



University of Wales Trinity Saint David
School of Engineering

Title of the Coursework : Two possible material manufacturing processes
for company to replace sand casting

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Abstract

A company whose products are bushes and sleeves is adopting sand casting and secondary machining process at present. In order to gain higher surface quality of products and less waste and costs, a better manufacturing process is indispensable for them. Through the analysis of the task requirements, several alternative processes that meet the requirements are initially selected from the casting methods, including low-pressure casting, centrifugal casting, continuous casting and lost foam casting, and their analysis and comparison are carried out. Combined with all the information, low pressure casting and lost foam casting are determined to be the replacement processes that best meet the task requirements.

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1 Introduction

Material molding methods are essential factors in material processing and are also problems of great concern to manufacturers. The technology of material processing refers to the ability to obtain specific and beneficial shapes according to the properties of materials in a specific environment.

Material molding methods can be divided into: cast molding, plastic molding, powder metallurgy, metal injection molding, welding, 3D printing and so on (Ahmed N. Oumer, 2013). Cast molding is widely used in the processing of metal composite materials due to its high adaptability, wide source of materials and low equipment investment. Since the factory has adopted sand casting in the early stage, two other possible cast molding options can be explored to solve the current problems.

After searching the relevant research and using basic CES operations, the article mainly compared and analyzed the application scope, advantages and limitations of various cast molding processes. Combined with the task background, it finally selected the two most suitable casting processes to replace the sand casting to satisfy the task needs.

2 Technology analysis

2.1 Casting process overview

The broad definition of casting molding is to pour a specific composite metal into a mold and make it conform to the predetermined size, shape and performance of the casting process through cooling and solidification and secondary processing. Generally, it can be divided into the following categories: sand casting, continuous casting, low-pressure casting, centrifugal casting, metal mold casting, vacuum casting, lost foam casting and investment film casting (Xiaoming, 2017). According to the task background and requirements, CES was first used for initial casting process selection. Then some advanced techniques have been taken into consideration. Finally the processes to be analyzed are as follows: low-pressure casting, centrifugal casting, continuous casting and lost foam casting.

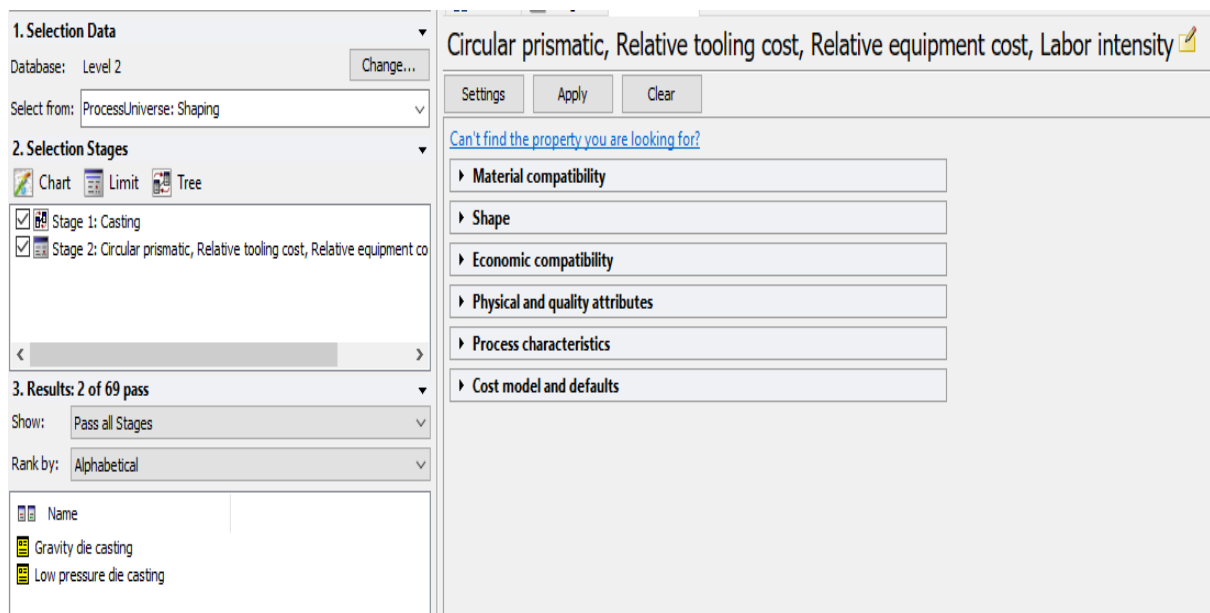


Figure 1 two possible options of casting

2.2 Sand casting

Sand casting refers to the casting method of producing castings in sand mold. Steel, iron and most nonferrous alloy castings can be obtained by sand casting.

