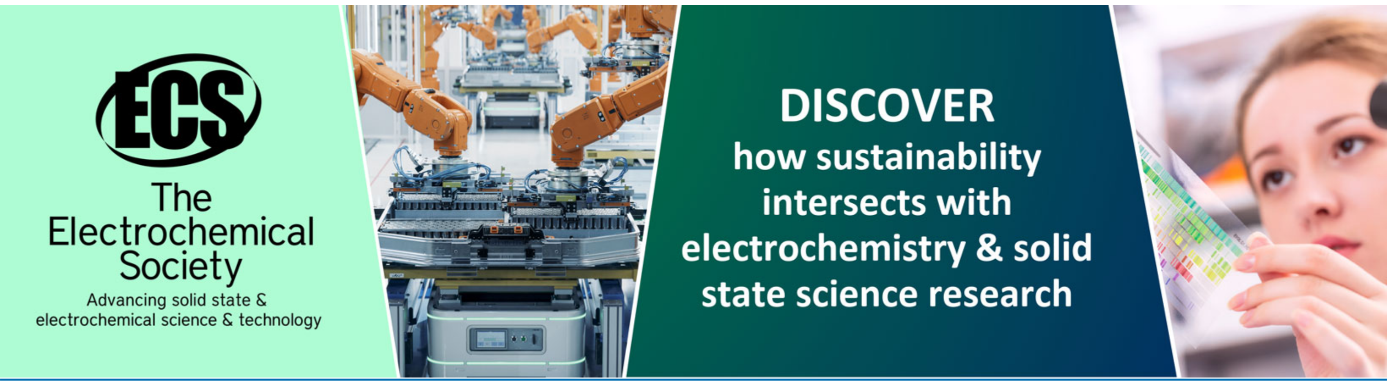
Application of Non-mold Casting Technology in the Tractor Diesel Engine Cylinder Block



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Application of Non-mold Casting Technology in the Tractor Diesel Engine Cylinder Block

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Abstract. This paper researched the application of non-mold casting technology for reducing the development cycle and cost of tractor diesel engine cylinder body. The detail of the each process method has explained which based on the non-mold casting process of a diesel engine cylinder block. The results showed that rapid casting of diesel engine cylinder block can be realized by the non-mold casting composite forming technology, combined with CAD/CAE technology and virtual reality technology. The advantages of this method have fast speed, low cost, green, and lightweight, that is to say, piece manufacturing cycle was shortened by more than 50%, single piece manufacturing cost was reduced by more than 81%, and 8-9 molds were saved.

1. Introduction

With the development of machinery manufacturing, the speed of product development competition has become the focus of the market. In this case, the ability of autonomous rapid product development has become the strength foundation of the competition in the mechanical manufacturing industry [1]-[2]. Non-mold casting technology is a method to obtain castings by using the manufacturing technology of adding materials or reducing materials with the help of data model without direct molding of molds [3][4][5]. Because this technology directly eliminates the development and manufacturing process of the mold, the manufacturing cycle and manufacturing cost are greatly reduced, providing strong technical support for the rapid development and manufacturing of new products.

At present, in the trial production of new products of tractor diesel engine cylinder block, the traditional molded casting method is still adopted for the manufacture of blank parts, that is, the design and manufacture of molds first, and then the sand core is manufactured, and the blank parts are obtained after the core forming. In this traditional method, the development and manufacture of moulds take up most of the time of the whole production process. The application of non-mold casting technology to the trial production of new products of tractor diesel engine cylinder block can effectively solve the above problems.

2. Non-mold casting process for diesel engine cylinder blocks

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This paper expounds the features of complex structure and low yield of diesel engine cylinder block and in combination with the application of non-mold casting technology at home and abroad, and design the process flow of non-mold casting to blank parts, as shown in figure 1. In the process, the main processes are: ①use UG and other software to build 3d models of products. ② use CAE simulation software and virtual reality technology to design and optimize the casting process of complex cylinder parts. ③After the reverse calculation and design the casting mold. ④The mold forming of the cylinder body sand core is carried out, and to be assembled . ⑤The blank is formed by casting.

In the process of non - mold forming of sand core of cylinder body, Use the CAMTC series triaxial and five-axis forming equipment independently developed by the China Academy of Machinery Science and Technology. The forming process of furan self - hard resin sand core is completed by casting technology.

