G. SONG, H. C. JI, W. C. PEI, J. S. Li, S. CAI, B. X. LIU

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# HOT FORGING FOR PRODUCING RAILWAY WAGON BOGIE ADAPTER

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Hot forging forming of railway wagon bogie adapter is a new railway wagon bogie adapter processing technology. In this paper, a hot forging die for railway wagon bogie adapter was designed, and the forming quality were analyzed by using DEFORM-3D software. Then, the feasibility of the process was verified by experiments. It was found that using this mold can eliminate the defects such as loose as-cast in metal smelting process, optimize the microstructure, forging products with good density, product quality and other characteristics of stability.

*Keywords:* hot forging forming, railway wagon, bogie adapter, producing, numerical simulation

## INTRODUCTION

For a long time, railway occupies a dominant position in the comprehensive transportation system of the country. At present, rail transit equipment is still one of the key directions for the development of high-end equipment manufacturing industry in China. The railway wagon bogie adapter is installed between the rolling bearing of the railway freight car wheelset and the guide frame of the side frame of the bogie. It acts as the bearing seat of the railway freight car wheelset and is an important part of the railway freight car bogie. The railway wagon bogie adapter is subjected to alternating loads such as tension, pressure, impact and bending in the process of operation. The working conditions are poor and the quality requirement is high. [1] Typically, a freight train carriage requires four axles, two railway wagon bogie adapters per axle, and eight railway wagon bogie adapters per carriage. The annual demand for freight trains is large. For example, in 2015, the annual demand for 1,2 million carriages reached 9,8 million railway wagon bogie adapters. [2] The railway wagon bogie adapter is usually processed and manufactured by casting. Its structure is shown in Figure 1. From Figure 1 we know that it has uneven wall thickness and exists a part with increased wall thickness at the top ring belt. Because the girdle part is used in conjunction with the axle bearing, welding repair is not allowed in this part. Scrap treatment must be carried out once casting defects occur for that the quality requirements are very strict. It is urgent to find a new forming method because the existing processing method of railway wagon bogieadapter cannot meet the demand of product quality. In recent years, hot precision forging forming technology has become a research hotspot. [3]

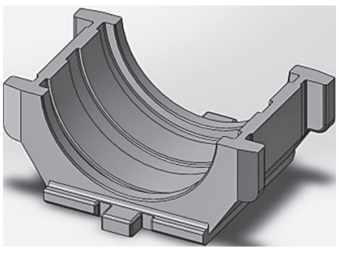

**Figure 1** Schematic diagram of railway wagon bogie adapter product

G. Song, H. C. Ji (E-mail: jihongchao@ncst.edu.cn), W. C. Pei (pwc@ncst.edu.cn), S. Cai, B. X. Liu, College of Mechanical Engineering, North China University of Science and Technology, Hebei, Tangshan, China; J. S. Li, MCC Heavy Industry (Tangshan) CO., LTD., Hebei Tangshan, 063035.

Forging forming mainly has obvious advantages in the following aspects [4,5]:

Eliminate the defects such as loose as-cast in the process of metal smelting and optimize the microstructure.

Forging products have better compactness, stable quality and consistency.

Higher material utilization rate.

With the continuous improvement of science and technology, hot precision forging has been widely used in industrial production and manufacturing. Many scholars have creatively proposed using forging instead of casting to produce complex parts, and they finally realized the industrial application of the products through basic experiments [6,7] combined with numerical simulation and laboratory trial production.

Based on the structural characteristics of railway wagon bogie adapter and the advantages of forging technology, a kind of railway freight car railway wagon bogie adapter pre-forging and final forging forming technology is presented in this paper. Firstly, the forging die of railway wagon bogie adapter composite technology was designed. The pre-forging and final forging process of railway wagon bogie adapter were studied by establishing 3D finite element elastic-plastic model.

## EXPERIMENTAL MATERIALS AND PROCESSES

AISI 1035 is one of the representative medium carbon steel. Due to its good balance of strength, toughness

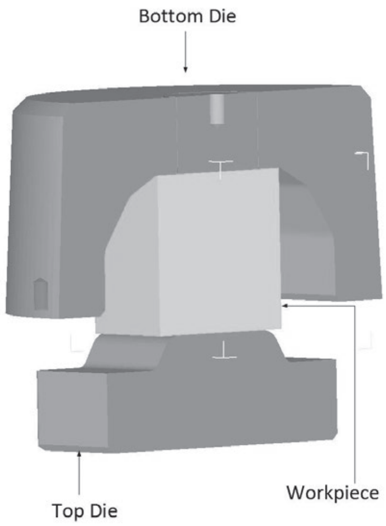


**Figure 2** 3D geometric model of pre-forge process

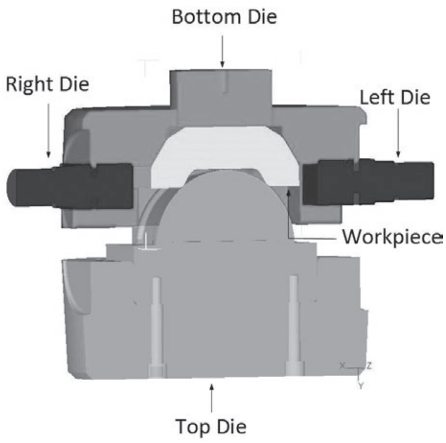


**Figure 3** 3D geometric model of final forging sequence

and wear resistance, it is widely used for many general purpose parts including automotive crankshaft, rams, spindles, etc. The chemical compositions of AISI 1035 steel are 0,32 % C, 0,79 % Mn, 0,89 % Si, 0,01 % S, 0,021 % P.