The basic process of traditional sand casting process has the following steps: sand preparation, molding, core making, molding, pouring and shakeout, polishing processing, inspection and so forth. The molding of the sand is the core of the entire production, and it's usually necessary to determine the

process and equipment of the molding department by analyzing the characteristics of the casting produced (Dalquist S, 2004).

Sand casting is often used to produce automobile engine cylinder block, cylinder head, crankshaft.

2.3 Low-pressure casting

Low pressure casting is a casting method in which liquid alloy is pressed from bottom to top into the mold cavity under the action of pressure and solidifies under the action of pressure to obtain the casting. The specific principle is as follows: the sealed crucible is filled with dry compressed air or inert gas, and the metal liquid is filled with 60 ~150kPa from bottom to top through the sprue by means of the pressure acting on the metal liquid surface (baidubaike, 2017). When the casting is completely solidified, the gas pressure on the liquid surface is relieved, and the unsolidified metal liquid in the riser and runner flows into the crucible by its own weight, then the casting mold is opened and the casting is taken out.

The low-pressure casting process is as follows:①metal smelting and preparation of molds or castings.② preparation before pouring: including crucible sealing (assembly of sealing cover), slag scraping in lifting pipe, liquid level measurement, sealing test, mold matching, fastening mold or casting mold and so forth.③ pouring: including rising liquid, filling mold, pressurization, solidification, pressure relief and cooling and so on.④demoulding: including loose demoulding and casting removal (Ghomashchi, 2000).

The main production of low pressure casting is traditional products , like cylinder head, wheel hub, cylinder frame.

2.4 Centrifugal casting

Centrifugal casting is a casting method that generates centrifugal force using a rotating mold, fills the injected metal to the entire mold and mold it through solidification.

The process of centrifugal casting is simple and easy to operate. The first step is to prepare the liquid metal, then start the casting mold to rotate to generate centrifugal force, then pour the metal into the

casting mold, and use centrifugal force to fill the metal into the whole casting mold, and finally make it solidify (Zelei Z, 2010).

Centrifugal casting is widely used in the production of tube castings, such as iron pipe, copper pipe, but also used in the production of wheel castings, such as pump wheel.

2.5 Continuous casting

A special container named crystallizer can be cast from the rear end by solidifying the raw material poured from the front end and then discharged from the rear end so that castings of any length can be obtained, which is continuous casting.

The process of continuous casting is mainly completed in the mold, in which the bottom of the mold needs to be detachable flexibly, which is called dummy ingot. When the liquid metal is poured into the mold and reaches a certain height, the dummy ingot will be removed to make the casting continuously discharged from the lower end of the mold (Hasse Fredriksson, 2012).

Continuous casting can be used to pour steel, iron, copper alloy, aluminum alloy, magnesium alloy and other long castings, such as ingot, pipe and so on.

2.6 Lost foam casting

It is a new casting method in which the required casting shape is bonded by easily gasified materials such as paraffin wax or foam to form a model cluster, and then refractory materials are coated on the outer surface of the model cluster and dried, and then the negative pressure gasification model is used to pour metal, which will fill the whole model cluster and form a casting after solidification (Charles E. Bates, 2010).

The technological processes are as follows: Foam pattern→clustering→coating→drying→compaction→casting→completed casting

Lost foam casting is a relatively advanced technology, which is most suitable for the production of

precision and complex casting structure. What is more, there is no limit on the type of alloy and production batch.

3 Discussion

Through the introduction of the five processes mentioned above that may meet the manufacturer's needs, each process has benefits and disadvantages. The following will compare and analyze them to obtain the most two suitable processes.

3.1 Advantages

Sand casting: 1.The Sand has good heat resistance and wide application 2.Soil texture is soft and it has high flexibility which is useful to make complex shape casting 3.Sandy soil rich in resources, low cost, and can improve the economic benefit of the manufacturers 4. The cycle of making mold is short, the process steps are simple and easy to operate.

Low pressure casting: 1. According to its principle, the pressure and speed during casting are controllable, so it is suitable for various casting types (such as metal type, sand type and so on), casting molds of multiple shapes and sizes 2.The use of low pressure to fill the metal upwards from the bottom is more stable and the products qualification rate is high. What is more, it saves the gate and riser system, reducing production costs and improving recovery 3.The equipment is simple and easy to achieve mechanization and automation 4. The surface of the casting is smooth and the mechanical properties are good (baiduwenku, 2018).