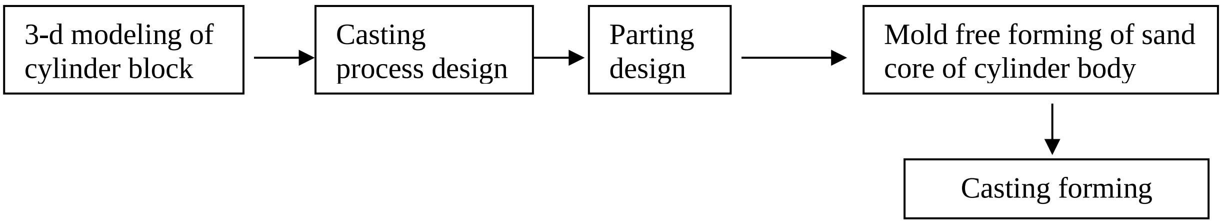


Figure 1. Flow chart of casting process for a diesel engine cylinder block.

3. Non - mold casting of diesel engine cylinder block

3.1. 3-d modeling of cylinder block

UG software is used to model a diesel engine cylinder parts and analyzed its structure characteristics. 3d model of cylinder parts and structural features of parts: The product is a four cylinder diesel engine cylinder block that is beyond to the engine part, the dimensions is 600mm*500mm*450mm, material: HT250, the total casting weight is 173kg.Inner structure of the casting is complex and thin, the thinnest wall thickness is only 5mm,expecially the water sleeve core of the cylinder body, which is extremely thin here and is prone to defects such as partial core and broken core, resulting in extremely high reject rate of the products.

After establish the 3-dmodeling of cylinder block, fill the hole structure that needs to be processed in the later stage, offset the machining surface on the processing surface to retain the machining allowance of 4-6mm, and scale it by 1% scale according to the grey iron material, so as to obtain the 3d model of the casting of the cylinder block.

Based on the 3-d modeling, use the CAD technology, CAE casting simulation system and virtual reality technology were used to design and optimize the casting process of the cylinder block.

3.2. Optimization of cylinder block casting process design

According to the analysis of the structural features of the cylinder block, two casting techniques of side lateral pouring and bottom vertically pouring were determined: side lateral pouring design and two exhaust risers were designed, with dimensions of 45 x 10mm; The bottom vertically pouring vertical casting design has multiple air holes. Two technological design schemes of cylinder block are designed using UG software on the casting 3d model.

The feasibility of the above two technological schemes was verified by CAE casting simulation system. Through the simulation of casting stress, filling and solidification, the possible deformation, porosity and shrinkage cavity and other defects of the metal liquid during filling and solidification in the resin sand mold are predicted. The simulation results of cylinder block should be analyzed on the flow field of metal liquid at the core of the lateral pouring process. Figure 2 shows the defects result of the partial solidification and shrinkage porosity. A dynamic virtual reality visual simulation model is rendered according to the simulation data of cylinder casting to reproduce the filling and solidification process of liquid metal. The virtual reality visualization model is displayed in the virtual reality lab in 3D visualization, and the process review and optimization is conducted by technicians such as casting process, smelting and modeling, as shown in figure 3. The above methods can perform more accurate process virtualization verification. The results of CAE simulation and process review showed that both of the two processes of the cylinder block could guarantee the steady filling of the metal liquid, and the shrinkage porosity and shrinkage hole defect in the body met the casting quality requirements. The simulation results showed that the process was qualified. The following two casting techniques are designed for rapid casting of cylinder block blank.

