How to establish the process system systematically of low carbon steel lost foam casting

CASTCHEM INC. is a Sino-American joint venture. The company has strong technical force, has obtained 3 national invention patents, including"STMMA copolymer resin and preparation method" which filled the domestic blank. Castchem is the only one manufacturer of expandable copolymer resin in China, and it is also the draftsman of the mechanical industry standard "Lost Foam Casting white-side raw material, expandable copolymer resin (JB/T11846-2014)".

凯斯特
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系统建立

低碳钢消失模铸造的工艺体系

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FIRST

The "bottleneck" restricting the progress of low carbon steel lost foam casting process

In our country, the LFC process starts from gray cast iron. As the advantage of eliminating sand core, lost foam casting technology has made rapid progress in casing products with more complex shapes such as gearbox, engine cylinder block, flywheel housing and electric housing. In that case, its industrial scale has been formed in a relatively short period of time.

The promotion of nodular cast iron is slightly more difficult, and some

industries and clients even do not accept lost foam casting products for a long time. It was not until around 2010 that the production capacity was really formed.

The exploration of casting steel technology is almost synchronous with that of nodular cast iron, and has made some progress, once showing a strong development trend. However, the lost foam technology of cast steel has not risen to a higher level, and has not achieved the expected and ideal effect. It is not successful in general, especially for mild steel. The "bottleneck" of process progress is very clear:

1. White foam pattern decomposition brings a lot of carburization to the casting, and the defects distribution are uneven and unstable.

2. The internal and appearance defects formed by a large amount of carbon slag which seriously restrict the yield.

3, Sand hole, porosity defects are produced in large numbers. Compared with sodium silicate-bonded sand, precoated sand process, LFC defects are very obvious.

FIG. 1: Surface carbon defects caused by the burning of white pattern

FIG. 2: Internal carbon defect due to vanishing of white pattern

FIG.3: Sand hole, porosity defects occurring centrally

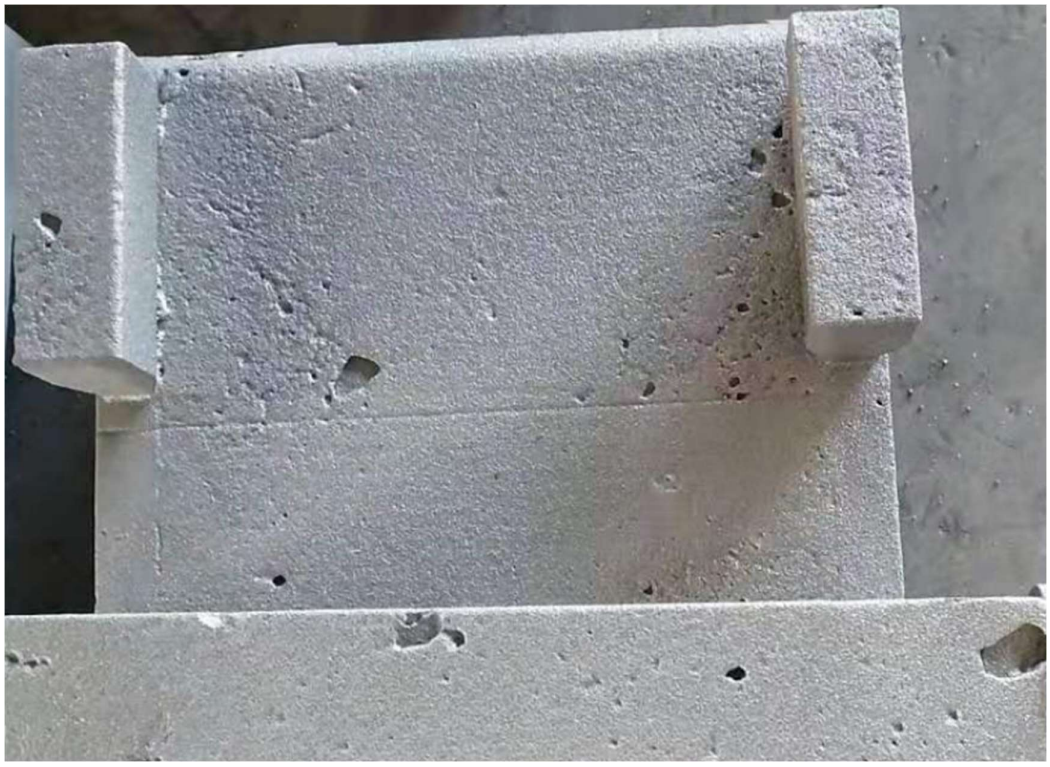


FIG 4: Carbon slag, sand hole, porosity defects are founded in large numbers at the same time.

Both the product quality and economic benefit is low, more and more people negate this process direction. Some foundries are overwhelmed and directly judge the failure of the project. Some of them, at a high cost, go to replicast. The replicast is that the white foam pattern is roasted before packing and burying into flasks. Most of the projects turn to the process of burning before pouring.

SECOND

The progressive significance of burning the pattern before pouring.

The tendency of carburization and carbon defects caused by the decomposition products of white pattern is really exist, and we must face the fact.

It only one right movement is to reduce the impact of white pattern decomposition products to a lower level by finding a rational technological process.

Burning before pouring is invited by this kind of philosophy . It seems to use a very simple and easy process, solved the problem in lost foam steel casting. And it had been really popular for a period of time.

Before pouring, the white pattern is burned cleanly, or most of it is burned, and the white pattern in the cavity is disappeared or reduced, which naturally produces the effect of reducing carbon and reducing carbon

defects.

Mass production practice has proved that the burning before pouring is indeed effective in improving and overcoming the problem of carburization, which has positive significance for the process of lost foam casting.

