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Simulation study on the fracture splitting process parameters of the large end of the connecting rod of a certain engine

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Abstract: Connecting rod as the key parts of the engine, its manufacturing quality directly affect the engine performance and reliability[1]. Compared with the traditional manufacturing process, the modern manufacturing process of the big end of the connecting rod is the fracture splitting process. Not only the quality of the manufacturing has been improved, the cost has been reduced, the efficiency is improved, the technology has been improved, and it can ensure the precise positioning and assembly between the two, eliminate the relative motion, improve the NVH performance of the engine, meanwhile, improve the overall strength of the connecting rod. This paper focuses on the problem of Separated Surface in the fracture splitting process, using finite element software to simulate the fracture splitting process parameters to find the best fracture splitting force to reduce and avoid the occurrence of the problem of Separated Surface.

Key words: The fracture splitting process, Separated Surface, Process parameters, Simulation study

I. Introduction

There are two methods for manufacturing the connecting rod body and connecting rod cap in the traditional manufacturing process: One kind is forging the connecting rod body and the connecting rod cap as a whole, sawing and cutting, machining the interface, assemblying. The other kind is forging the connecting rod body and the connecting rod cap separately, machining the interface, assemblying [2]. But the modern manufacturing process of the big end of the connecting rod is the fracture splitting process, moreover, is the development direction of connecting rod manufacturing technologies [3].

Manufacturing technology of the fracture splitting for engine connecting rod is fracturing the cover between the connecting rod body and the connecting rod cap without any quality defects[4]. Its principle is designing and fabricating gaps at the fracture line of the big end of the connecting rod, also called prefabricated crack groove, causing stress concentration, then pulling a thrust pin with a wedge shape at a certain speed to fracture, so producing radial force at the hole of the big end of the connecting rod to appear cracks at the prefabricated crack groove, then the cracks extending to the outer contour. Brittle fracture and separation appear at the gaps in the case of almost no deformation so that it can realize fracturing the cover between the connecting rod body and the connecting rod cap without any quality defects[5]. There are three methods to process the prefabricated crack grooves: mechanical broaching, laser processing[6] and prefabricated molding.

The main advantages of the fracture splitting process of this engine connecting rod: the three dimensional uneven structure of the fracture cover between the connecting rod body and the connecting rod cap can achieve automatic and accurate mesh between the cap and the body, then mutual lock, so ensure accurate positioning and assembly between the two parts, meanwhile greatly improve the overall strength of the connecting rod; no further processing faying surface, no need grinding and other processes, such as bolt hole and positioning pin and positioning sleeve[7] and other parts to locate, reduced the processing procedure for nearly half, so that improved production efficiency, reduced production costs and improved the stability of production.

II. Existent quality defects and analysis during the fracture splitting process

Although the fracture splitting process of the connecting rod has many advantages and progresses comparing with traditional manufacturing processes, it exists the quality defects in the production process, such as drop-dregs(just like Separated Surface[8]), dislocation, slags, excessive deformation of the hole of the big end of the connecting rod, unilateral fracture caused by one side of the crack grooves quickly crack and open. The reasons causing these quality defects are both internal and external causes. The internal causes include the connecting rod material, the geometric parameters of prefabricated crack groove, etc. External causes have the fracture splitting force, the fracture splitting speed and so on. In this paper, we focus on the optimal fracture splitting force of the connecting rod in the process of fracture splitting without any quality defects so that enterprises can refer to in the future production.

III. The fracture splitting process of the large end of the connecting rod of a certain engine and finite element analysis

