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STUDY ON MATERIAL PROPERTIES OF AISI (1010) BY FLOW FORMING

*Lakshmana Rao M [1], Gopala Krishna A [2] and Rao T V L N [3]

[1] K.L.University,Green fields,Vaddeswaram Guntur 522502, India
[2] Department of Mechanical Engineering, University College of Engineering, JNT University, Kakinada, Andhra Pradesh- 500085, India
[3] Sundaram-clayton Limited, Chennai- 600050, India

ABSTRACT

Flow forming process is an innovative process for producing axi-symmetric components from plates or preforms. This process has several advantages when compared to conventional forming processes. Components produced through this process are widely used in aero space and missile applications. Usually, thin walled seamless high precision low carbon alloy steel tubes are produced by forward flow forming using CNC flow forming machine. The present work deals with the study of the mechanical properties of ultimate tensile strength, elongation, and hardness at different stages of flow forming.

Key words: *Flow forming, Mechanical properties, Low carbon steel*

1. Introduction

Flow forming is an advanced echo-friendly chip less metal forming process for producing axi-symmetric components from plates or preforms. The cylindrical blanks, called preforms are stretched over a rotating mandrel by means of one or more rollers, arranged equidistant to each other. The preforms are stretched to the required lengths in one or several passes. Usually, all the materials which are ductile enough to be cold formed by any process can be flow formed. However the maximum percentage thickness reduction that a material undergoes without intermediate annealing between passes is different for different materials. Rolled and welded cylinders, forgings, extrusions, cold drawn tubes and castings can be used as initial preforms. The application of the flow forming technique ranges from the manufacture of rocket motor casing, warhead casings, nozzles, cartridge cases, critical items of jet engines, exhaust pipes for motorcycles, automobile components and household appliances. Flow forming can be combined with deep drawing to economically form otherwise difficult components in near to net finished condition. This process offers several advantages over conventional methods of tube forming like extrusion and drawing. By flow forming one can achieve excellent specific strength, good surface finish, close dimensional accuracy, minimum material waste, low tooling cost, considerable design freedom, formability of hard-to-work materials and the possibility using low strength materials to achieve high strength by the mechanism of strain hardening [1].

2. Literature Survey

Thin low carbon alloy steel AISI (1010) tubes with good dimensional accuracy are manufactured by flow forming process. Very sparse literature is available on the analysis of flow forming. Analysis of incremental forming of solid cylindrical components has been carried out by Wong et al. [1]. A theoretical study on mechanics of flow forming has been conducted by Chandra Sekharan and Venkatesh [2].

Checker and Ramesh Kumar [3] have analyzed flow forming for manufacturing of thin walled maraging steel tubes. Rajan and Despande [4] have conducted experimental studies on bursting pressure of thin-walled flow formed vessels. In another study, theoretical and experimental assessment of heat treatment of preform on the mechanical properties of flow formed AISI steel tubes has been made by Rajan and Despande [5]. Lakshmana Rao et al.[6] have carried out the simulation of forming for processing circular Al 2219 tube.

3. Work Piece Material

Low carbon alloy steel AISI(1010) with the composition shown in Table 1 is considered as the material of the preform in the present work.

**Corresponding Author - E- mail: chowdarymlr@gmail.com*

Table 1: Chemical Composition of Low Carbon Alloy Steel

C	Ni	Co	Mo	Ti	Zr	Al
0.03	0.19	0.08	0.24	0.3	0.02	0.14

4. Experimental Work

Experiments have been carried out on a three roller CNC flow forming machine of Model ST 56-90 made by Leifeild of West Germany.

The preform is formed over the rotating mandrel. While the blank metal and mandrel (which are locked together) rotate, the rotating forming rollers follow the mandrel contour at a preset gap as programmed by a CNC flow forming machine. The preform plastically deformed by the localized application of heavy compressive forces exerted by the rollers and the deformed metal takes the shape of mandrel. The input data and the preform dimensions used for experimentation are as follows:

Initial length of preform	: 152mm
Initial thickness of preform	: 8mm
Inner diameter	: 120mm
Roller feed	: 0.36 mm/rev
Spindle speed	: 290 rpm
Stroke of tail stock cylinder	: 2400mm
Total connected load of the machine	: 375 kVA

5. Results and Discussion

In the initial stage, the preform had the mechanical properties of 35.24 UTS (Mpa), 31.25% elongation, and RC 55 hardness. After flow forming, UTS and hardness have been increased to 80.64, 92 respectively where as the elongation has been reduced to 6.25 %. Another case is taken where the preform is subjected to heat treatment process before forming. Annealing is carried out at 400ºC. The mechanical properties after the annealing and the flow forming are noted and listed in Table.2. It is observed from the table that because of the annealing, UTS and hardness are decreased while the ductility is increased. As the ductility is increased, the preform has become more suitable for flow forming. The microstructures of the preform before annealing, after annealing and during flow forming are shown in Fig.1 to 3. Fig.1 shows the microstructure of the preform in which the equi-axed fine grain structure is observed. This microstructure contains a large amount of ferrite and low carbon content so that it is soft and ductile. Fig.2 shows the microstructure after flow forming in which the elongated grains can be observed and Fig.3. displays the microstructure of the preform after annealing. After annealing, grain growth has taken place so that coarse grains are formed and because of this factor UTS and hardness are reduced while the ductility has got increased.