However, it also magnifies the adverse factors in other aspects:

1. Under vacuum pressure, the decomposition temperature of the flame formed in the cavity is low, which can only reach several hundred degrees Celsius. Under the condition of low temperature and oxygen-rich combustion, the gasification is poor, and the carbon residue will be too much.

The inner surface of the coating and the residual surface of the white pattern will form a continuous layer of carbon slag.

The main component of carbon slag is carbide, its decomposition temperature is much high. Even if the metal liquid above 1500℃,it still can not be fully decomposed. After pouring, it will inevitably produce a large number of carbon defects.

Complex structural castings, white patterns are more difficult to burn clean. The unburned white mold, because the surface is covered with a continuous layer of carbon slag, affects the full gasification and decomposition during the pouring process, and promotes the production of carbon slag in larger quantities.

FIG 5: The continuous carbon slag layer formed on the inner surface of the coating of the ERP white pattern after combustion

2. After burning the white pattern, a large amount of air enters the combustion channel, and the actual vacuum pressure in the sand flask is very low (generally reduced to about 0.02MP). The strength of the sand mold is seriously decreased, which is easy to lead to flask swelling and iron coated sand. And in the worst case, the flask collapse.

The metal liquid flowing through the places is easy to form sand flushing, a large amount of coating and sand is flushed into the cavity, forming sand holes defects.

FIG. 6: Flask collapse caused by burning before pouring

3. If burn before pouring, the mold is opened and filled under low vacuum pressure. A large amount of gas entering the cavity cannot be discharged fully in time, which is easy to be captured by the metal liquid flow and form pore defects, especially the residual places of white pattern.

FIG. 7: Pore defects occurred in the process of burning before pouring

THIRD

How to establish a systematic and balanced technology system?

Compared with other casting processes, lost foam casting is a more systematic process. It is necessary to give full play to its technological advantages, through reasonable and systematic process design, rigorous process control, the white pattern decomposition products "increase income and reduce expenditure", to achieve the ideal effect.

(Chapter ONE) Gas exhaust is the most important thing

1, Sand mold strength is obtained by vacuum pressure, vacuum pressure is achieved by gas exhaust. Only smooth exhaust can achieve sufficient vacuum pressure, so as to ensure enough sand mold strength, reduce the risk of collapsing flask, swelling, reduce and eliminate iron coated sand,

sand hole and other casting defects.

2. The burning of the white pattern produces a large amount of gas, which must be discharged instantly to effectively maintain the strength of all parts of the sand mold. Ensure smooth casting and filling process. And reduce the chance of metallic liquids capturing gases, thereby reducing and eliminating pore defects.

3. The free carbon produced by the decomposition of the white pattern can be partially absorbed by the coating through the exhaust process. The exhaust effect is good, the coating absorbs more carbon.

Exhaust is the technological advantage of LFC, and full exhaust is the core of LFC process system. The design and process control of casting process must be based on this. All the factors affecting the exhaust should be highly sensitive to give full play to its technological advantages and maximize the " increase income " to reduce the carburization.

The factors affecting the exhaust:

1, Sufficient exhaust power

1) Vacuum pump with enough power and negative pressure system.

Exhaust power and exhaust volume should be large rather than small.

In order to reduce power consumption, multiple units with small power can be connected in parallel, which can be opened and closed flexibly according to product characteristics and negative pressure.

If possible, variable frequency motor is used to automatically control the switch according to the negative pressure setting range.

If you have better conditions, to hold two sets of vacuum pressure system with automatic switching both in pouring and pressure keeping.

2) High enough and relatively stable pouring negative pressure value.

Combined with the design of the gating system and the gating speed, generally it prefers as higher as possible. Do not consider the wall effect too much.(If negative pressure is too large, it will collapse the flask or extract out the metal liquid).

Pouring negative pressure value must be stable in the range of process design, the range can not be set too large.

Frequency conversion control is better.

Specially-assigned controls at fixed values will be the best.

2, Smooth exhaust channel

1) Good design of the flask: the negative pressure pipeline distribution is uniform, should be close, should not be sparse, strengthen the bottom pumping. The total area of air holes should be large and not small, the bigger the better.

2) Check the flask regularly and maintain it in time to keep the ventilation rate good enough.

3) The cross-sectional area of the exhaust pipe, or the total cross-sectional area, make sure it is large enough and keep it unblock. Including the main

exhaust pipes, branch exhaust pipes, air valves built-in channel, rubber bellows, flask outlet channel, etc.

3. Good air permeability coating

1) The breathable properties of the coating must be good.(Internal cause and basis to achieve the permeability of the coating)

The air permeability of the coating shouldn't be reduced in order to increase the strength of coating. Choose a coating with good strength and air permeability both at room temperature and high temperature.

Self- formulated coating: choose a binder with good strength and breathable property. Under the premise of ensuring the effective content, the aggregate must be stable in particle size structure.

2) Uniform coating, and the thickness is controllable. Reasonable concentration can form good surface tension and improve the levelling property, so that to promote coating to be even.

Keep the concentration stable, examine it regularly and make timely adjustment.

Don't make it flow to the same direction.

3) Dry the coated pattern thoroughly.

Maintain a steady drying temperature, low enough relative humidity. Adequate drying time, especially for the last paint (more than 20 hours is recommended). The shorter the better for the time between the coated patterns leave the oven and pack into flask, this is to protect the coating

from cooling to room temperature and absorbing moisture.

4, keep molding sand fully dried and has good particle size structure.

Continuous production, maintain appropriate sand temperature between 30 ~ 50℃. Remove dust sufficiently.

(Chapter TWO)

Choose suitable polymeric beads for your casting.

