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Simulation and analysis of four lobe hollow steering shaft by roll forming

D. Ravichandran[1], V. Karthikraja[2], R. Karthikeyan[2], K. Prawinkamashi[2], S. Sakthivel[2]

[1]Assistant Professor, Department of Mechanical Engineering, Nandha Engineering College, Erode-52, Tamil Nadu, India.

[2]UG Students, Department of Mechanical Engineering, Nandha Engineering College, Erode-52, Tamil Nadu, India.

ABSTRACT

This paper presents the analysis result of forming a four-lobe hollow shaft used in steering column. The FEM analysis is performed using the ANSYS Workbench 15.0 software. The objective of the work is to analyze and simulate the roll forming of four lobe hollow steering shaft

Index Words: Hollow Shaft, Roll Forming, Steering Shaft, Four lobes

INTRODUCTION

One of the most widely used methods of reducing production and maintenance costs of vehicles is to minimize the mass of the product. Hollow shafts are more widely used instead of their solid counterparts in order to reduce mass of structures. When compared to solid shafts the costs of manufacturing hollow shafts are usually higher. The cost of producing the hollow parts can be reduced by minimizing the material consumption and keeping machining to the minimum. Since the strength of the hollow shaft is more than the solid shaft with the same weight. It is necessary to produce hollow steering shaft by promising manufacturing method.

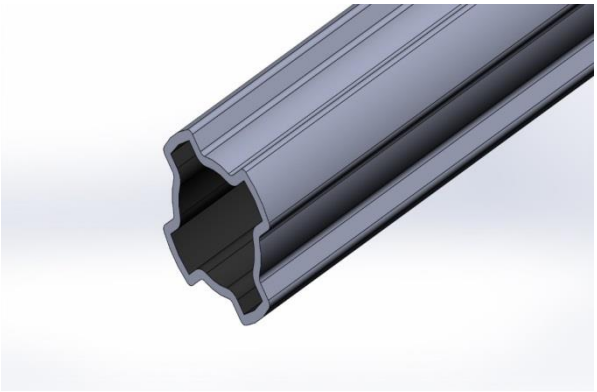


Fig.1 Hollow shaft

STEERING COLUMN

The steering column is a mechanical device mainly used for connecting the steering wheel to the steering mechanism by transferring the driver's input torque from the steering wheel. The steering column consists of a collapsible housing containing a collapsible rotating shaft. As a safety

Author for correspondence:
Department of Mechanical Engineering, Nandha College of Technology, Erode – 638052, Tamil Nadu, India

measure, the steering column is designed to collapse in the event of a front-end collision. If a steering column has collapsed, it must be replaced. The steering shaft is a two or more piece component located inside the steering column. It is supported at the top and the bottom of the steering column by bearings

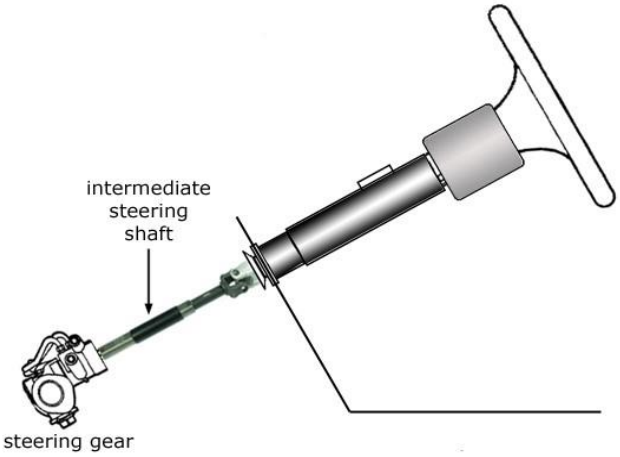


Fig.2 Steering column setup

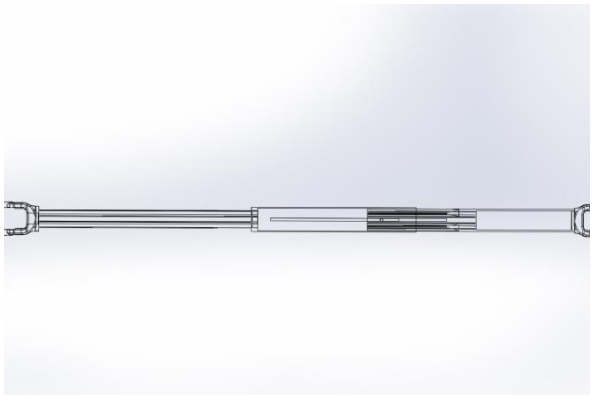


Fig. 3 Steering design

MANUFACTURING OF HOLLOW SHAFT

In general, high quality hollow shafts are made by skew rolling, forging, high pressure forming yet they have their own drawbacks.

ROLL FORMING

The Roll Forming is a continuous machining process. This process is mainly preferred for sheet metals. The process does require bendability and ductility. However, the final step of the process requires subsequent forming steps. The deformation of the shaft's length increases when the yield strength is increased. In roll forming.

