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Optimization of Forging Process Parameters for Wheel Hub Using Numerical Simulation

Vasuki Gopal Deshak *[a], Ganapathi K.N [b], Bikash Musib [c], Malay Sarkar[d]

[a,b]*M S Ramaiah University of Applied Sciences, Bangalore 560054, India*

Abstract

Present work is on the optimization of forging process parameters for wheel hub using numerical simulation. Aim of this paper is to reduce the loading conditions within the specified limit of 1600T and also to reduce the machining thickness. A Finite Element Method based numerical simulation is used to simulate from current design of die till finalized modified design. DEFORM 3D software was used to validate the modifications done in dies and process through simulation. The loading conditions were optimized in blocker and finisher operations with an improvement in yield by 13% using numerical simulation.

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*Keywords:*Optimization; Forging process; numerical simulation

1. Introduction

Forging is one of the manufacturing processes which involve plastic deformation of material to be formed. As a replacement for historical trial and error method, validation of designs or modified designs of forging dies and tool using numerical simulation has been established with huge demand. This paper explains about the optimization of process parameters, monitoring of loading conditions and reducing material wastage using numerical simulation. DEFORM 3D software is used as the simulation tool to carry out numerical analysis for forging of wheel hub component.

* Corresponding author. Tel.: +91-080-23449271;.
E-mail address: arvind.deshak@gmail.com

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2. Theory

In order to support the numerical analysis of forging process with optimized process parameters, suitable research works are provided with justifiable results. (Cheng et al., 2008) carried out the validation of forging process for a 3D compressor blade using FEM. Comparison of results from both experimental and with simulation are almost similar. For complete die fill and the importance of multi-stage operation for complex shapes are also clearly explained in this paper. Also a clear insight of design considerations to be made for forging process is discussed [1]. Also (Peng & Jun, 2008) work explained about the 3D FEM based analysis for forging of automotive piston skirt. Importance of software package in monitoring process parameters and defect control are clearly explained. Also analysis of component through different loading and temperature conditions are carried out for monitoring the die fill[2]. Also (Chandan 2014) carried out study of process parameters towards improving efficiency of closed die forging process. The capability of FEM based numerical software i.e DEFORM for monitoring and control of critical parameters affecting process to a larger extent are explained. Also Monitoring of parameters using DOE method for multiple input variables are also clearly discussed in this particular work. Certain limitations of work are with regard to analysis of loading conditions in each operation, which directly affects the die life. And the consolidation of stages of operation through appropriate design might reduce the processing cost and time which led to this particular study [3].In this study, AFTC is one of the companies which deals with simulation based services in process and product design. One of its clients came up with a requirement to offer solutions for optimizing the process parameters for an automotive wheel hub and to counter the problem of piercing inserts through the material. The forging process carried out at the shop floor facility was impression die forging method. Based on the machine drawings being shared from the company end, the results depicted from the simulation software for the loading conditions of initial designs was very high. Also the machining thickness of the component was very high. Thus optimization of the process parameters, monitoring of loading conditions and reducing the material wastage are primary objectives which are to be achieved using numerical simulation. On an iterative approach the suitable process design considerations are made to get the best results, with the assistance of advanced optimization technique.

3. Methodology

Analysis of 3D model: The initial machine drawings of the component were converted into 3D models using CATIA software. Later the numerical analysis was carried out using DEFORM 3D software. The 3D models are imported and with the assistance of AMG (Automatic Mesh Generation) system they are finally meshed and later provided with the input data shared by the shop-floor.

The input data shared by the shop floor is clearly depicted in table 1.

Table 1 Input data for the component

Material	**S48C-1048 steel**
Material section in cold condition	56mm in diameter
Billet weight in cold condition	2.3kg
Billet length in cold condition	121.5mm
Billet temperature	1170-1220°C
Forging press	1600T
Finisher flash thickness	3± 0.8mm
Die material	H11- chromium hot work tool steel
Die temperature	150-200°C
Finisher stroke per min	26
Stroke height	300mm

Design modification of dies and tool: With suitable research work to support, design considerations in terms of the die design and process are carried out till the complete filling of the die cavity is achieved. And other preference is with regard to optimizing the loading conditions and minimizing the machining thickness thereby reducing material wastage. During the initial design stage, the machining thickness and loading conditions were high which led to design modifications in terms of dies and tool. Whereas in variant 1 with a modified die design and tool, presence of disturbed structural integrity in the finisher operation led to further modification in design of dies. However loading