1. The decomposition products of foam pattern are solid carbides, free carbon, carbon dioxide and water.

At high temperature, the carbon dioxide and water are in gas. As long as they can be discharged in time, they will not cause defects in the castings. Carbon dioxide discharges through the coating is the best and main way of carbon emission.

Free carbon is a very fine monomer, the coating layer can absorb a small part of it. Most of the free carbon are absorbed and carburized by liquid metal. The un-absorbed carbon will not form defects if it is dispersed on the surface of the casting. If concentrated, a macroscopic carbon defect is formed.

Solid carbides are large particulate matter that cannot be absorbed or expelled and it will exist as carbon defects.

In order to effectively reduce and eliminate carbon defects and reduce carburization, it is necessary to select the polymeric beads with good

decomposition and gasification, high carbon dioxide production and less solid residue to make the white foam pattern.

2. The difference between EPS and STMMA copolymer

1) EPS, combustible polystyrene, contains 92% carbon.

Each one ethylene molecule combines with a benzene molecule, that is a benzene ring, it forms a styrene molecule.

The benzene ring is very stable and resistant to react with additives, can not be oxidized and decomposed. EPS has a big quantity of benzene ring in proportion, its gasification is difficult and makes much solid residue, it will form a lot of carbon defects and a large amount of carburization (can be more than 0.2%).

If flame-retardant additives are added in the polymerization process during the EPS production, the gasification will be worse and produce more solid residues.

2) The STMMA is a copolymer of styrene and methyl methacrylate, containing 62% carbon.

Methyl methacrylate has no binding benzene ring and it is molecular chain structure which is easy to decompose. After the polymerization of styrene and methyl methacrylate, the proportion of benzene ring in the polymerized molecular chain decreases. Meanwhile, the decomposition of methyl methacrylate can catalyze the decomposition of benzene ring. Therefore, the copolymer decomposition is more sufficient, the

gasification will be much better and the solid residue will be less.

Copolymerization reaction is a complex chemical reaction process, styrene and methyl methacrylate according to the best proportion to participate in copolymerization. The carbon dioxide produced by bead decomposition can be close to or reach the peak, improve the carbon discharge in the form of gas. Free carbon and carbide residue can be reduced to a minimum level.

Therefore, the higher content of methyl methacrylate in the copolymer is not always the better. The excessive increase of methyl methacrylate can only increase the decomposition of gas volume. The lower the carbon content of copolymer, the large the gas production will be. But the CO2 outcome will be not the highest. Then, under the same process design, too much MMA in the copolymer will makes the carbon emission efficiency not to be the best.

The copolymer (STMMA) is a special beads for casting and does not add any flame retardant and stabilizer. According to the principle of chemical reaction, styrene and methyl methacrylate are in the best proportion to participate polymerization reaction. Its decomposition and gasification are sufficient, CO2 production closes to the peak so that it ensures a large amount of carbon discharge. It makes a less solid residue, so as to effectively reduce the carburization. Minimize carbon defects, maximum income of casting.

The copolymer (STMMA) covers more than 70% of the American market. Before it was popular in China, STMMA has been fully demonstrated and recognized in the field of lost foam casting in USA.

With rational casting process design, the carburization formed by STMMA can be controlled below 0.03%.

3, Make qualified white foam pattern

1) On the premise of strength enough foam pattern, reduce the pre-expansion density and weight of pattern as possible as you can.

2) Make sure the fusion is good both inside and outside of the pattern, and reduce water content in the foam.

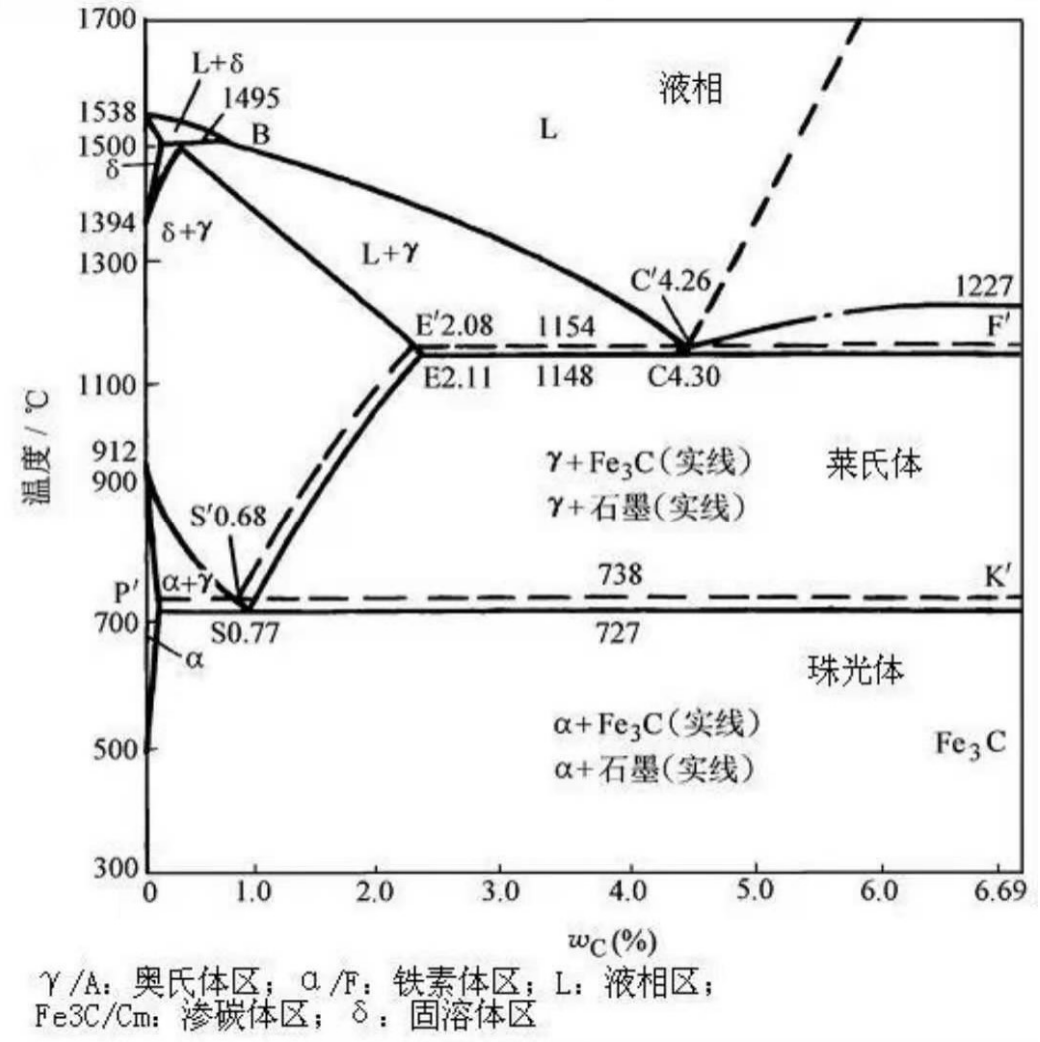
3) Pay attention to the ageing time of foam pattern.

