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Analysis of Elastic Recovery in cold Drawing of Sectional Seamless Tubes

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Abstract

Different diameter and sectional tubes form an important segment of Indian Seamless tube market. The paper emphasizes on the problem of Spring-back effect on sectional seamless steel tubes faced in production. The study will perform the analysis & modification to be done on land width of Die in controlling the spring back of sectional seamless steel tubes.

Seamless tubes manufactured by hollowing out solid heated billets in a Piercing mill and then cold drawing process continued. Cold drawing is the process of reducing the dimensions of sectional tubes as per required size. Both the tension & compression acts on the tubes. So required thickness of tube is achieved. In case of sectional seamless steel tubes, corresponding cross sectional plugs of suitable cross sectional dies are to be used.

The cold drawing process is the process of reducing the cross-sectional area of wire, bar or tube by drawing the material through a die without any preheating. Cold drawing process is used for the production of bright steel bar in round, square, rectangular, hexagonal, and flat section.

I. Introduction

It is proposed to study the dimensional changes in the sectional seamless tubes. The study will be confined to tubes of thickness 2mm and above. When the sectional tube is drawn through a die of average nominal dimensions, it is generally observed some dimensional variation due to elastic spring back. The spring back depends upon the land width of the die and the design of the plug used for cold drawing.

In the present study, it is proposed to study the effect of any one or two sizes with land widths of 5 or 10mm, which will be studied theoretically using analysis software to analyze the effect of design changes in the die and plug angles, land width etc. To arrive at the best possible combination to achieve dimensional stability and least spring back, this will be well within the permitted dimensional specifications.

Review of various research papers from 1962 shows that Parameters affecting the spring back are Die and plug land, Die and Plug angles, Material of the tube, Die & Plug material ,Lubrication and friction.

Generally the major contribution to the spring back is based on the length of the die and plug land. The die and plug entry angles are made optimum based on maximum cross section reduction with minimum load.

II. Finite Element Method

The finite element method is a numerical analysis technique for the approximate solutions to the varieties of engineering problems. The finite element analysis method is originated as a method of stress analysis method. Finite element procedures are used in design of buildings, aircrafts, ships, spacecrafts, electric motors and many other sectors which deal with stress, heat flow, fluid flow, etc. The finite element procedure produces many simultaneous algebraic equations, which are generated and solved by using computer software's available like ANSYS, IDEAS etc.

The studies of springback analysis were done of the tube in ANSYS 10.0. In first study the land was taken 5 *mm* on die and spring back was measured, while in second study the land portion was taken equal to 10 *mm*. Then the comparisons of springback in the tubes were done and also compared with the experiment. In both the cases the model was modeled as half model as shown in fig. 1

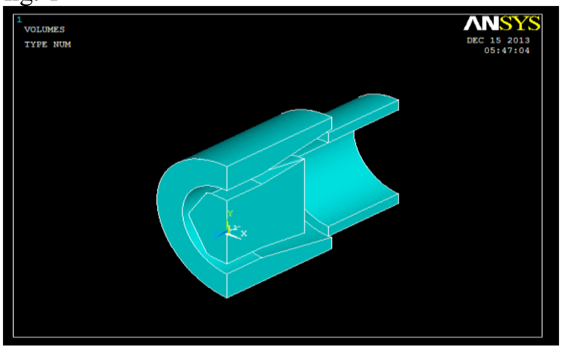

Fig. 1 3-D model of die & tube

The material for the die and the plug was D3 steel, which is generally tool steel, which contains high carbon & high chromium in it. In this analysis the die and the plug was assumed to be

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rigid with high young's modulus. The mesh was used as the mapped brick type mesh. Which is as shown in fig 2 .The element type for die, plug, and the tube was use as solid 95. The contact was defined between the die and tube and between plug and tube using target 170, and contact 174 respectively which is as shown in Fig.3.A symmetric boundary condition is applied to the side faces of the die, plug, and tube. The die, plug is constrained to move in any direction; the plug is given a displacement in X direction so that it passes completely through the die. A Multi linear isotropic property was selected for the tube material.