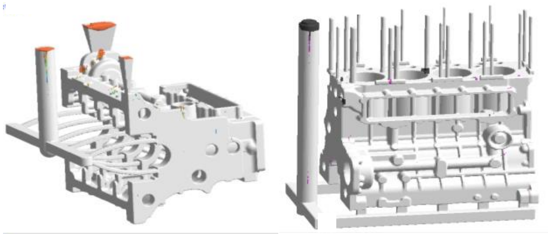


Figure 2. Simulation results of solidification of process cylinder head

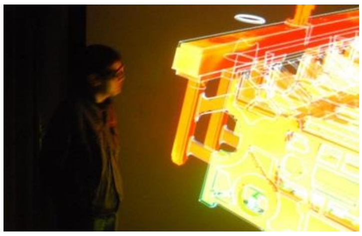
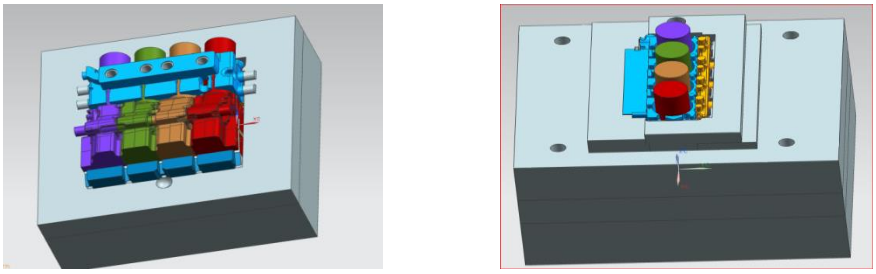


Figure 3. 3d visualization of simulation results of cylinder casting in a simulated real environment

3.3. Mold parting design and virtual assembly technology

After determining the two casting processes of the cylinder block, the appropriate amount of sand is selected. By using UG software, combining the existing processing equipment and features of five axes and triaxial, the fractal design is carried out on the basis of the original three-dimensional model. The classification scheme is shown in figure. 4. According to the plan, the cylinder shape core is mainly divided into water jacket core, four cylinder cylinders and multiple external dies.



a) side lateral pouring b) bottom vertically pouring

Figure 4. Casting mold design scheme of cylinder block

In the virtual assembly environment of UG, or through the human-computer interaction and virtual scene technology of the virtual reality system, the virtual assembly and visualization of the partial parts of the cylinder body shape are realized. Figure 5 is the virtual assembly verification between the cylinder body shape cores in the virtual reality environment. Through verification, all the designed fractal schemes can realize assembly, in which the assembly of side injection leveling scheme should first assemble the four cylinder barrel cores and the water jacket cores before the overall lower core. 4 cylinders should be numbered to prevent confusion.

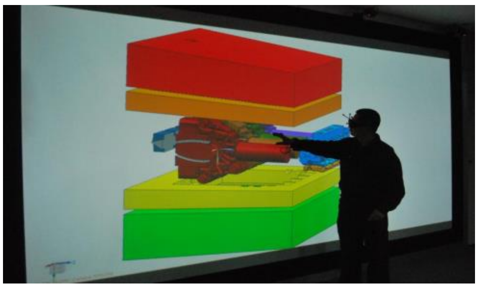


Figure 5 Virtual assembly process of the cylinder body core in virtual reality environment

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3.4. Non-mold casting

Triaxial and five - axis equipment is used to fabricate cylinder sand core. According to the structural characteristics of the sand core of the cylinder body, the water sleeve core and cylinder barrel core are processed by five-axis linkage method, while the other three shafts are processed on one or both sides.

3.4.1 Design of machining tool path. On the basis of the fractal design scheme, the process USES UG software to design the blank and machining tool path respectively on the water jacket core, cylinder barrel core and external mould parts. The processing method is to choose the Cavity to be machined, and the processing order is generally M16 Cavity-Milling→M8 Rest-Milling→B6 Zlevel-Profile, Less use of external mold for bevel and curved surfaceM16 Cavity-Milling→M8 Rest-Milling or M16 Cavity-Milling, The processing mode can be completed. After the design of machining tool path for each part is completed, it is processed into PTP file respectively, and the corresponding naming is conducted, which is imported into the secretnon-mold molding machine. Figure 6 shows the design of machining cutter for part of the cylinder block.

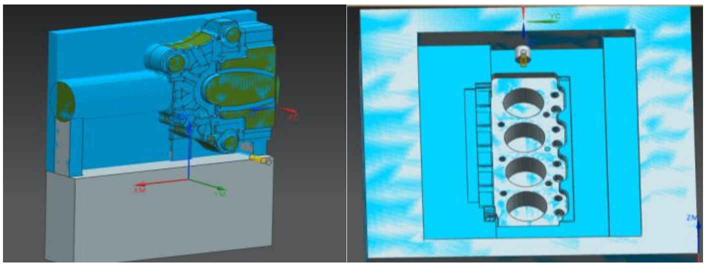

Figure 6 Part of the cylinder shape core processing design

3.4.2 Manufacturing of sand billets. The size of different sand cores of the cylinder body varies greatly, so it is necessary to make multiple sand billets. The sand cores of the cylinder body adopt furan self-hardening resin sand. In order to improve the production efficiency, the manufacture of sand billet adopts the method of artificial manufacturing sand billet: the sand is mixed through the sand mixing machine, the simple sand mould is made by using wood or aluminum alloy plate, and the sand lump is made by manual filling, tamping and scraping, and then the mold is unformed after hardening.