(Chapter THREE) Make rational design of casting process according to casting properties and solidification characteristics

1. Phase transition characteristics

To study the casting properties and solidification rules of metals, we must have a certain depth of understanding of the phase transition process. Especially for carbon steel products, the cast state is rarely used.

FG. 8: FE-C (Fe_3C) alloy double phase diagram



ɤ/A= austenite region, ɑ/F= Ferrite region, L= liquid phase region, Fe3C/Cm= cementite region.

1) Ideal conditions:

In hypoeutectoid steel, before eutectoid transformation, the solution of C in austenite is always in an unsaturated state, so there will be no C (graphite) or Fe3C precipitation.

For eutectoid steel, when the eutectoid temperature is reduced, the solid

solubility of C in austenite can reach the saturated state, and there will be no C (graphite) or Fe3C precipitated before eutectoid transformation. Therefore, in theory, hypoeutectoid steel and eutectoid steel, before the eutectoid transformation is only the mutual transformation between the Fe is oforms, there is no difference between the stable system crystallization and the metastable system crystallization.

The effect of cooling rate on microstructure is only limited to grain size, that is, the faster the cooling rate, the finer the grain. And the slower the cooling rate, the larger the grain.

Ideally, hypoeutectoid and eutectoid steels change the cooling rate with little effect on hardness and machining properties. The microstructure can be refined by normalizing heat treatment.

However, with the increase of anti-graphitization element content and cooling rate, the eutectic point will shift to the left correspondingly. If the carbon value at the eutectic point is less than the actual carbon content, the Fe3C structure will be precipitated. With the increase of the difference between the carbon value at the eutectoid point and the actual carbon content, the time for Fe3C precipitation is prolonged and the amount of Fe3C precipitation increases correspondingly.

2) Before eutectoid transformation of hypereutectoid steel, according to the different carbon content, as the temperature decreases to the corresponding temperature below 1148℃, the carbon content exceeds the

saturated solid solubility in austenite, the suplaturated C will continue to precipitate in the form of C (graphite) or Fe3C until the eutectoid transformation.

According to the crystallization mode of the stable system, the fatigue strength and elongation of the matrix will be reduced when a certain amount of graphite is precipitated. A certain amount of Fe3C is precipitated according to the crystallization mode of the metastable system, which can improve the hardness and wear resistance of the matrix, but reduce the elongation and impact toughness, and increase the microstructure brittleness.

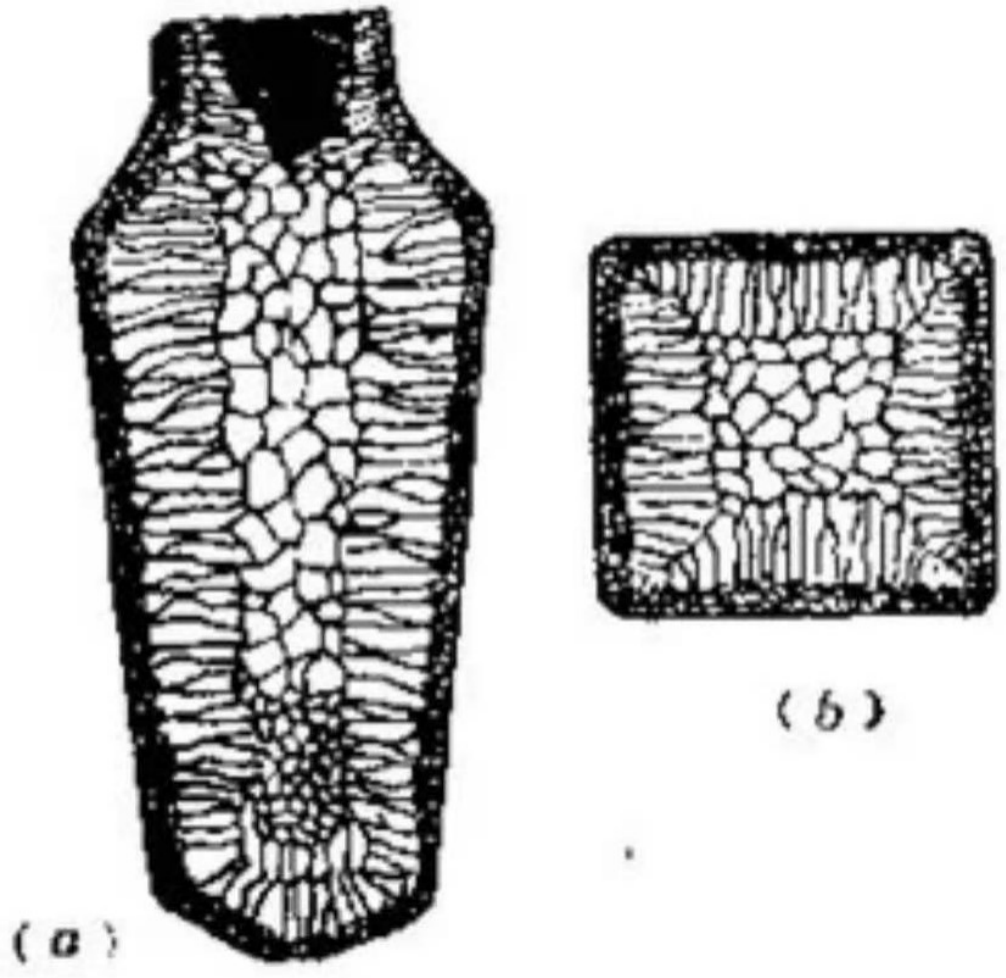
3) The carbon content exceeds 0.0218%, no matter eutectoid, hypoeutectoid and hypereutectoid steels, all of them will have eutectoid transformation process.