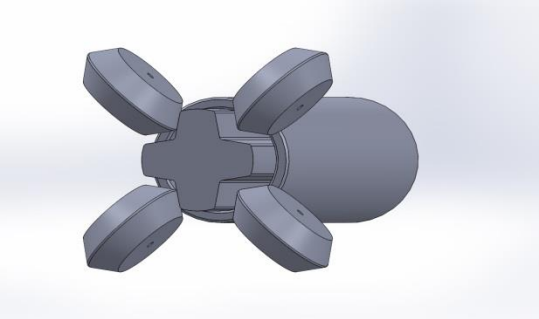


Fig. 4 Roll Forming

FORGING

Forging is a manufacturing process involves the shaping of metals using localized compressive forces. The metal is formed into desired shape by hammering, pressing, rolling, squeezing. It is carried out either hot or cold.

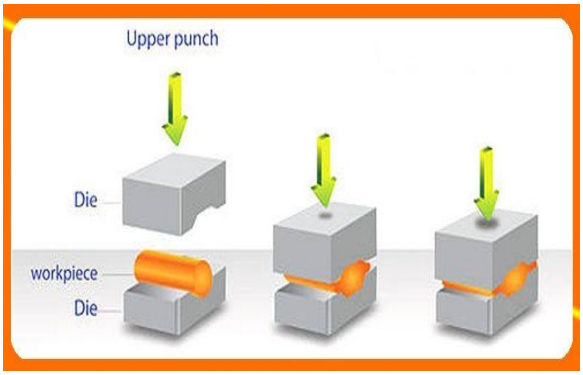


Fig. 5 Forging

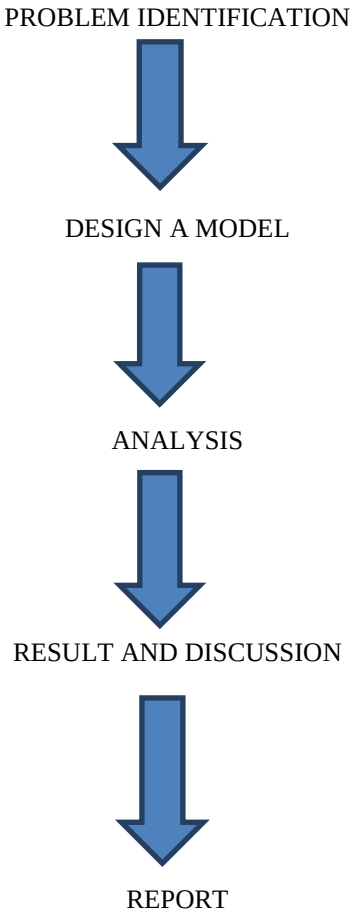
LITERATURE SURVEY

1. Z Pater et al made a study and concluded that rotary compression is considered as a promising method for producing symmetrical hollow stepped shaft and its simple design allows to form parts on small batches and mass production [1].
2. Farid Utyashev et al showed that possibility of shape-forming of complicated parts of heat-resistant alloys under superplastic deformation condition. It also implemented the technological process of rotary swaging under SP conditions has been developed for fabrication parts made of high alloy heat-resistant [2].
3. J Tomczak et al have carried out a study and confirmed the possibility of forming hollow forgings by means of rotary compression and the finished products are happened to exhibit better resistance properties and increased machine safety [3].
4. R Neugebauer et al conducted a study to produce hollow shafts by warm forming process. It discusses the determination of local forming parameters and different simulation methods [4].
5. Chang Li et al have found and explored the rolling parameters such as roller spacing, rolling velocity, residual stress and strain which can provide a reliable theory basis for improving the performance of hot rolling seamless steel pipe and the optimization of rolling technological parameters [5].
6. Wen Kang et al conducted a study to analyze the performance of roll forming with MS980 and effect on roll strength and roll compressive distribution scheme on roll forming [6].

PROBLEM IDENTIFICATION

Existing Solid shaft have provided desired performance yet it is time to change to hollow shaft because of its light weight and reduced cost. In order to produce hollow shafts of higher length the traditional methods are not suitable.

METHODOLOGY



Forming setup

The forming setup is established as shown in figure. The forming setup consists of four rollers, mandrel and a hollow billet. The operation consists of a simple deformation process. The mandrel is of 50 mm length and outer diameter 22.98 mm. There are four rollers of same dimensions each of them mounted at diagonal corners, such placement is needed in order to produce four lobe profile in the shaft. The tolerance provided between the mandrel and billet is 0.1 mm. The thickness of the billet is 2.625 mm. The tolerance is provided minimal hence the mandrel should be inserted into the billet manually. The material used for the billet is STKM11A. The yield strength of the STKM 11A is 200 MPa.

