A COMPARATIVE STUDY OF EXPERIMENTAL AND SIMULATION APPROACHES FOR FLOW FORMING OF CIRCULAR ALUMINUM TUBE (2219)

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Abstract

Precision thin walled Al tubes are required for several critical applications. Flow forming is commonly used to manufacture such components as it is an economical and efficient process. In this process, wall thickness of pre-form is reduced and the length is increased with out changing inner diameter. The dimensional accuracy is largely affected by various forming parameters such as mandrel speed, roller feed, and roller geometry. This paper deals with important findings during the production of Al tubes for getting the optimum parameters. The experiments were conducted on two roller CNC flow forming machine. The present work compares the results obtained by the experimental approach and the simulation process carried out by DEFORM-2D. The experimental results exhibited a good agreement with the simulated values.

Keywords: Flow forming, simulation, experimentation, forming parameters

1.0 INTRODUCTION

The selection of a suitable roller is a major problem in any flow forming process. Although there are a large number of references [1-9] available in the literature on the mechanism of flow forming and flow forming parameters affecting the properties and dimensional accuracy of the flow formed components, there is little data available on roller selection. The geometry of roller is such an important issue that the inappropriate selection of geometrical parameters hinders the material flow, leading to specific types of defects. The present work involves the reduction of number of trail experiments to achieve a defective-free process by selecting an appropriate geometry of roller. Analysis is carried out through the simulation package, DEFORM-2D.

Flow forming is a process by which cylindrical parts are produced from cylindrical blanks. The cylindrical blanks called pre-forms are stretched over a rotating mandrel by means of two rollers, arranged equidistant to each other. The pre-forms 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 are used as initial pre-forms. They are two types of flow forming processes. The first one is the forward flow forming process in which the cup shaped preform is held on the rotating mandrel by means of a tailstock and as the roller feeds towards the headstock, the tube is also elongated in the same direction. Thin walled cylinders with thick bottom can be flow formed by this method. The second type is the reverse flow forming process. In this process ring type preform is held on the rotating mandrel at headstock end and the tube is elongated in the opposite direction to that of roller traverse. This method is used to flow form tubes which have both ends open. The advantage of this process is that tubes longer than the mandrel can be flow formed. In the present work, Al tubes were manufactured by the reverse flow forming process.

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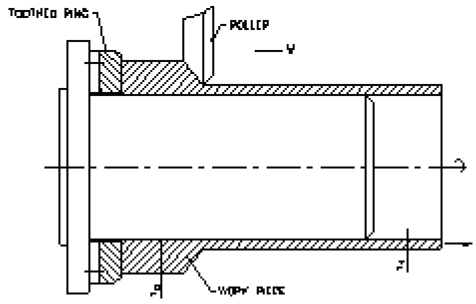

Fig .1 Reverse flow forming

2.0 EXPERIMENTAL WORK

Flow forming experiments were carried out on a two roller liefeld Germany flow forming machine. Chemical composition of the Al2219 is shown in Table 1. Table 2 lists the sample set of experimental values set for the process. The parameters fixed for the process are given below:

Initial length	:	495mm
Initial thickness	:	21.6 mm
Final thickness	:	13mm
Outer diameter	:	170mm
Inner diameter	:	126.8 mm
Spindle speed	:	190 rpm
Maximum force	:	7T

Table 1. Chemical composition of Al 2219

Al	Cu	Mn	Ti	V	Zr	Si
93	6.3	0.3	0.06	0.10	0.18	0.2

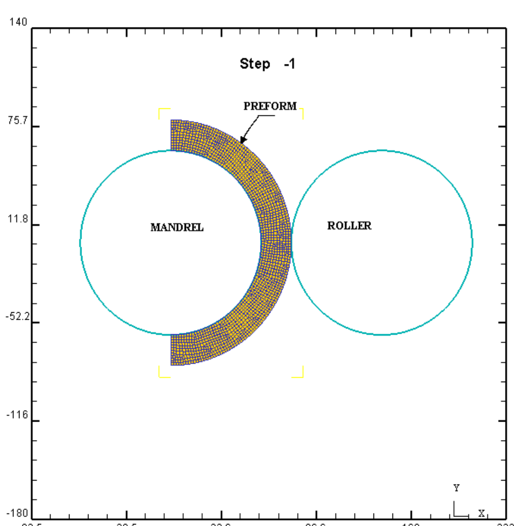

Figure 2. 1st stage in plane-strain model

3.0 SIMULATION PROCEDURE

The numerical simulation of the entire flow forming process is a difficult task. The accurate determination of the effects of various parameters involved in the process has become possible only recently when the Finite Element Method was introduced in to the analysis.

