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PRODUCTION DEVELOPMENT OF ONE AXIAL - SYMMETRICAL WORK-PIECE OUT OF SEAM TUBE THROUGH NECKING-IN METHOD

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ABSTRACT

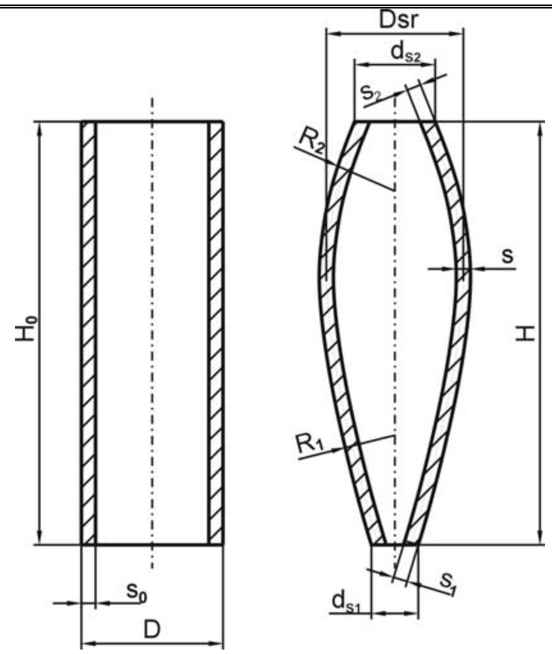
In the Study, there is a production process of one axial-symmetrical work-piece out of steel seam tube analyzed. Work-piece development is based on the preparatory sample out of seam tube in order to prove the optimality of the production. Preparatory sample diameter necking-in process is performed within two phases using two tools. Samples produced during the experiment fulfilled required mechanical and dimensional requirements.

1. INTRODUCTION

Within the research on stability of necking-in process of the work-pieces out of steel seam tubes in the Laboratory for Metal Forming Technology at the Faculty of Mechanical Engineering in Banja Luka, there is production of one axial-symmetrical work-piece out of seam tube developed through application of necking-in method, and presented on the Fig. 1.

The work-piece is produced out of steel seam tube with the D = 60 mm external tube diameter and s_o =3.5 mm wall thickness. The seam tube is produced out of steel strip through rolling procedure with series of lined up cylinders and high frequency welding of ends with subsequent calibration. There is St 37-2 Material with the following mechanical characteristics used:

$$R_m = 370 – 450 \text{ N/mm}^2$$
$$R_{eH} = 240 \text{ N/mm}^2$$
$$A_5 = 25 \text{ \%}$$



a) b)

Fig.1 View of the preparatory sample out of seam tube (a) and the view of axial-symmetrical work-piece (b)

2. NECKING-IN PROCESS ANALYSIS

Necking-in process is based on reduction of tube-like preparatory sample ends to the appropriate profile. During the experiment, there is a steel seam tube used for the preparatory sample. The aim is to prove whether the necking-in process is stable when a preparatory sample is used out of seam tube.

Necking-in forming is realized through stamping of the preparatory sample, with a profile mandrel, (4) into the necking-in ring (1), Fig 2. Safe guidance of the preparatory sample within the tool is ensured with a ring (3).

Preparatory sample dimensions (Fig.1) are determined out of volume equivalence before and after forming, i.e.:

$$\pi . D . H_o . s_o = \pi . D_{sr} . H . s_{sr} \qquad (1)$$

For creation of processing system for the necking-in process, workability potential is the most important factor. It depends on stress-strain state within forming zone, that is defined by:

- The form and size of forming zone,
- Work-piece geometry, and
- Friction factors of tool-material contact layer.

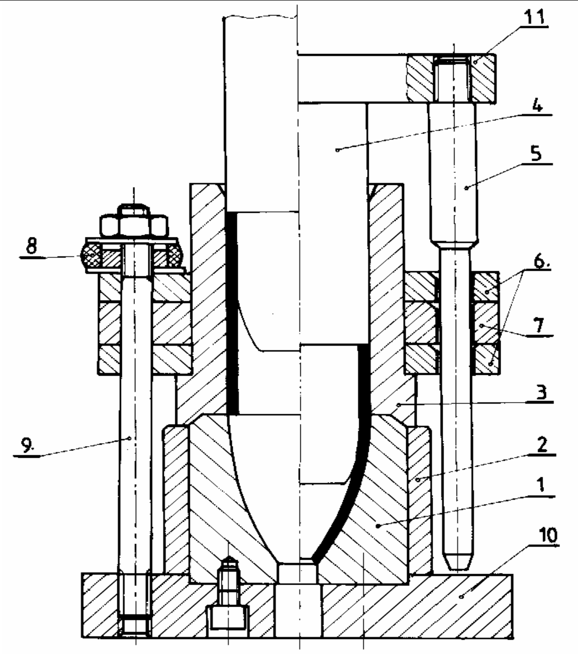


Fig.2 –View of the tool for necking-in process of an axial-simetrical work-piece

Stress-strain state in necking-in forming zone is presented on Fig. 3.

