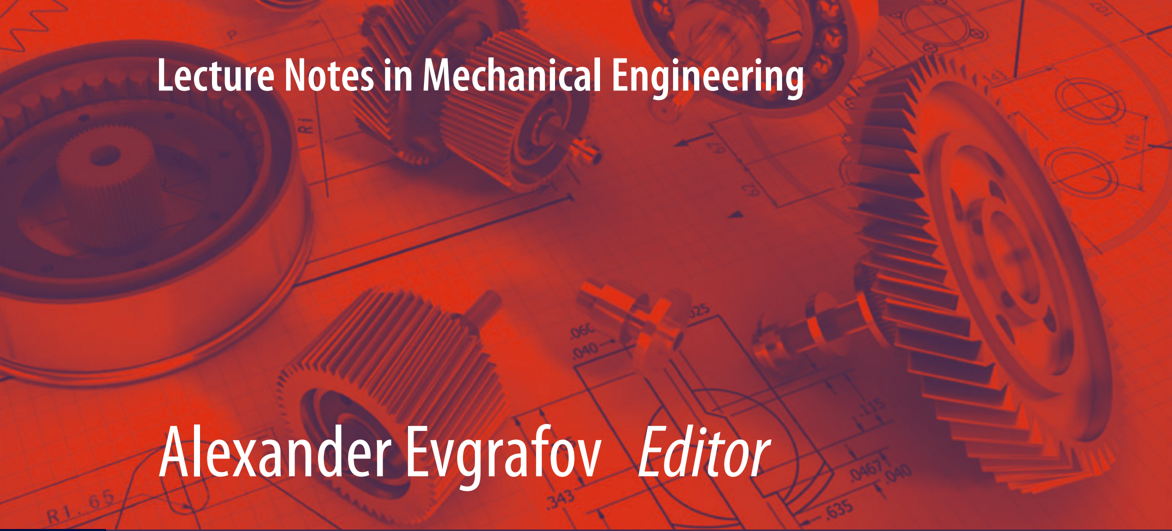

Lecture Notes in Mechanical Engineering

Alexander Evgrafov *Editor*

Advances in Mechanical Engineering

Selected Contributions from the Conference "Modern Engineering: Science and Education", Saint Petersburg, Russia, June 20–21, 2013

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Lecture Notes in Mechanical Engineering

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Preface

The “Modern Engineering: Science and Education” (MESE) conference was initially organized by the Mechanical Engineering Department of Saint Petersburg State Polytechnic University in June 2011 in St. Petersburg (Russia). It was envisioned as a forum in which to bring together scientists, university professors, graduate students, and mechanical engineers, presenting new science, technology, and engineering ideas and achievements.

The idea of holding such a forum proved to be highly relevant. Moreover, both location and timing of the conference were quite appealing. Late June is a wonderful and romantic season in St. Petersburg—one of the most beautiful cities, located on the Neva river banks, and surrounded by charming greenbelts. The conference attracted many participants, working in various fields of engineering: design, mechanics, materials, etc. The success of the conference inspired the organizers to turn the conference into an annual event.

The third conference, MESE 2013, attracted 150 presentations and covered topics ranging from mechanics of machines, materials engineering, structural strength, and tribological behavior to transport technologies, machinery quality and innovations, in addition to dynamics of machines, walking mechanisms, and computational methods. All presenters contributed greatly to the success of the conference. However, for the purposes of this book only 16 reports, authored by research groups representing various universities and institutes, were selected for inclusion.

I am particularly grateful to the authors for their contributions and all the participating experts for their valuable advice. Furthermore, I would like to thank the staff and management of the University for their cooperation and support, and especially, all members of the program committee and the organizing committee for their work in preparing and organizing the conference.

Last, but not least, I would like to thank Springer for its professional assistance and particularly Mr. Pierpaolo Riva who supported this publication.

Saint Petersburg Alexander Evgrafov

Contents

Chapter 1
Rotary Forging of Hollow Components with Flanges

Leonid B. Aksenov and Sergey N. Kunkin

Abstract This paper is about development and testing of cold rotary forging technology for manufacturing of hollow shaft flanges. Rotary forging mills with rotated die and conical roll were used for forming. Pre-machined blanks were made from pieces of welded or extruded pipes from carbon steel with 0.2 % of carbon. Design of tool-sets, sketches of blank and forged parts are presented.