The connecting rod of a certain engine adopted powder forging process to manufacture blanks, connecting rod parts used powder metallurgy, HRC：21-30.The temperature of the production environment was mainly constant temperature(about 26 degrees centigrade). The positioning method of the two hole clamping rod is setting the centers of the large hole and the small hole and pressing plane. Manufacturing the fracture cover between the connecting rod body and the connecting rod cap is the fracture splitting process. Due to adopting the combination of powder metallurgy[9] and fracture splitting process to manufacture this engine connecting rod, there are a lot of advantages as follows comparing with traditional connecting rods. Powder metallurgy materials have good properties of brittle fracture, so it applies to the fracture splitting process. Powder forging change the microstructure and properties of metal materials effectively so that metal materials are more intensive, greater intensity and have higher performance. Preloading fabricated crack grooves along with the blank forming can cancel the initial prefabricated crack groove machining process. Blank forming have high precision and good consistency. Blank parts have little quality deviation. The separation of the uneven surface increases the contact area so that connecting rod itself has high strength, strong bearing capacity. Without the need to process the combination of surface and positioning components, so the processing process is less, the equipment investment is small and the manufacturing cost is low. Three dimensional explosion diagram of an engine connecting rod is shown in Figure 1.

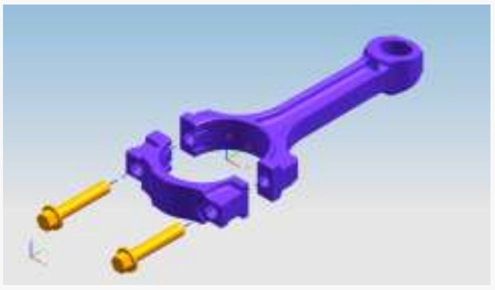


Figure1 Three dimensional explosion diagram of an engine connecting rod

Manufacturing enterprises are concerned about the impact of fracture splitting force on the problem of Separated Surface in the fracture splitting process. The finite element simulation analysis method is used to solve the problem and to understand the relationship between the two, it has important practical significance to the manufacturing enterprises.

The research object is a connecting rod working in 2.4 liters of a certain engine. Prefabricated crack groove parameters: depth of groove (h) is 0.4mm, curvature (r) is 0.2mm. Due to rod and the small end of connecting rod have almost no deformation and displacement during the process of fracture splitting, they can be neglected In the process of finite element analysis, meanwhile, straight cut connecting rod is about the symmetrical parts of the spindle center. In order to improve the analysis and calculation efficiency of finite element, a large end of half of the connecting rod is used as research object during the finite element analysis. For easy cleaning and import, the engine connecting rod model is simplified in CATIA. The connecting rod model imported in HyperMesh is shown in Figure 2.

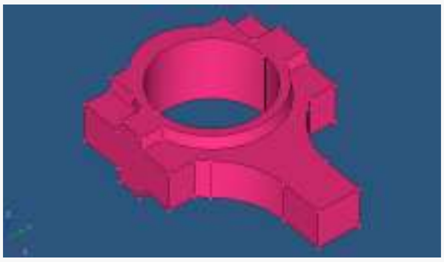


Figure 2 Connecting rod finite element model

Next is the grid division of the connecting rod model after importing in HyperMesh. Because of the finite element put a continuous whole discretized into discontinuous individual units, the boundary of the plastic zone must be in connection with the unit in the process of postprocessing. The maximum error will be equal to the width of half unit from the aspect of calculation errors. Thus, the smaller the unit is, the smaller the error will be. However, in fact, taking into account the limitations of computing resources, refine the grid cannot be infinitely small. It must have the choice to use the grid end to the elastic region of the material is gradually increasing. On the one hand, it is the need to accurately calculate the stress field distribution of the crack tip. On the other hand, it is also the need to save computational resources. The results of the final mesh are shown in Figure 3.