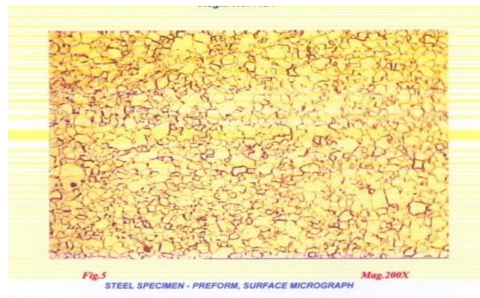

Fig. 1 Preform Microstructure

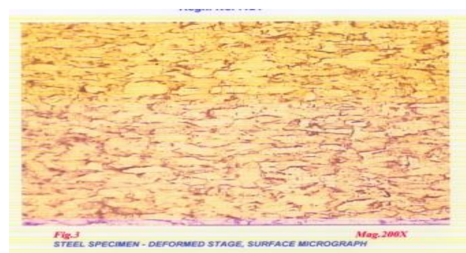

Fig. 2 After Deformation Microstructure

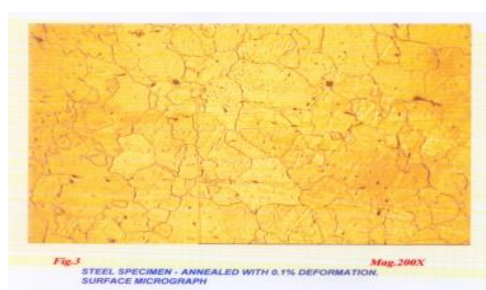

Fig. 3 After Annealing Microstructure

Table 2: Material Properties at Different Stages

Stage	U.T.S (Mpa)	Percentage Elongation	Hardness
Preform	35.24	31.25	55
After forming	80.64	6.25	92
After annealing	27.66	44	40

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With the preform having acquired improved ductility with annealing, flow forming is carried out and the mechanical properties at different stages of the process are observed. Fig.4,5 and 6 display the measured values of elongation, UTS, and hardness at various stages during flow forming. Tubes at different stages are shown in fig.7.

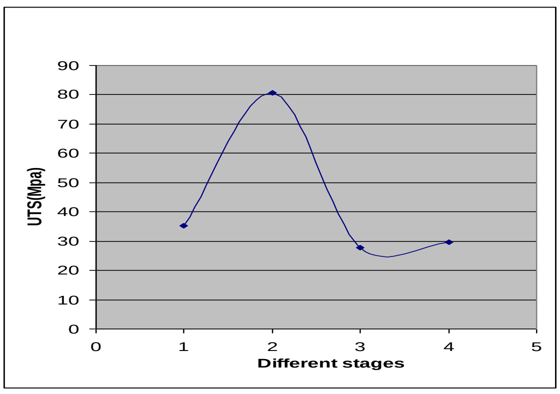

Fig. 4 Different Stages vs UTS (MPa)

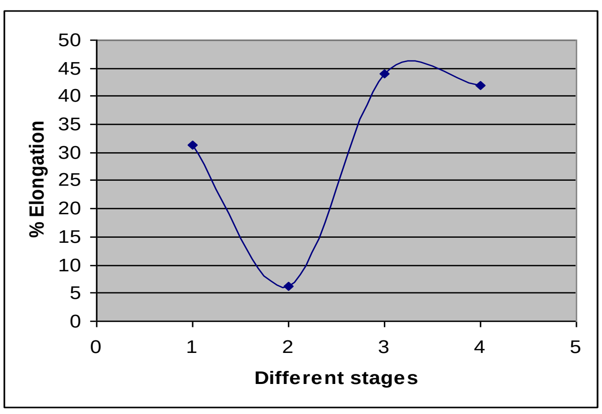

Fig. 5 Different Stages vs % Elongation

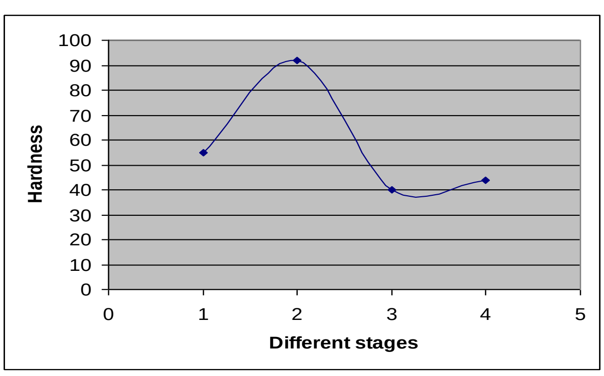

Fig. 6 Different Stages vs Hardness

Fig. 7 Tubes at Different Stages

6. Conclusions

Initially annealing is carried out on the preform to improve its ductility. During annealing ductility is increased, However, it is at the expense of strength and hardness. Once the ductility is improved, the preform is then flow formed to get the required shape. The mechanical properties at different stages are observed.

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