As a part of split structure, combined with its structural characteristics, a pre-forging and final forging forming process of railway freight car railway wagon bogie adapter was proposed. A 3D finite element elastic-plastic model was established in DEFORM-3D software to study its forming process, so as to provide theoretical guidance for subsequent experiments.[8]

Because of the complex structure of the railway wagon bogie adapter, it is difficult to realize by only one forging. Therefore, the blank was pre-forged first according to the scheme of design of load-railway wagon bogie adapter forging forming process. To establish a numerical simulation of the pre-forging process of the railway wagon bogie adapter, we used Solidworks software to establish 3D geometric models of molds and workpieces, and import them into the pre-processing of Deform-3D software in the form of STL files, as shown in Figure 2. In the forging process, model establishment mainly includes five steps: mesh division, material setting, boundary definition, model positioning and process parameter setting.[9,10]

The upper and lower dies used in the final forging were modeled by using Solidworks, and were imported the pre-processing of DEFORM-3D software in the form of STL file. As shown in Figure 3, the numerical simulation of the final forging process of the railway wagon bogie adapter was established. The modeling steps were the same as those mentioned above. Meshing mainly includes the meshing of molds and workpieces. Too few meshes will result in lower accuracy, and too many meshes will lead to long calculation time. Therefore, after discussing calculations, the number of meshes for the workpiece is finally selected as 200 000 , the number of grids of the mold is 100 000. The friction factor is 0,3, and the forging speed is 100 mm / s. The actual production time of final forging is short, but DEFORM-3D software can be used to understand the deformation at any point in the forging process.

## RESULTS AND DISCUSSION

The pre-forging process of the railway wagon bogie adapter forging is a forward extrusion process. The upper die gradually compresses the blank under the action of the press. The extrusion process simulation is shown in Figure 4. It can be seen from the figure that with the extrusion convex, the metal flows along the cavity of the cavity along the direction of the punch movement, and the left and right sides of the pre-forged part appear bulging, which is a typical upsetting performance. With the movement of the die, the pre-forged piece is gradually formed, and finally an extruded pre-forged piece is obtained. The simulation analysis results show that the pre-forged parts are well deformed, and there are no forging defects such as instability and folding. The pre-forging process can provide a good deformed blank for the subsequent process.

The final forging process is divided into two processes, the upper die pressing down and the left and right die extrusion processes. The extrusion process is shown in Figure 5. In order to prevent defects such as folding and filling dissatisfaction during the extrusion process, the extrusion process was completed in three more stages. The first process is to squeeze the left and right punches along the transverse direction and stop moving when they reach the designated position. The second stage is the movement of the upper punch. The upper die moves in the axial direction under the action of the press. This is the most important movement. The workpiece gradually begins to deform under the pressure of the upper die. At the end of the second stage of movement, the top and bottom surfaces of the saddle and the saddle ring belt are completely formed. At the end of the second stage of the stroke, the upper punch stops moving, the left and right punches start the third stage of movement, and continue to squeeze the workpiece along the transverse direction to complete the forming of the pedestal part of the railway wagon bogie adapter. When the movement is completely finished,