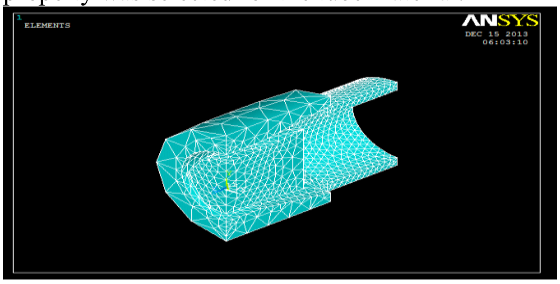

Fig.2.Meshed model of die, plug and tube assembly

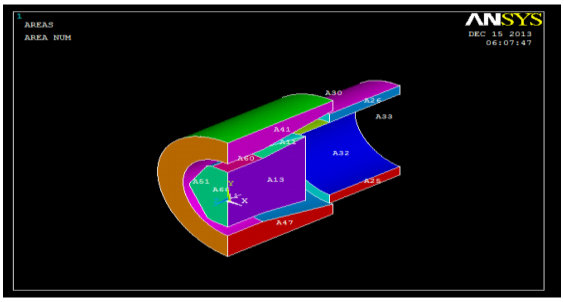

Fig.3 Contact pair simulation

III. Results and discussion

1) Von misses stress

In order to check the design safety of tubes to avoid failure it is necessary to obtain stress plot from simulation.von misses stess is maximum stress induced at particular point which is obtain for 10 mm die land as shown below.

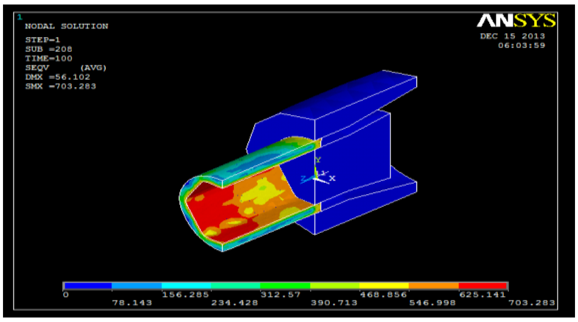

Fig.4 von misses stress plot

Above von-misses stress plot from fig.4. shows that maximum stress induced is 703.283 which is well below the ultimate stress value thus is no braking of tube takes place.

2) Stress-strain plot

As stess-strain curve is given as input for simulating material properties of various materials like ST-52 for tube.stress strain curve is obtain from ANSYS general postprocessor as shown below in fig. 5

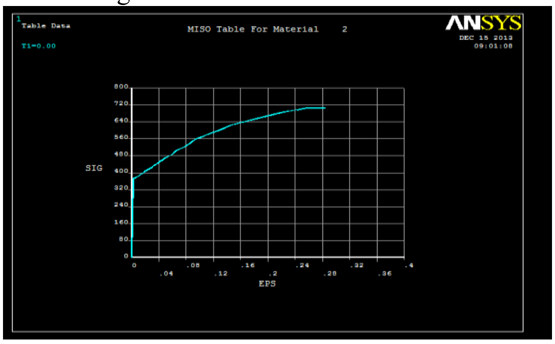

Fig.5 Stress strain plot from ANSYS

It is clear from stress strain plot that cold drawing of tube is simulated properly showing multilinear elastic property.

3) Displacement of X,Y,Z co-ordinates for both die lands.

A detail simulation of cold drawing process for tubes has been done to study the spring back effect. The actual drawing angles and die land length is used while modeling the process.

Sr No	Node	X	Y	Z
1	9686	0	12.3913	25.573
2	10490	0	9.63094	25.573
3	8686	0	-9.63111	25.573
4	8685	0	-12.3923	25.573
5	10626	-10.836	0.00200	25.573
6	9656	0	12.7136	-3.4095
7	10494	0	9.65198	-3.37033
8	8690	0	-9.65186	-3.3596
9	8714	0	-12.7146	-3.395

Following results are given by the general postprocesser of ANSYS 10 for both die land. As shown in table .I

Table I. The displacements of X, Y, Z, coordinates for 10 mm die land using ANSYS.

Similar results are obtained for 5mm die land which is tabulated as below in table II.

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Table II. The displacements of X, Y, Z, coordinates for 5 mm die land using ANSYS.

Sr. No	Node	X	Y	Z
1	9686	0	12.3352	20.8
2	10490	0	9.623434	20.8
3	8686	0	-9.634	20.8
4	8685	0	-12.3352	20.8
5	10626	-10.839	0.0011234	20.8
6	9656	0	12.7244	-8.39936
7	10494	0	9.65328	-8.38063
8	8690	0	-9.65368	-8.37031
9	8714	0	-12.7239	-8.38641

Table III. ANSYS result comparison of 5 and 10 mm land

Die Land	A/F	Thickness	OD	Springback
10 mm	19.3017	3.06215	25.426	0.0261
5 mm	19.3068	3.066	25.4483	0.0483

Above table III. Shows that springback was minimum for 10 mm die land as compared to 5 mm die land.