3.4.3Non-mold digitizing. After making the sand billet, the magnetic block is clamped and fixed on four sides in the digitalnon-mold precision forming machine for triaxial machining or five-axis machining. The process USES compressed air to blow out the sand. Figure 7 shows the five-axis machining process of the cylinder.

Figure 7 Five-axis machining of cylinder body cylinder core

3.4.4 Repair and size detection. After the core processing is completed, repair and size detection is carried out. The modification is mainly to remove the base and connection structure of the five-axis processing of sand core, such as water jacket and cylinder core. Some of the rectangular structures will not be able to process also need to use tools to make the processed rounded corners into right angles by hand. The precision of the processed sand core is tested on the three-coordinate measuring instrument. The accuracy of the sand core prepared by the above method is about 0.3mm.

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3.5. Assemble and casting forming

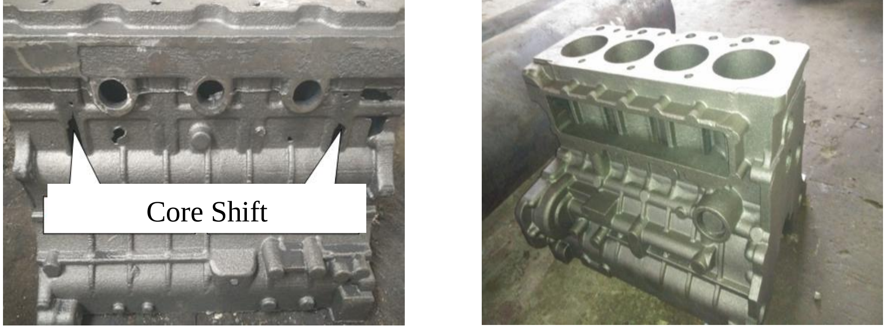
According to the classification process and the assembly plan, the two plans of the cylinder block and sand core are combined and assembled: after the finished outer mold, water sleeve core and cylinder barrel are painted and dried, the assembly is carried out in accordance with the assembly sequence, among which the horizontal placement process needs to integrate the water jacket core and cylinder barrel core into the lower core. During the assembly process, the mud bar is used to measure the wall thickness. After passing the measurement, all parts are assembled together, and the casing is used to increase the height of casting and air outlet. The iron is pressed and then cast into shape. The assembly and molding process is shown in figure 8 and figure 9.

a) side lateral pouring b) bottom vertically pouring

Figure 8 Core assembly of body type core

Figure 9. The cast shape of the cylinder block and the state to be poured after pressing the iron

Two blank parts of the cylinder block are obtained after casting cooling, sand removal, shot blasting, casting risers removal and grinding, as shown in figure 10. The results of performance testing and anatomic verification of the castings showed that the sand core was floated or shifted by side lateral pouring , forming waste. Qualified casting was obtained by bottom vertically pouring.



a) side lateral pouring b) bottom vertically pouring

Figure 10. Cylinder block blank

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4. Conclusion

Through applied research, it is feasible to test the new product of cylinder block and to verify the different technology quickly by the method of non-mold casting technology. The manufacturing of cylinder block with non-mold casting technology has the following advantages:

1) Speed is fast, Replace the traditional mould-casting method with the non-mold casting method, and the manufacturing cycle of individual parts is reduced by more than 50%. The single part of cylinder is manufactured by non-mold casting, wood and metal, and the expected cycle is 16 days, 32 days and 90 days respectively.

2) The cost is low, Replace the traditional mould-casting method with the non-mold casting method, and the cost of individual parts is reduced by more than 81%. The single part of cylinder is manufactured by non-mold casting, wood and metal, and the cost is 15,000yuan, 79,000 yuan and 8,035,000yuan.

3) Greenization and lightweight. Non-mold casting technology saves 8-9 sets of molds and realizes energy saving and emission reduction. Due to the fact that non-mold casting of does not need to consider the draft angle, it can reduce the machining of the casting and provide technical support for the lightweight design of the cylinder block.

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