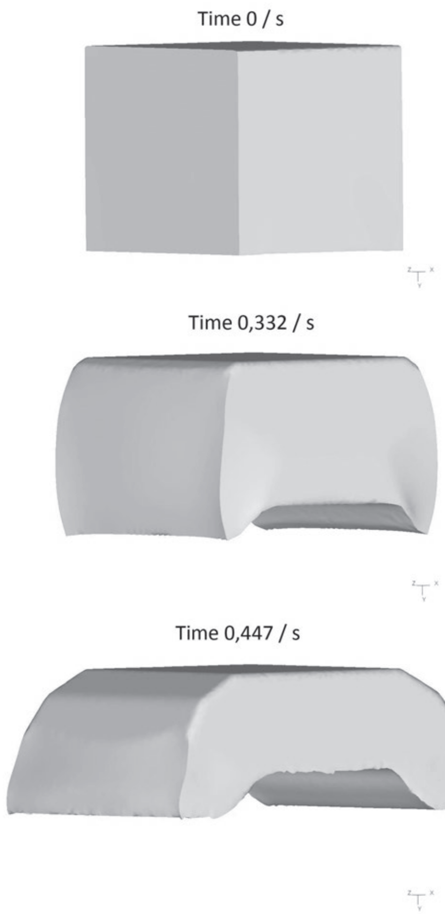


**Figure 4** Simulation results of pre-forging process

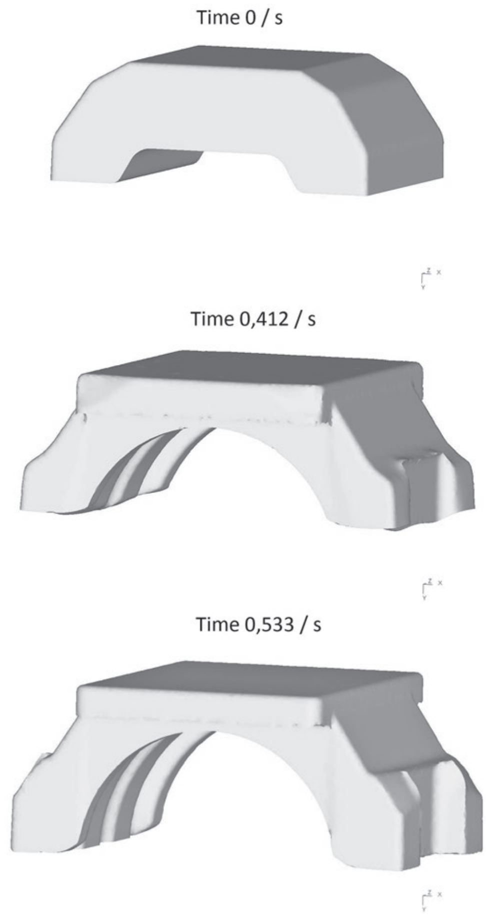


**Figure 5** Simulation results of final forging process

the forming quality of the railway wagon bogie adapter is good, and there are no other defects.

Figure 6 shows the load-stroke curve of the railway wagon bogie adapter forming process. The final forging process of the railway wagon bogie adapter is divided into two main deformation stages: the first stage is the pressing stage of the upper die. The billet is put into the cavity of the lower mold, and the upper mold compresses the billet into the hall. The billet is squeezed to make the metal flow outward, and its lateral size increases. At the same time, part of the metal is squeezed into the mold cavity. In this deformation stage, the required forming load is relatively small. The second stage is the completion of left and right die pressing and forging. At this stage, as the degree of deformation gradually increases, the required forming load at this time gradually increases. At this time, the cavity is completely filled, but the upper and lower planes of the mold have not been hit. The height of the forging is generally still greater than the required height, so the upper and lower dies are further pressed together, so that the metal at the height of the railway wagon bogie adapter forging near the parting surface continues to flow to the burrs. When the forging is formed, the maximum load of Top Die is 22 400 KN and the maximum load of Bottom Die is 21 900 KN.

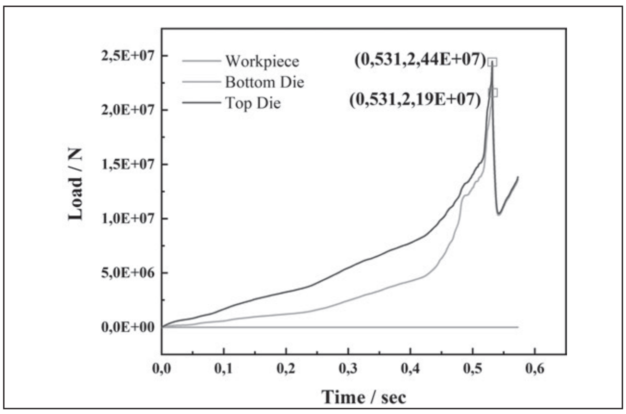


**Figure 6** Load-stroke curve in forming

Figure 7 shows the adapter obtained by hot forging using the designed die. During the experiment, the molds were preheated to 200 °C with a heating belt before the experiment, and the preheating time was not less than 4 hours. The molds were lubricated with Flowserve brand water-based graphite lubricant. The

**Figure 7** Railway wagon bogie adapter formed by forging

blank material is AISI 1035, and the box-type resistance furnace was used to heat to 1 200 °C before hot forging, and the total heating time was not less than 1,2 h.

By observing the railway wagon bogie adapter formed by forging, it can be seen that the railway wagon bogie adapter formed by forging is better than the one formed by casting, the ring belt and the pedestal part of the adapter are well formed, and there are no defects such as folding or filling dissatisfaction that are easy to occur in the casting process. It is tested according to the quality standard of railway wagon bogie adapter, and compared with the railway wagon bogie adapter formed by casting. The results show that the railway wagon bogie adapter forged with the designed die has better performance than the railway wagon bogie adapter formed by casting, which fully meets the actual use requirements.

## CONCLUSION

A hot forging-finishing die for the adapter was designed, and the hot forging forming process of the adapter was analyzed. Each cavity was filled during the forming of the adapter. The forged adapter has a complete filling and no folding, which means that a fully filled pre-forged part can be hot-forged at one time.

Simulation analysis and experiment verified that the extrusion method can achieve the purpose of finishing the railway wagon bogie adapter. A finishing process of railway wagon bogie adapter is designed: the upper die is compressed first, and the left and right dies are extricated, which can effectively prevent the flapping phenomenon in forging process.

## Acknowledgments

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**Note**: The responsible translator for English language is Z. S. Peng -North China University of Science and Technology, China