4. Comparison of theoretical, experimental and ANSYS result for 10 mm and 5 mm die land.

Table IV. Comparison of theoretical, experimental and analytical result for 10 and 5 mm die land

Die land	Dimension	Theoretical	Experimental	ANSYS
10 mm	A/F	19.30	19.285	19.2620
	A/C	22.17-22.29	22.317	21.6738
	O/D	25.35-25.45	25.42	25.426
5 mm	A/F	19.30	19.28	19.2574
	A/C	22.17-22.29	22.35	21.679
	O/D	25.35-25.45	25.44	25.448

From the theoretical, experimental and ANSYS results of 10 mm and 5 mm land it is clear that elastic recovery is minimum for 10 mm also experimental results obtain are found in good agreement with ANSYS results as shown in table 3.4

5) Graphical result:

Sprinback variation of tube drawing process against die land for both experimental and ANSYS can be shown more clearly with the help of graphs as shown in fig.6 and 7 as below.

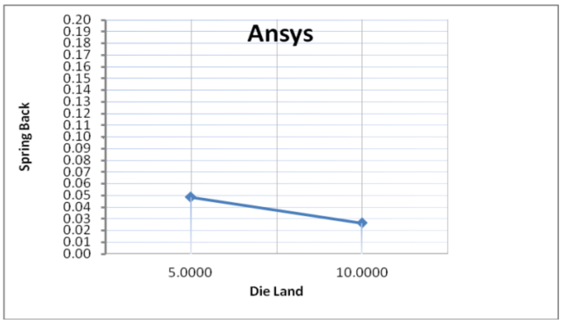

Fig. 6 Springback vs. die land using ANSYS.

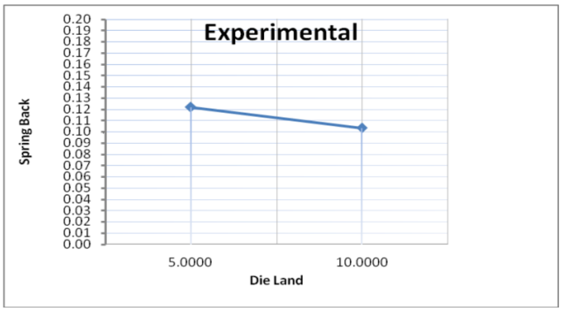

Fig.7 Springback vs. die land using experimental study.

From the above table and graph it can be concluded that the simulated results are in good agreement with the experimental and theoretical results for both 10 and 5 mm die land also springback is minimum in 10 mm die land.

6) Discussion on result

- Both experimental and ANSYS result shows that springback is minimum for 10 mm land as compared to 5mm land also table 3.4. Shows that theoretical, Experimental& ANSYS Results of 10 and 5 mm die land are in good agreement with each other.
- The dies and plugs are designed to ensure the minimum spring-back in tubes various measurements were taken for spring-back and wall thickness is tabulated.
- The maximum stress induced in the hexagonal tube was found to be 703 MPa. This is well below the ultimate stress limit of tube material. Hence tube will not break or crack in the process of manufacturing.
- Stress-time plots of various nodes are obtained showing the ability of FEA tool to simulate the variation of stress at various points during tube drawing.
- Stress-strain plot obtain using ANSYS shows nonlinear behavior of tube material is simulated successfully by using FEM.
- The experimental studies are to be limited to a minimum, because the use of each die set is very costly. The comparison of theoretical and experimental studies will lead us to a further direction for die and plug design for cold drawing the sectional seamless tubes.

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IV. Conclusion

- 3D modeling of the tube drawing process helped in visualization and conceptualization. The modeling saves the research time and minimizes the risk of design failure.
- When the sectional tube is drawn through a die of average nominal dimensions, it is generally observed some dimensional variation due to elastic spring back.
- Simulation of the process helps to check the design of dies and plug as well helps to visualize the formation of hexagonal shaped tube.
- Simulation helps to predict the metal formation as well as gives the idea of region of high stress formation. This helps us to check or correct the design of die and plug.
- The simulation helps to predict the dimension and the spring back of the tube.
- The spring back measured was found in an agreement with the experimental studies.
- The end effect found in the simulation was also found in experiment
- The FEM analysis can also be used for predicting the dimension of the actual process. Hence results in minimizing failures.
- The simulation techniques can also be used for validation of die and plug design when used for sectional tube formation such as rectangle, square, hexagonal, ovule, elliptical, octagonal etc.

V. Future scope

With reference to the above work done, it is proposed to study the dimensional changes in the sectional seamless tubes, mainly rectangular or square cross sections. The study will be confined to tubes of thickness 6 *mm* and above. The dimensions to be selected will be among.

Square tubes 101.6 x 101.6, 120 x 120 and 140 x 140, Rectangular tubes 101.1 x 50.8, 120 x 80 and 160 x 80.

Present study deals with variation of die land while keeping die angle of 11□ .in future variation of die angle can be study for optimum design.

Stress analysis is to be done and the stresses acting at various key points can be validated.

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