According to the stable system of crystallization, C tends to precipitate in the form of graphite, and the fatigue strength and impact toughness of the matrix are reduced. Therefore, the general carbon structural steel limits the content of silicon.

According to the mode of metastable crystallization, C tends to precipitate in the form of Fe3C, which promotes the formation of pearlite structure and improves the fatigue strength and impact toughness of the matrix. Therefore, the general carbon structural steel's manganese content is relatively high.

In general, inhibiting carbon graphitization is the basic need for carbon steel eutectoid transformation.

FG.9: Microstructure crystallization diagram of cast steel



2. Casting properties and solidification characteristics of low carbon steel:

1) The casting temperature is higher than 1600℃, which is conducive to the gasification and decomposition of the white foam pattern.

2) The temperature of the initial crystal is up to 1500℃, the lower the carbon content, the higher the temperature of the initial crystal.

3) With the decrease of carbon content, the end temperature of solidification increases and the solidification speed is accelerated.

4) The as-cast microstructure is coarse, and the grain is generally refined by normalizing treatment.

5) In order to reduce oxidation and shrinkage tendency, avoid excessive as-cast grain bulky, the solidification will be too quick and liquidity will be poor when pouring temperature between 100 ℃ and 150 ℃.

6) High temperature low carbon steel is easy to be oxidized, and the gas and non-metallic inclusions in liquid steel are difficult to float, which is easy to form internal defects.

7), Carbon steel's solidification shrinkage is large, generally more than 2.1%. Alloy steel can be more than 2.5%, easy to deformation and crack.

8). Under the condition of sequential solidification, it is difficult to self-repair the shrinkage. The size of the hot joint producing shrinkage porosity or shrinkage hole is smaller, it needs more sprues with large size.

3. The design of the gating system should be for the purpose of improve the formation of a positive solidification temperature.

It is conducive to maintain high temperature on the liquid surface, promote the formation of bottom-up sequential solidification, and maximize the top-down self-repair of shrinkages.

The high liquid level temperature is conducive to the full gasification and

decomposition of the white foam pattern.

The casting height and structure are combined to determine the gating system mode.

(Chapter FOUR).

Other factors that should be taken seriously

1, coating performance

Coating is a very important part of lost foam casting. Good air permeability, high enough heat resistance, high enough strength at room temperature and high temperature are the basic properties that must be possessed at the same time.

1) Coating's heat resistance mainly depends on the refractoriness of the aggregate.

Normal temperature strength and high temperature strength are mainly obtained by binder components.

The main component that affects the permeability is the permeability of the binder, and then the particle size structure of the aggregate.(There is not much space to improve air permeability through aggregate particle size structure)

2) The influence of the operation and control process.

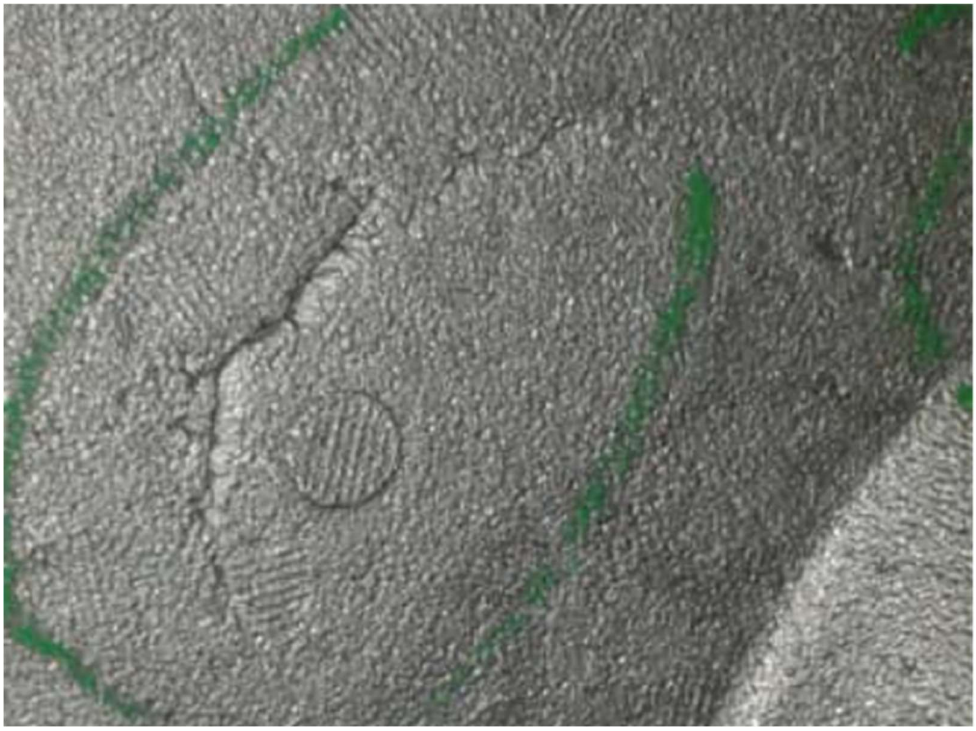
If the binder performance and aggregate particle size structure are excellent and reach suitable concentration, it can form good suspension and leveling so that to help to get uniform coating.
If the coating is not fully dried or moisture absorbing, its air permeability and strength at room and high temperature are badly declined.
The last layer of coatings must be fully dried. The shorter the exposure to room temperature before packing, the better.