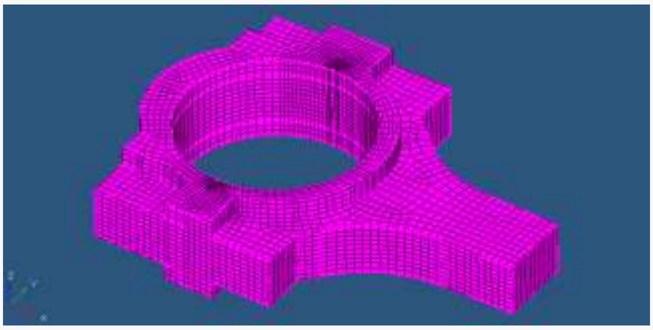


Figure 3 Finite element mesh

It needs to set connecting rod material properties and boundary conditions. Material properties: Connecting rod materials are powder metallurgical materials, Rockwell hardness is 21-30, Yield strength is 601MPa, Tensile strength is 947MPa. It needs to import Modulus of elasticity(E) and Poisson's ratio(ν) when it needs to define material properties. Boundary conditions(the actual working conditions in the performance of the finite element model): according to the stress analysis of the fracture splitting process, the fracture splitting process can be reasonably simplified. It is assumed that the connecting rod is subjected to the static action before the fracture splitting, so it can neglect the influence of speed and momentum. Join forces between the force and the pre-tightening force of the cover end is set to fracture splitting force. The final model of the constraint and load is shown in figure 4.

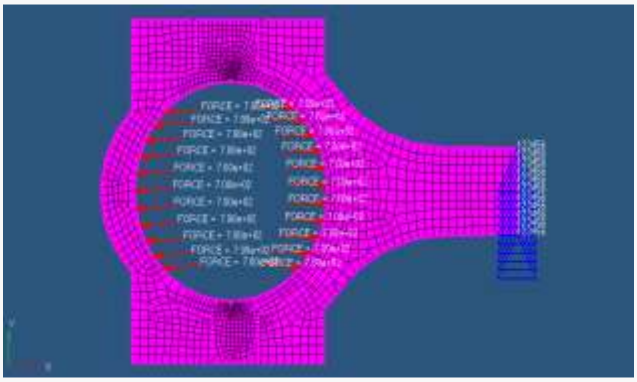
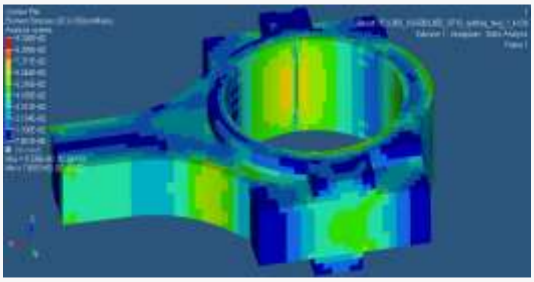
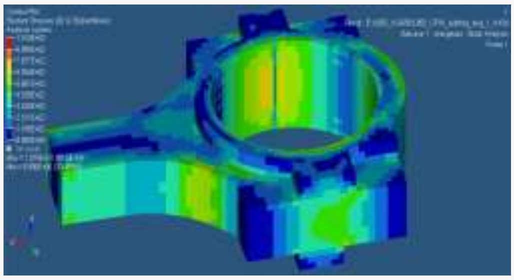


Figure 4 The final model of the constraint and load

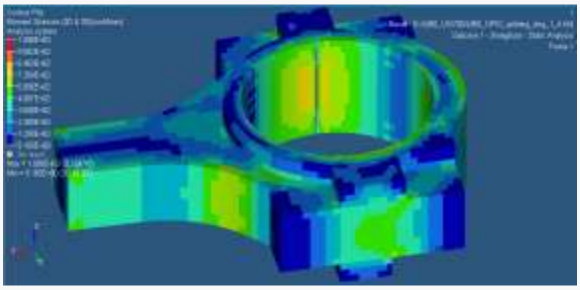
Simulation analysis results of connecting rod: analysis of the effect of splitting the connecting rod under different sizes of fracture splitting force. Results are shown in Figure 5.



(a) 60KN



(b) 65KN



(c)70KN

Figure 5 Connecting rod stress distributions in different sizes of fracture splitting force

IV. Conclusion

From the finite element simulation analysis results of Figure 5, along with knowing powder metallurgical material tensile limit value, the stress in the area of the fracture splitting grooves is greater than the tensile strength of the connecting rod when the fracture splitting force is 65KN. That is to say, when the fracture splitting force is 65KN, the connecting rod can be fractured without any quality defects like Separated Surface, the best fracture splitting force is 65KN. Through the finite element analysis, it is concluded that there is obvious stress concentration in the model of the fracture splitting groove by analysing the stress state of the fracture splitting area, and ensure higher quality of the fracture splitting compared with the connecting rod without the fracture splitting grooves.

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