3.1 Assumptions

In the present work, the problem has been modeled as both plane-strain model and axi-symmetric model. The work piece, mandrel and rollers are in the axis of symmetry and therefore the problem can be considered as an axi-symmetric problem and the problem is modeled as a plain strain model in order to take into consideration the rotational moment of rollers and mandrel. Figs.2 and 3 show different stages in the simulation of plasticity analysis (work piece thickness reduction) of the plain strain model and Figs. 4, 5, and 6 shows the different stages for axi-symmetric model.

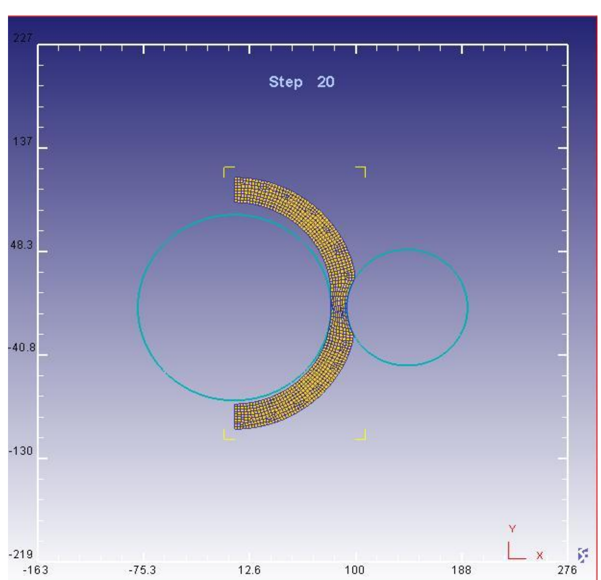

Figure 3. Analysis at 20th iteration

Table 2: Experimental Values

No. of Pass	In-feed (mm)		Thickness Reduction (mm)	Traverse feed (mm/min)	Elongation (mm)
	Roller 1	Roller 2			
1	5	5	21.6 -19.2	100	50
2	7	7	19.2 -17	100	100
3	8	8	17 - 16.3	50	120
4	9	9	16.3 -15.1	50	130
5	10	9	15.1 – 14	50	130
6	11	9	14 – 13.5	50	120
7	12	9	13.5 – 13	50	100

3.2. Modeling and Meshing

Modeling was done in AUTOCAD and exported as DXF files to DEFORM-2D package. Automatic mesh generation (AMG) was used to create a mesh by considering 1000 Quadrilateral elements.

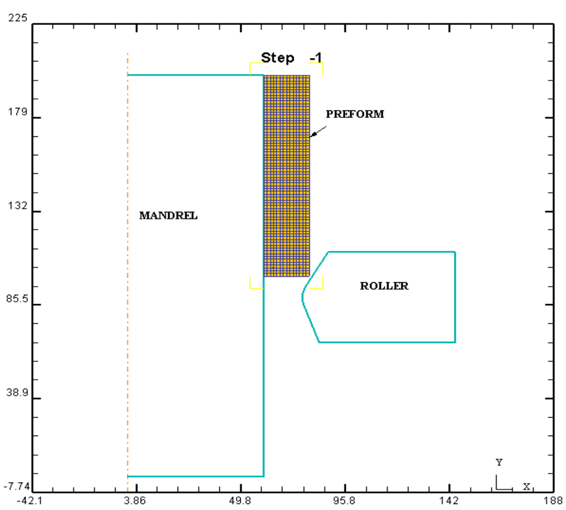

Figure. 4 Initial step in Simulation

4.0. RESULTS AND DISCUSSION

1. Optimum parameters obtained by conducting trail experiments are shown in Table 3. The optimum values of mandrel speed, roller geometry roller diameter and the number of passes for obtaining defect free work piece are listed.

