

8. Foam Molding Process Procedures

(3) Control of Heating and Molding Parameters

Select the molding process based on the thickness of the model and the density of the beads. The molding process should follow these guidelines:

If the internal fusion is not dense, extend the penetration time.

If the surface fusion is not dense, extend the holding time.

Under the premise of ensuring the quality of the model, try to adopt low pressure, high flow, and multiple heating molding methods (to reduce residual volatiles in the model).

(4) Cooling of the Model

After closing the air intake valve, wait until the steam and residual heat in the mold's steam chamber are completely expelled before starting water cooling. When using water cooling, pay attention to the water temperature, water pressure, and cooling time.

Under the premise of ensuring the white model is qualified, try to shorten the cooling time and reduce the amount of water used.

3.7 Process Control in Foam Molding

9. Quality Requirements for High-Quality Models

Optimal Raw Material Distribution in the Mold Cavity During Bead Filling
Ensure that there are no areas with inadequate filling.

Optimal Fusion During the Steam Stage
Ensure uniform fusion of the entire mold piece, avoiding poor fusion or localized over-burn.

Optimal Density Distribution Across the Entire Mold Piece
The density variation across the model should be controlled within ±1g/L.

Optimal Shrinkage Rate of the Entire Mold Piece

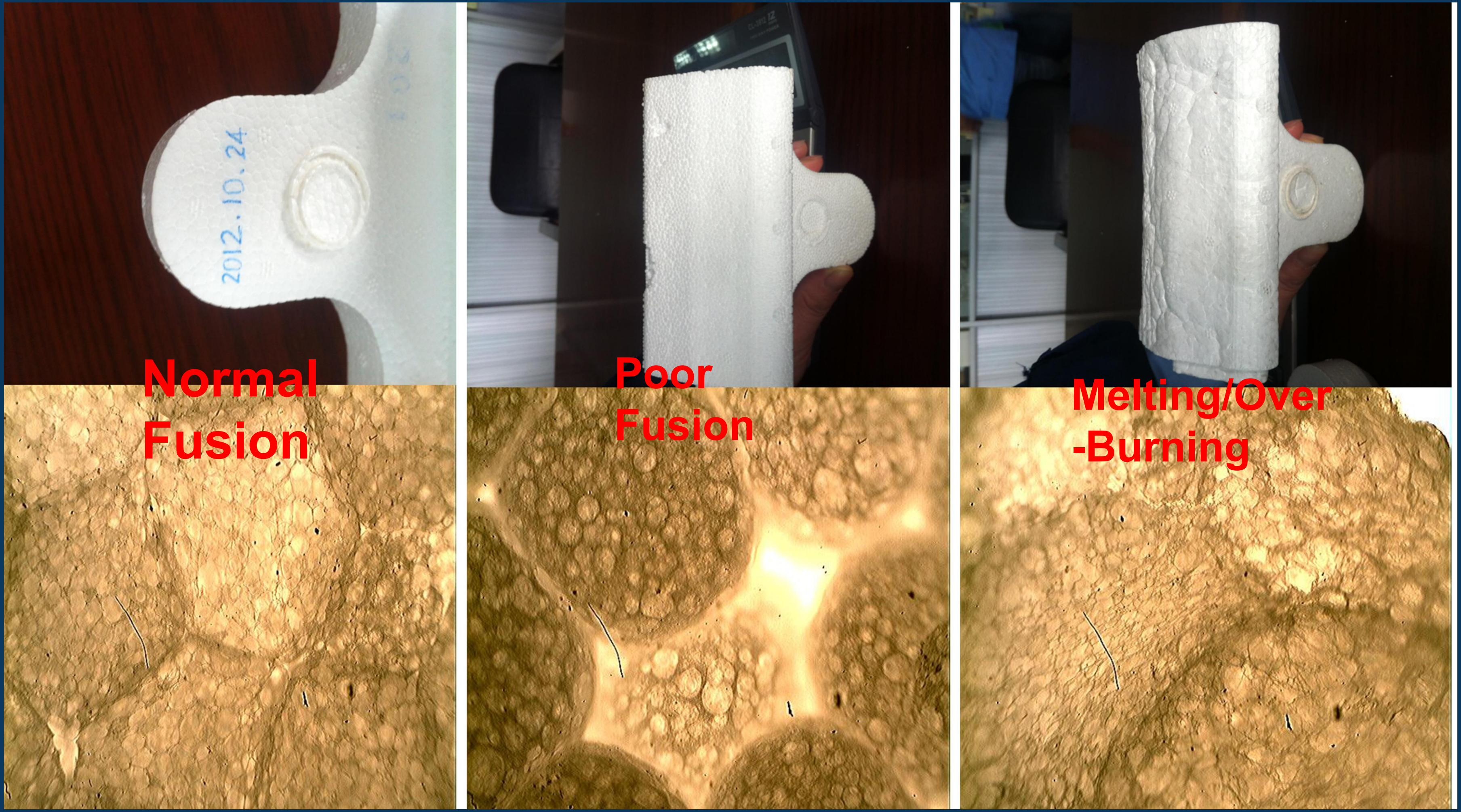
Copolymer models: Shrinkage should be <0.3%.

EPS models: Shrinkage should be between 0.3% and 0.8%.

Dense Surface
Ensure no gaps between the beads on the surface of the model (the gap between beads on the surface should be <0.3mm).

3.7 Process Control in Foam Molding

10. Three States of Model Formation



3.7 Process Control in Foam Molding

11. Curing Process of Foam Molds

I. Control of Volatile Content in Foam Molds:

Control of Volatile Content in Original Beads:
The control of volatile content should begin with the original beads (depending on the season and usage time).
The volatile content in STMMA copolymer beads is: 9.50%–10.00%;
In FD beads: 6.50%–7.50%.

Control of Volatile Content During Pre-Expansion:
During the pre-expansion of the beads, the volatile content is lost by 1–2%.

Control of Volatile Content During Bead Maturation:
The loss of volatile content during the maturation process is minimal (generally <1%). The main goal during maturation is to control the moisture content in the beads.

Control of Volatile Content During Molding:
During the molding process, the volatile content loss is between 1.5%–3%.

Control of Volatile Content During Drying of the Mold:
During the drying process of the foam mold, the volatile content loss is around 1%.

3.7 Process Control in Foam Molding

11. Curing Process of Foam Molds

II. Control of Moisture Content in Molds:

We require the residual moisture content in the mold before casting to be:

For gray cast iron and nodular cast iron: <1%

For cast steel: <0.5%

This requires us to quickly and thoroughly remove excess moisture from the molds after producing the white mold. Most lost foam companies immediately place the formed white molds into the drying room (drying for 2–5 days, depending on the situation). The method for checking if the drying process is complete is by weighing the mold on an electronic scale, measuring 3–4 times. When the weight changes little, it indicates that the mold is dry.

III. Moisture Loss Ratio:

We require that the moisture in the molded mold decreases by 60%–70% under natural conditions before entering the drying room for forced drying. In the drying room, the moisture content in the mold should be reduced by 20%–30%.

Once the foam mold is mostly dried, the temperature in the drying room causes the beads on the surface of the mold to slightly expand, which "locks" the surface of the mold to prevent reabsorption of moisture.