Centrifugal casting: 1. Use the effect of centrifugal force to facilitate the production of casing and pipe castings. 2. The maximum filling degree of the mold can be achieved and the pass rate of the mold can be improved. 3. The casting has good mechanical properties. 4. The casting system and riser system are not adopted to improve the production rate and reduce the metal usage.

Continuous casting: 1. It has no gate and riser system, which can save metal and raise recovery rate 2. The principle is simple, the operation process is simple, the labor intensity is reduced, and the production efficiency is improved. 3. The casting has good mechanical properties. It can be rapidly cooled in the crystallizer and the continuous casting process can make the whole casting evenly distributed and improve the quality of the casting.

Lost foam casting: 1. The mold can be composed of the random adhesion of wax and foam, the design is flexible, the degree of freedom is high 2 .The cast metal is filled to the whole model by the negative pressure, the casting accuracy is high and no sand core, the processing time is reduced. 3 The model is gasified and no environmental pollution, reaching clean production4 .The investment and production cost of the cleaner production is reduced, and the application is extensive (Tianya Community, 2015).

3.2 Limitations

Sand casting: 1.Due to the raw material is sand casting, stiffness is small, so the dimension of casting is accurate. 2. Since the original mold is destroyed every time it is poured, it is necessary to reshape the mold during the new casting, which reduces the gradual production efficiency. 3. Castings are also prone to problems such as sand washing, sand inclusion, and porosity.

Low pressure casting: Long casting cycle and poor productivity 2. The number and location of gates are limited, which limits the products. 3. Extra attention should be paid to the management and control of temperature, pressure and other parameters (Personal library, 2018).

Centrifugal casting: 1. There are certain limitations on the production of shaped castings. 2. The surface of the inner hole of the casting is rough, the quality is poor, and the margin is large. 3. Sometimes the specific gravity of the casting will be affected by the centrifugal action. 4. It is not suitable for alloys with small or large density segregation, such as lead, aluminum, magnesium and so on.

Continuous casting: Only long castings with the same cross-sectional shape can be produced.

Lost foam casting: 1. Since this process principle involves the need to vaporize the foam model, when a large casting is produced, there may be a problem of foam residue, which may hinder the production process (Chen, 2018).

4 Conclusion

Based on the above evaluation of these methods, the following comparison table can be obtained:

	Sand casting	Low pressure casting	Centrifugal casting	Continuous casting	Lost foam casting
Quality of products	The rigidity of the casting mold is low, so the dimensional accuracy of the casting is poor and the product quality is not high.	Easy to cast perfect casting, less internal defects, smooth surface.	The inner free surface of the casting is rough, the size error is large and the quality is poor.	The casting is crystallized under pressure, with compact structure, clear profile, smooth surface and high mechanical properties	No sand core, and the casting has high precision.
Production efficiency	Each mold needs to be remade, greatly reducing the production efficiency.	The casting cycle is longer and the production efficiency is reduced.	The production efficiency is general.	The principle is simple, the operation is convenient, the labor intensity is low, and the production efficiency is high.	There is no sand core in casting process, greatly reducing processing time, and improving production efficiency.

Environment implication	Dust and harmful gas emissions mainly exist in core molding, casting, pouring, unpacking, shot blasting and casting welding	Low pressure casting is adopted with little environmental impact.	Little environment al impact.	The pouring process is Continuous and has no gas emissions, less environmental impact.	During the pouring process, the model is almost completely gasified to achieve clean production and no pollution.
Waste recovery rate	The problem of sand washing and sand inclusion is easy to occur in castings, which reduces the utilization rate of sand and gravel.	It has no gate and riser system, which can save metal and raise recovery rate	It has no gate and riser system, which can save metal and raise recovery rate	It has no gate and riser system, which can save metal and raise recovery rate	As a result of model gasification, the amount of waste produced in the production process is greatly reduced, and the recovery rate of waste is indirectly increased.

Investment and operating costs	Sand is cheap and easy to get, reducing the cost of raw materials; The production process is simple and the equipment cost is saved.	The higher the factory production, the higher the economic benefit is. So When the production quantity is large, the producer gains the benefit greatly, and it saves the cost indirectly	The Casting shape and metal materials are required, so the costs of investment and operation are high.	It has simple procedures, high production efficiency, and the cost of investment and operation is low.	The cost of investment and operation is low and the economic benefit is high.
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In conclusion, according to the task requirements and the above comparison, two processes are selected, one is low-pressure casting, one is lost foam casting, the former is more traditional, the latter is more advanced. Both processes have low cost and good surface quality which satisfy the needs of company.

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