AN EXPERIMENTAL INVESTIGATION TO FIND THE OPTIMAL PROCESS PARAMETERS IN FLOW FORMING

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ABSTRACT

Flow forming process is an advanced eco-friendly chip less metal forming process which is used to manufacture a large variety of thin walled axi-symmetric shapes from plates or preforms.This process has several advantages like improved mechanical properties and surface quality for a finished part. Components produced through this process are widely used in aerospace and missile applications. In the present work, experiments were carried out on a three roller CNC Flow forming Machine. The optimum process parameters involved in the flow forming were determined for getting the minimum number of manufacturing defects by conducting a number of experiments. Moreover, the effect of different roller diameters was also studied. Theoretical values exhibited a good agreement with the experimental values.

Keywords: Flow forming, Optimum parameters, Roller, Surface finish

1. Introduction

There are large number of references [1-8] available in the literature on the mechanism of flow forming and various flow forming machine parameters affecting the properties and dimensional accuracy of the flow formed components. However, there are very few papers available for selecting optimum parameters in this process. Authors endeavored to select the optimal parameters so as to reduce the tooling cost and the number of defects. Flow forming has 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.

2. Description of Equipment

It is a three roller CNC flow forming machine, Model ST 56-90, Leifeild made of West Germany.

The specifications of the machine are as follows, machine view shown in fig . 1

1. Machine model: ST 56-90
2. Length of bed: 8155mm
3. Min. flow forming diameter: 60mm

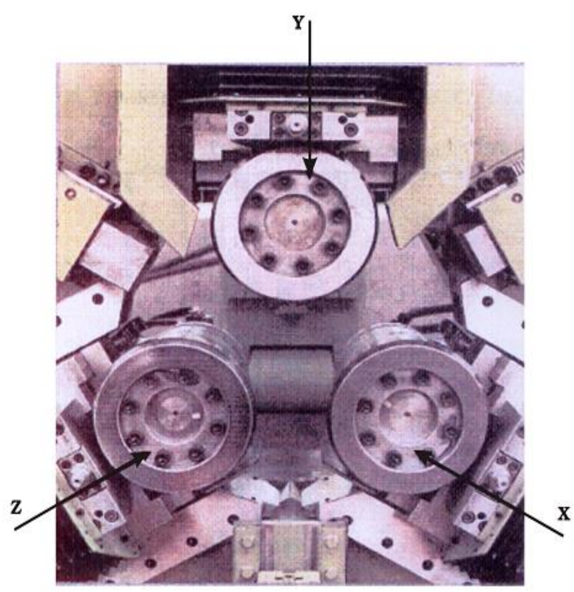

Fig. 1.a Flow Forming Machine with arrangement of three rollers

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4. Max. flow forming diameter: 660mm
5. Max. flow forming length: 2000mm
6. Stroke of tail stock cylinder:2400mm
7. Total connected load of the machine:375KVA

The control panel which is fitted in the CNC control switch cabinet contains all switches and keys required for programming and for the programmed control of the machine tubes at various stages of reduction

3. Experimental Work

Flow forming experiments were carried out on a three roller CNC flow forming machine, The chemical composition of the Low carbon alloy Steel which has been used in this study is given in Table 1. Some of the advantages of this material are high fracture toughness, high strength, good weldability, and less distortion during heat treatment.

Table 1. Composition (wt%)

C	Ni	Co	Mo	Ti	Zr	Al
0.03	0.19	0.08	0.24	0..3	0.02	0.14

Low carbon alloy steels are normally solution annealed(austenitised)1hour for each 25mm (1inch) of section size at 820c. Atmosphere control is necessary to minimize surface damage. after solutionizing the preform, its hardness will be around 30-35hrc i.e., the strength of the preform is 1050 to 1200mpa.at this stage flow forming process is carried out. Tubes at various stages of reduction shown in fig.2. The parameters fixed for the process are given below:

Intial length of preform : 152mm
Intial thickness of preform : 8mm
Outer diameter : 136mm
Inner diameter : 120mm
Roller feed : 0.36mm/rev
Spindle speed : 290 rpm

Fig. 2 Tubes at various stages of reduction

3.1 Number of passes

The operation is carried out in 3 passes as per the details given in the Table .2.