3) The determination of coating thickness.
For the same performance coatings, the heat resistance,strength at room temperature and high temperature are improved in case of the coating thickens. However, the air permeability is decreased accordingly.
According to the refractoriness, breathable performance and strength index of the coating and aggregate, combined with the casting temperature and casting structure, the coating thickness should be thin rather than thick to achieve the best air permeability under the premise of meeting the strength requirement-especially the high temperature strength requirement, and ensuring the non-sticking sands.
Complex structure castings, in the excessive heated position of

the casting such as blind or semi-blind areas, holes or concave areas, its thick wall area can be precoated to thicken the coating. If the air permeability of the coating is insufficient, it will cause is unsmooth flowing of the melted metal and even form of regurgitation. This will increase the carburize or a large number of carbon defects

The lack of coating strength is easy to produce a large number of sand-hole defects. Under high temperature, it will be worse.

FG. 10: Surface wrinkles formed by insufficient high temperature strength of coating



2. The connection of flask packing and sprue.

1) For the semi-blind area structure that no-requires manual assistance sand feeding, it is recommended to do one-time sand compaction.

2) The connection between the pouring sprue and the straight runner should be based on the principle that there is no gap and the molding sand is far away from the liquid metal.

3) When packing, ensure that the coating on the patterns is fully dry. It is not recommended to assemble in the flask.

3, Deoxygenation

Because of the high melting and pouring temperature, the molten steel must absorb a lot of oxygen in the melting and pouring process.The carbon content is low, more O and Fe are combined, and the matrix structure is oxidized badly. If it is not sufficiently deoxidized, a large amount of oxidized slag will be produced.

FG. 11: Insufficient deoxygenation leads to severe oxidation of the tissues:

Al and O and N have strong affinity, and the smelting process of steel generally uses pure aluminum to deoxidize and fix nitrogen.

Effect of aluminum on microstructure and properties of carbon steel:

1) Aluminum can refine the austenite grain and increase the temperature of grain coarsening, so as to significantly improve the impact toughness and fatigue strength of the microstructure. The ductile to brittle transition temperature is reduced, and the low temperature toughness is improved. The aging tendency is reduced.

When the residual aluminum content exceeds a certain value, the

austenite grain growth and coarsening can be promoted. This value is different for different types of steel.The highest residual aluminum content of carbon steel refined grain is 0.05%.

2).Aluminum can strongly promote the graphitization, which only second to silicon. If it is excessively used aluminum in Ferritic steel and pearlitic steel, it will strongly promote the graphitization tendency of the tissue, reduce the casting strength and toughness under high temperature.

3) The austenite phase zone is strongly reduced by aluminum element.

4) Higher aluminum content can improve casting's corrosion resistance, oxidation resistance and wear resistance (used in combination with other elements).

5) Aluminum can affect the thermal working performance, welding performance and cutting performance of steel.

6) At high temperature, aluminum is easy to absorb hydrogen, and excessive use of deoxy aluminum(more than 0.06%) is easy to form a large number of pinholes.

Considering the influence of aluminum on the structure and performance, taking into account the cost, the amount of aluminum used for the main purpose of deoxygenation should be low rather than high on the premise of ensuring the

deoxygenation effect. Generally, 0.1 ~ 0.15% deoxy aluminum is enough.

4. Slags

Slagging is an important link in steelmaking.

At the same time, due to the high pouring temperature, the whole smelting process is accompanied by a large amount of oxidation and excessive corrosion of the furnace lining. And, a large amount of liquid slag is constantly produced in the molten steel.

Before tapping, the furnace must be fully slagging so that the floating slag particles can be solidified and well collected to separate with liquid metal.

In the pouring process, the high temperature liquid steel continues to corrode the linings. Until the end of pouring, part of molten slag kept floating up.

Lost foam casting is difficult to achieve a closed mode gating process, and more difficult to avoid slag through a closed gating system. Therefore, it has to block the slags into the casting process, which we usually use a filter like a "teapot bag".

High temperature tapping and low temperature pouring, It is to allow sufficient time for the slag to rise to the liquid level through the standing process. However, in order to save power

consumption and improve efficiency, it is difficult to achieve it for most of the foundries. (For high-end products, the standing process is necessary).

5, Roast package

Low carbon steel initial crystal temperature is high, pouring overheating temperature is generally low. With poor fluidity, its solidification is fast. If the liner temperature is low, the liquid steel near of it is easy to quickly drop the temperature close to the primary crystal. And the liquid level drops, it forms hanging slags on the liner surface.

Increasing the heating temperature can promote the furnace liner to absorb more heat, and increase the surface temperature of the liner accordingly. However, the unidirectional increase beyond the pouring temperature easily leads to other problems. And,it is difficult to increase the liner temperature evenly in a short period of time.