Keywords Rotary forging · Shaft flanges · Conical roll

Introduction

Ax symmetric parts with flanges at some distance from the tube face (Fig. 1.1) are widely used by industry for the production of various machines. Technologies for their production differ greatly. One such process is radial extrusion of tube blanks in hot condition. Also technology of hot die forging at maxi-presses and forging machines is very popular. In most cases, the coefficient of use of metal is low, and forged parts require a large amount of machining.

Manufacturers of pipes and pipe fittings in various industries would like to make flanges directly from its main product—pipes. This is possible to realize with technology of rotary forging [1]. The rotary forging technology is intended for manufacture of ax symmetric parts from bar or pipe blanks. This technology is representative of processes with local deformation [2]. Only part of the blank is in contact with a deforming tool. It reduces the contact area, contact stresses and the required forming force. Rotary forging is attractive technology in the field of metal

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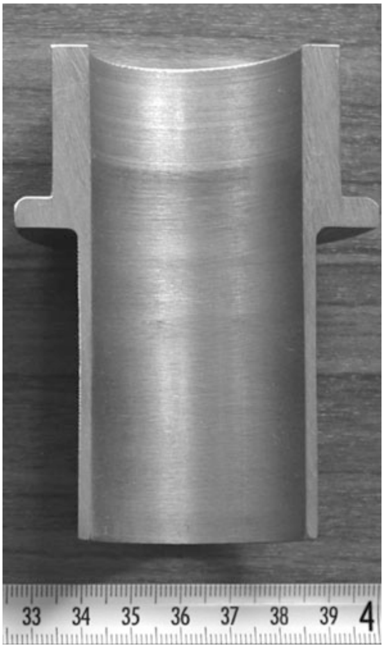

Fig. 1.1 Cross section of hollow shaft with flange

forming, because it has many advantages over any other processes: smaller deformation force, longer die life, less investment in equipment [3].

The process of cold rotary forging provides additional advantages. It does not require heating, provides high accuracy and good quality of the formed surfaces [4]. Obviously, in a cold forging, technological force will be higher than at a hot one with lower plasticity of metal. That is why this technology needs more stringent requirements in their analysis [5].

Experimental Procedure

Investigation has been done in the direction of development of rotary forming in which a rotating blank is deformed by forging a roll moving along the axis of the blank [6]. The rotary motion is provided by a motor driving the lower turntable while the upper die rotates as a follower through the blank.

The blank is placed in the die with a radial clearance of 0.3 mm. It is not necessary to fix a blank during the forming. On the first stage of forming, the rotation of the blank takes place due to friction force between the face of the blank and forming roll. Then the blank is pressed to the die and this provides a reliable transmission of torque. During the rotary forging, the blank is shaped in the space that is formed by the die, mandrel and deforming tool—forging roll. The tool set (die and forging roll) is manufactured from die steel with heat treatment for hardness HRC = 56–63 [6].

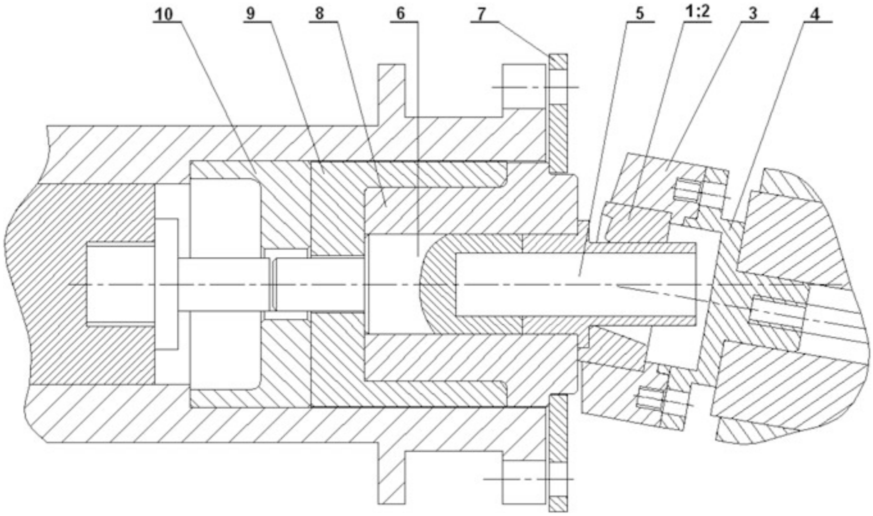

Fig. 1.2 Tool set for axial rotary forging of hollow shaft flanges: *1*, *2* forging roll, *3* mandrel, *4* shank, *5* inner mandrel, *6* stop, *7* top, *8* die, *9* cup, *10* base

This experimental work investigated the possibility of manufacturing ax symmetric hollow parts with outer flange. A tool set for rotary forging (Fig. 1.2) was designed and manufactured for a horizontal type of mill [7].