Table .2

SI.no	Pass number	Initial thickness(mm)	Final thickness (mm)	% of reduction
1.	First	8	5.1	36%
2.	Second	5.1	2.7	47%
3.	Third	2.7	2.0	40%

4. Results and Discussion

4.1. Some of the observations found out during the experimentation were as follows:

- The large radius on the rollers increases the feed rate. The choice of roller diameter effects the area of flow deformation and hence the forces. The larger the roller diameter smaller torque was observed.
- More the contact geometry between the roller and the work piece, greater the number of defects in the process. However good surface finish was obtained, the only disadvantage is that more power is required because more metal is moved per unit of time.
- The contact geometry between the roller and the work piece plays a critical role in the successful operation. when roller diameter is decreased, contact geometry is minimized and hence the number of defects were reduced.
- When surface finish is not of primary importance, the standard type of rollers are preferred as the contact area is low and it leads to the minimization of defects and power requirements.
- Number of trail experiments were done for finding optimum parameters

4.2 Effect of Roller Feed on Tangential Force

Tangential force is calculated form the following equation [11] :

$$F_T = (t_i - t_f).f.K \frac{\epsilon^{n+1}}{n+1}$$

where

t_i = initial thickness of the wall (preform thickness) in mm,

t_f = final thickness of the wall in mm,

f = roller feed in mm/sec,

f_t = tangential force in n,

k = strength coefficient of the material in N/mm^2,

$\in$ = strain (three times of ln (t_i/t_f)),

n = strain hardening exponent,

r = roller radius in mm,

The results are plotted in fig.3. It is observed from the fig that optimum feed is obtained at point 2. At this point defects were also minimized.

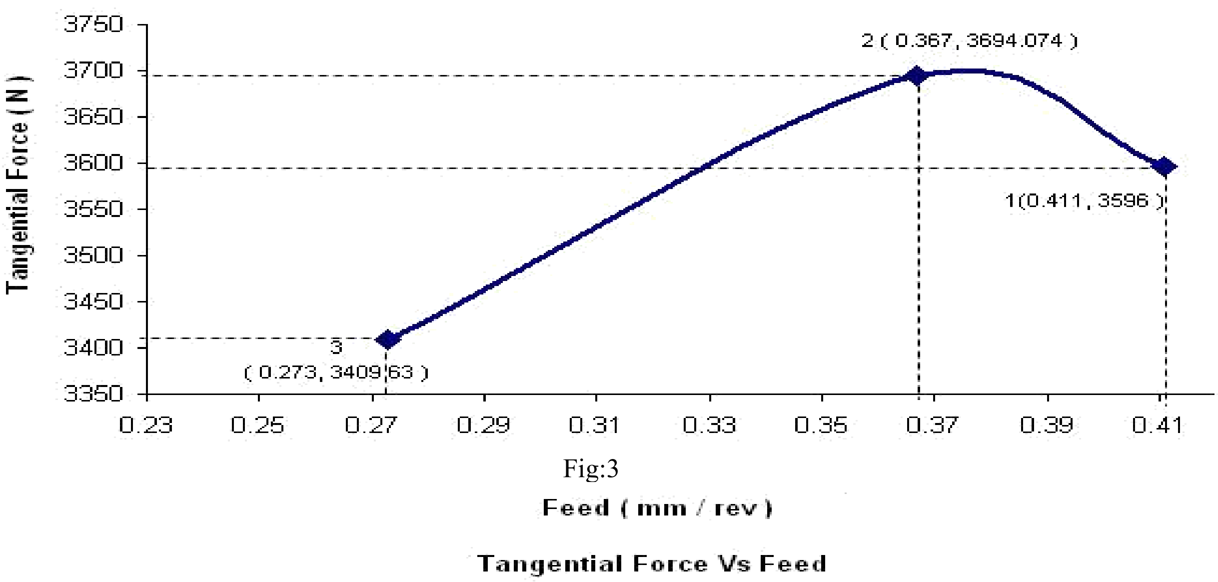

Fig:3

4.3 Optimum Results

The optimum parameters were obtained are given below:

Optimum parameters:

1. Mandrel speed (RPM)	:290
2. Roller geometry (Entry angle/ Corner radius/ Exit angle)	: (22.5 º/8/6º)
3. Roller diameter	: 250mm
4. Roller infeed	: 1.4mm

5. Conclusions

1. Theoretical values exhibited a good agreement with the experimental values.
2. Different roller sizes were examined through flow forming process .
3. Optimum feed was found through fig.3
4. Optimum parameters were found by conducting number of trail experiments.
5. Final strength of the tube is improved up to the requirements through age hardening.

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