After the ladling of the molten steel, the cold ladling will make the temperature of the molten steel to be more uneven. And the temperature difference between the initial pouring temperature and the final pouring temperature will become big too, which will increase the instability of the pouring temperature and reduce the

casting quality.

A new repaired furnace liner or a liner at room temperature, it contains more moisture. And the moisture will be partially absorbed by the molten steel, which will aggravate the oxygenation of the liquid steel and increase porosity defects.

(Chapter Five).

The right technical craft idea is very important

The ability to establish a systematic and balanced process system depends on having the right process concept, which is very important.

Only with the right idea, we will determine the right craft. Under the premise of the correct process craft, in order to fully combine the site resources, comprehensive development and implementation of effective process measures, we will be able to obtain a suitable process system for the foundry.

Blindly learning from others' experience and limiting our thinking to the space of imitating more methods will make it difficult to systematically form our own core technology or have continuous improvement of product quality.

(Chapter Six).

Successful cases

(I) Shandong Penglai Wanshou Machinery Co., LTD., who produce heavy truck axles and parts.

In the second half of 2019, they started casting steel project.

Heavy truck axle, connecting plates, security products.

No.25 steel, need to be welded on the stamping axle housing, carbon content control must be very strict.

Spectral analysis, 2mm casting surface carburization is less than 0.03%,and no carburization below 2mm surface.

Annual output reached 700 ~ 800 tons in 2020. In 2021, the monthly output was more than 1,000 tons.

STMMA 2#, 3# specifications, the monthly consumption is about 4 tons.

Casting quality is always stable.

FG.12: White foam and coated patterns for low carbon steel castings of heavy truck axle





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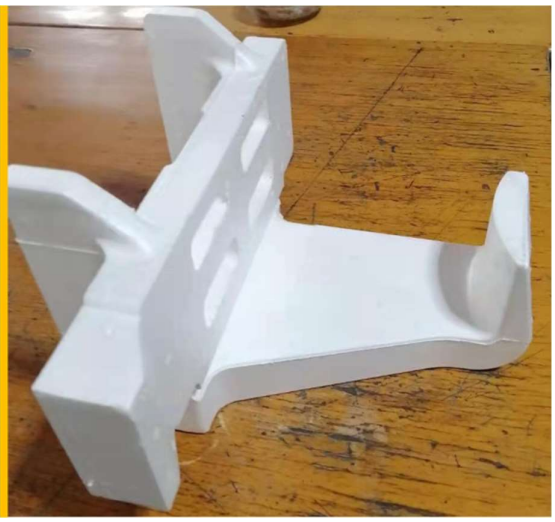


FG.13: Welding parts of low carbon steel heavy truck axle

Why they are successful?

1, The process philosophy is clear

In 2010, the philosophy of special beads for LF casting was proposed. All nodular cast iron and gray cast iron products were produced by copolymers. The comprehensive product rate of gray cast iron is more than 98.5%, and the comprehensive product rate of nodular cast iron is more than 97%.And, it has achieved quite ideal economic benefits. According to the casting characteristics of carbon steel, on the basis of the original process system, the specific process measures are formulated and implemented systematically, and the batch production can be formed in only two months by direct pouring.

2. Strictly control the casting process.

3. Highlight the role of key staff and strictly examine the implementation of stipulated process, castings output and yield shall be attached to employee's income.

Casting rate without welding repair is up to 99%, it is unbelievable but the data is from the foundry's management system.

(2) Guizhou Kali Fu 'an Hongda Precision Casting Co., LTD., cast steel products involve heavy trucks, railway locomotives, military, intelligent equipment and other fields.

They use copolymer STMMA and burn the foam pattern before pouring, there were a large number of carbon slag, sand hole defects, poor casting surface and internal casting defects. The casting quality rate is very poor. After 6 years investment, the yield rate has been very low.

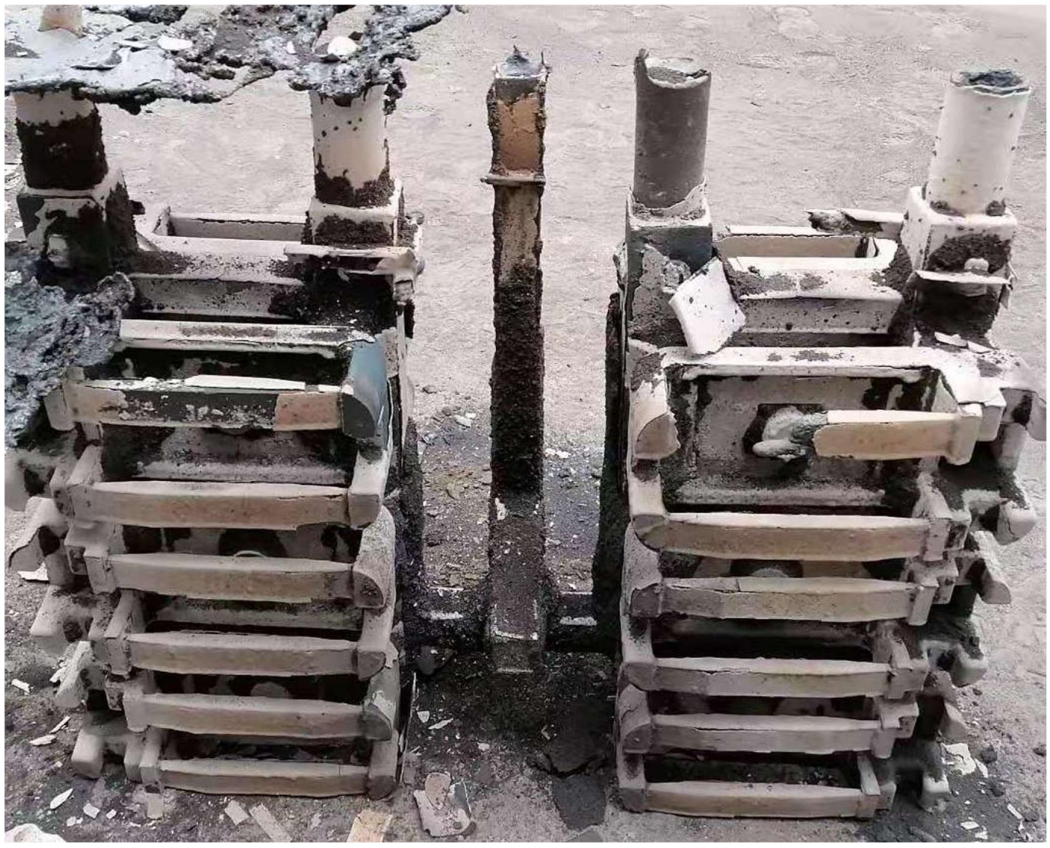
FIG. 14: white pattern cluster of burning before pouring process