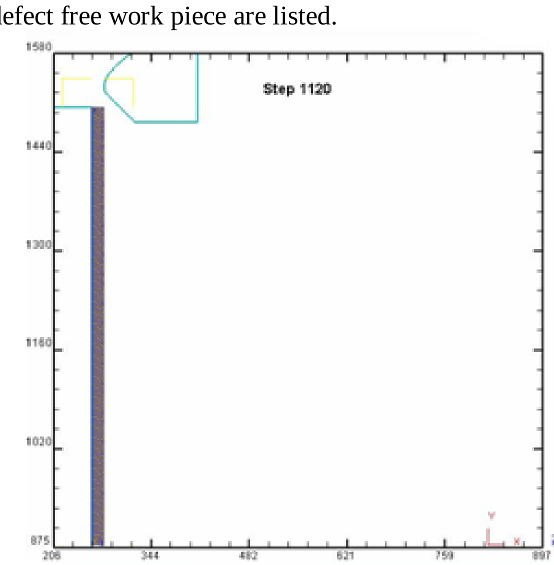

Figure. 5 Simulation in 1st pass

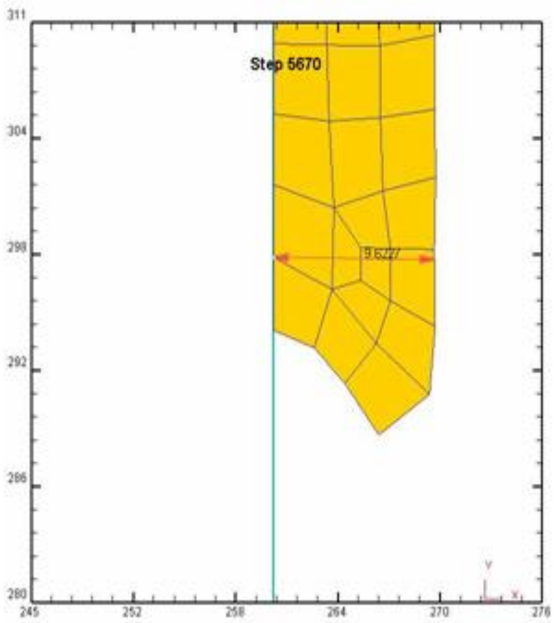

Figure. 6 Simulation in Final pass

2 .Experimental results were compared with simulated results. The experimental results exhibited a good agreement with the simulated values. With the proposed analysis, not only the tooling cost can be reduced but also the appropriate tool geometry can be obtained. Table 4 shows a comparison between results obtained by the both approaches.

5.0 CONCLUSIONS

1. The optimum parameters were obtained by both experimental method and simulation.
2. The experimental results exhibited a good agreement with simulated values.
3. Computer simulation reduces the number of trail experiments for finding optimum parameters
4. Simulation also reduces the tooling cost.

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Table 3 : Optimal parameters

1. Mandrel speed (RPM)	: 190
2. Roller geometry (Entry angle/ Corner radius/ Exit angle)	: (22°/8/5°)
3. Roller diameter	: 260mm
4. Roller in-feed	: 1.2mm
5. Number of passes	: 7

Table 4: Experimental results Vs Simulated results

	Experimental		Simulation	
No. of Pass	Thickness Reduction (mm)	Elongation (mm)	Thickness Reduction (mm)	Elongation (mm)
1	21.6 -19.2	50	21.6 -19.3	14
2	19.2 -17	100	19.3 -17.4	64
3	17 - 16.3	120	17.4 - 15.5	94
4	16.3 -15.1	130	15.56 – 13.629	120
5	15.1 – 14	130	13.62 – 11.6	104
6	14 – 13.5	120	11.62 – 10.456	161
7	13.5 – 13	100	10.4562 – 9.5997	113
Total		750		700

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