Rotary forging was realized with the following main process parameters:

- angle of inclination of the conical roll—10°;
- speed of rotation of a spindle of the machine—130 rev/min;
- feed of forging roll—0.3 mm/rev in the beginning of the process and about 0.05 mm/rev at the end of the forming;
- lubricant—machine oil;
- duration of rotary forging (forming time)—20–25s.

Pre-machined pieces of pipe were used as blanks for rotary forging. Material—steel 20, Russian standard: GOST 1050-88. Outer diameter—57 mm and internal diameter—42 mm as at pipe billet. The initial hardness of steel 20 was HV 140…145.

Results and Discussion

Sketches of a pre-machined steel blank for further rotary forging and a rotary forged part are presented in Fig. 1.3. Final dimensions of rotary forged parts are shown in Table 1.1. Dimensions of the blank are determined by dimensions of the manufactured part and volume of the metal required for flange forming.

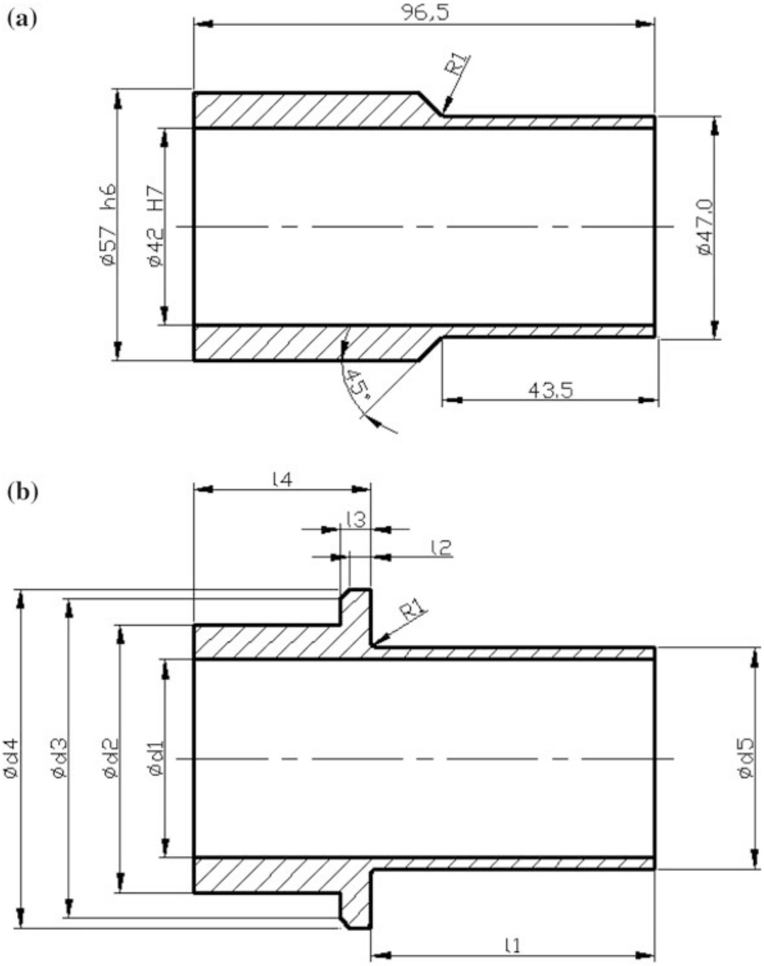

Fig. 1.3 Sketches of pre-machined blank (**a**) and rotary forged part (**b**)

Table 1.1 The main dimensions of rotary forged parts

d1 (mm)	d2 (mm)	d3 (mm)	d4 (mm)	d5 (mm)	l1 (mm)	l2 (mm)	l3 (mm)	l4 (mm)
42.0	57.0	68.5	72.0	47.0	62.2	5.5	6.5	37.4

For guarantee of full filling of the flange of the parts from steel 20 required the forging force to be 400…500 kN. Research also found that the use of a pre-shaped blank and plasticity resource of material (steel 20) were sufficient for rotary forging the parts in one operation and to obtain a flange with a diameter of 72 mm without any cracks (Fig. 1.4).