Attached Figure 15: Firing before pouring process

FG. 15: Burn pattern before pouring

FG. 16: Burn pattern before pouring(cluster)

FG. 17: Burn pattern before pouring(casting result)



FG 18: Surface carbon defect by burning before pouring process.

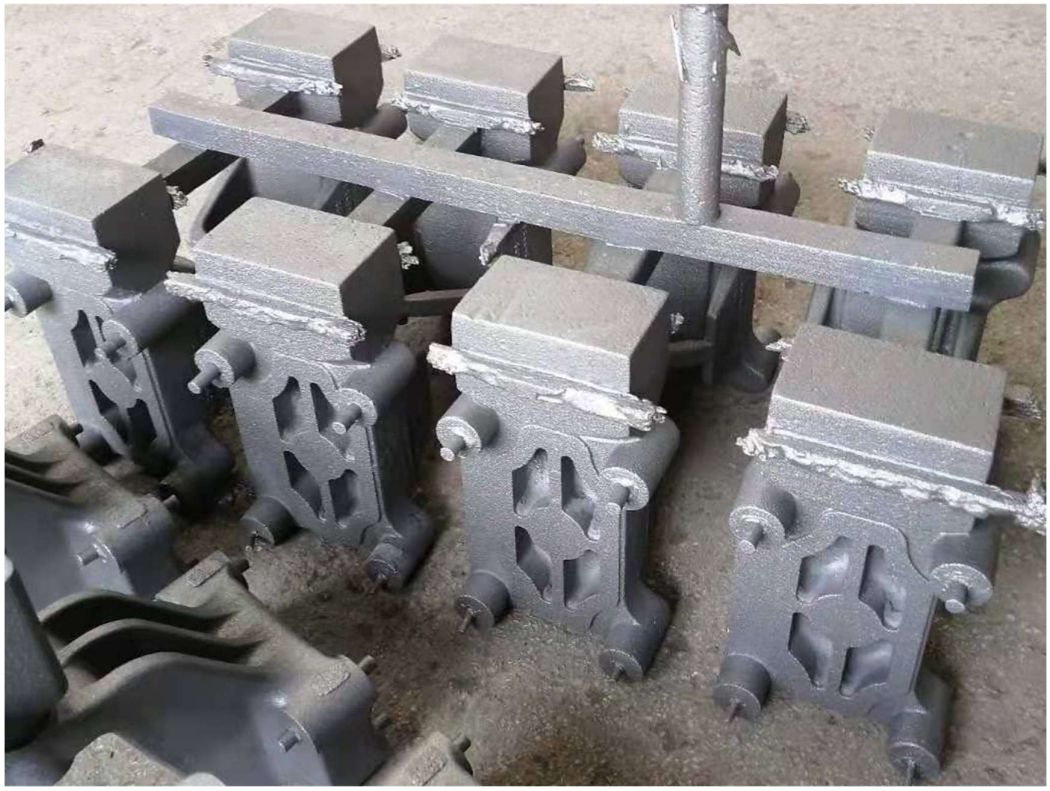
FG 19: Made by EPS foam blocks, a lot of fold defects on surface.

FG 20: The below defects are caused by insufficient gas exhausting during pouring process:

After May 2021, they are assisted by Castchem INC and changed the process to direct pouring:

Attached Picture 21: Heavy truck auto parts steel 35 (direct pouring):

Attached Picture 22: heavy truck auto parts steel 45 (direct pouring):



Attached Picture 23: railway locomotive parts B grade steel, carbon content is equivalent to steel 15 (direct pouring):

Attached Picture 24: railway locomotive parts grade B steel, carbon content is equivalent to steel 15:

Attached Picture 25: low alloy steel track plate, carbon content is equivalent to steel 35:

Attached Picture 26: Assembling of alloy steel track plate

It took 4 months to revolutionize the original process system and realize the comprehensive transformation from burn-pouring process to direct pouring.

No additional investment was made in the process of technological transformation.

Saved the cost of burning patterns, and the production rate of process is increased by more than 10%.

The quality of products has undergone qualitative changes:

The surface carbon defects rarely appear, surface quality deeply improved.

Few carbon defects were found in the machining process.

There is no internal carburization, and the machining surface has no color difference.

Surface carburization is less than 0.03%, and it is even difficult to be detected.

The comprehensive yield is more than 95%.

FG 27: Surface of large castings (Grade B steel)

CASTCHEM began planning and promoting steel lost foam casting technology since year 2020. By providing customers with more comprehensive technical services both in white side and black side, to promote the use of STMMA copolymer in the field of casting steel. Then, promote the direct pouring technology of steel casting for lost foam.