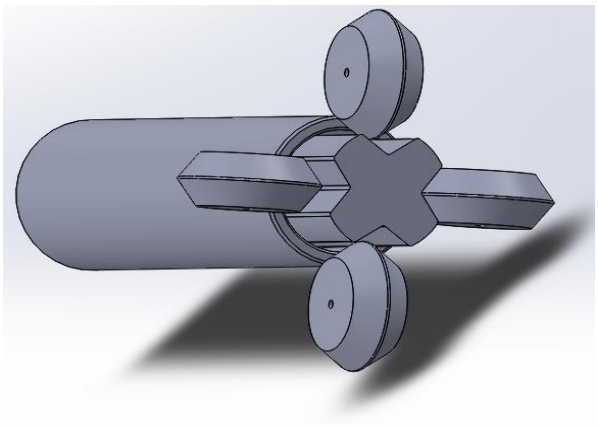


Fig.6 Roller Setup

Analysis

The analysis of this forming process is done by using ANSYS 15.0. The mesh value of the billet is 2 mm. The mesh value of the rollers is 2 mm. The mesh value of the mandrel is 1 mm. Number of elements is 18244. Number of nodes is 77737. The frictional coefficient of the roller and billet is 0.02. The roller and the mandrel were assumed to be rigid throughout the analysis. The mandrel is considered to be fixed and the rollers and billet considered being movable. Both ends of the billet is chamfered so that rollers roll over the billet smoothly and also to avoid cracks or damages since sharp corner are susceptible to damages.

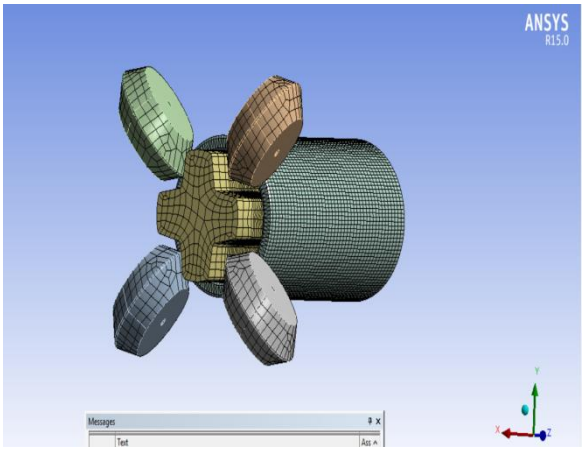


Fig. 7 Mesh part of the Forming Setup

The displacement allowed for the billet is 100 mm then the roller which rotates over the billet to produce the required profile. The rollers roll over the billet simultaneously in order to avoid distortion on the surface of the billet.

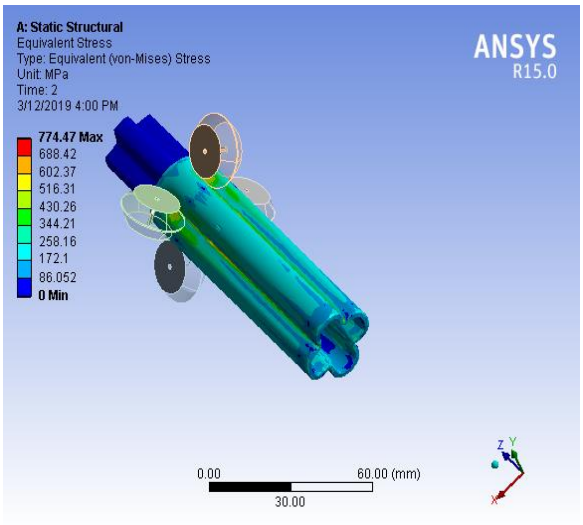


Fig. 8 Equivalent stress analysis

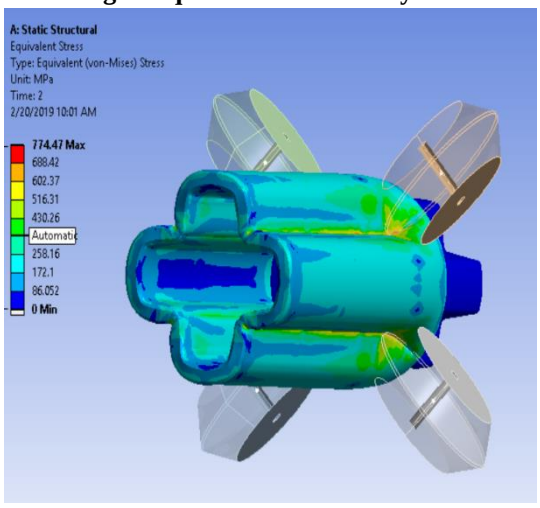


Fig. 9 Stress analysis of hollow steering shaft

RESULT AND DISCUSSION

The results of the forming analysis performed by using ANSYS 15.0 helped to determine the deformation changes in the billet. As the process complete, we obtained the controllable physical properties which listed below

Table. 1Stress, Strain Value

Sl No	Max	Min
Equivalent Stress	774.47 MPa	1.1487 MPa
Equivalent Strain	5.9201e-003 mm/mm	6.4966e-006 mm/mm

CONCLUSION

It is clear that the obtained results of the analysis confirm the possibility of forming a four-lobe hollow shaft by means of roll forming. From our observation we found that various authors suggested different roller designs, manufacturing methods. After going through the available literature, it is found that production of hollow shaft can be achieved by Roll forming. There is massive scope for this method since it proved to be

a promising manufacturing process to produce hollow steering shaft despite the length of shaft.

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