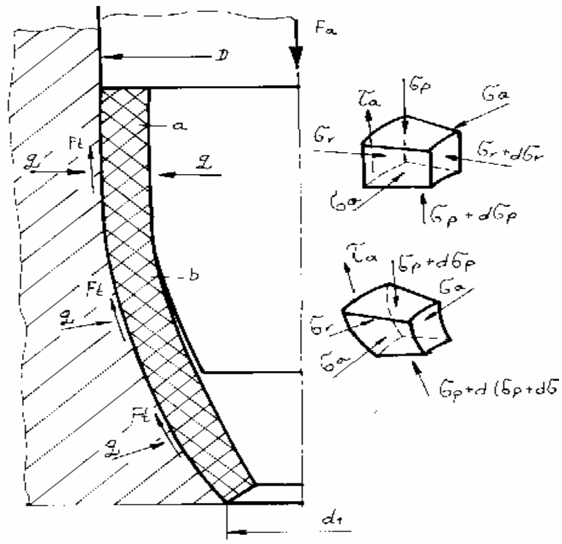


Fig.3 – Stress-strain state in necking-in forming zone

In contact zone (a), Fig. 3, there is D to ds_1 diameter necking-in realized, where the maximal necking-in forming has appeared.

Necking-in force (F_a) is calculated on the base of balance conditions of the loaded body element, and amounts to /2/:

$$F_a = \pi . D_{sr} . s_o . k_{sr} . (1 - d_{s1}/D_{sr}) . C_1 . C_2 \quad (2)$$

where:

$$C_1 = 1/2 . \left(1 + \sqrt{\frac{D_{sr}}{d_{s1}}}\right) \quad (3)$$

$$C_2 = \mu \sqrt{\frac{4R_1}{D_{sr} - d_{s1}} + \frac{s_0}{4R_1}} \quad (4)$$

D_{sr} i d_{s1} - work-piece medium diameters before and after necking-in
s_o i s_1 - walls' thicknesses before and after necking-in
R_1 - necking-in radius
μ – coefficient of contact friction
k_{sr} – medium forming resistance.

3. PRODUCTION DEVELOPMENT OF AN AXIAL-SYMMETRICAL WORK-PIECE

Production development of an axial-symmetrical work-piece is performed within two phases through necking-in from both ends of the tube-like preparatory sample, Fig. 2 and Fig. 5, because the experiments performed through simultaneous both ends necking-in of the tube-like preparatory sample within the mutual tool have not given satisfactory result, Fig. 4.

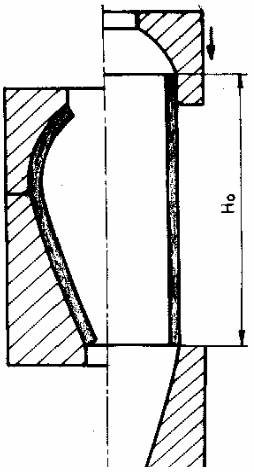


Fig. 4 - Scheme of the tool for simultaneous both ends necking-in

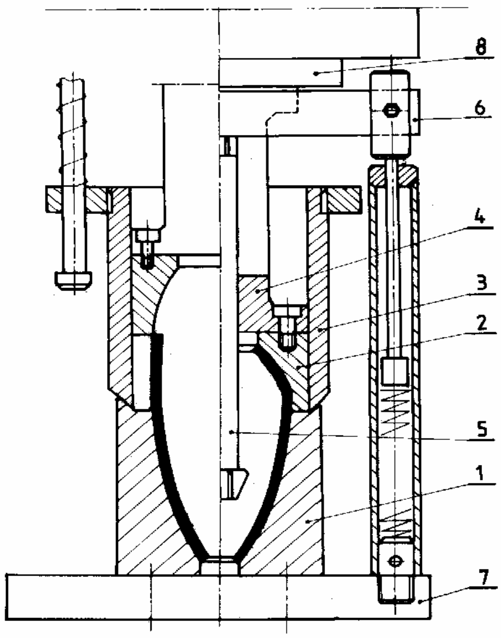


Fig. 5 - Tool for the necking-in second phase

Used preparatory samples during the necking-in experiment were previously lubricated with:

- Zn-phosphate + molybdenum disulphide suspension (MOS_2).

Ratio of realized radial and axial bending strain was analyzed through the brought coordinating net on the preparatory sample. View of the strained net on the work-piece is presented on Fig. 6. Analysis has showed that the process has been performed within stable (permitted) forming area.

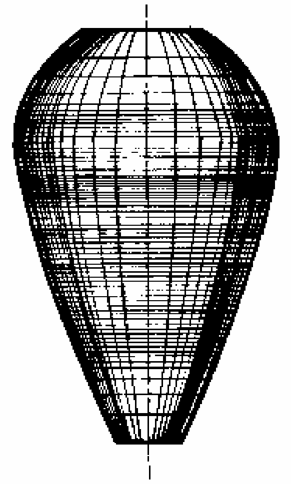


Fig.6 - Distortion of engraved net

Fig. 7 – Split work-piece photo

Work-piece satisfactory quality is also presented on the split work-piece, Fig. 7, where signs of cracks and reams have not been noticed.
Change of wall thickness has also been analyzed on the longitudinal and transversal section, whose measured values are presented on Fig. 8.

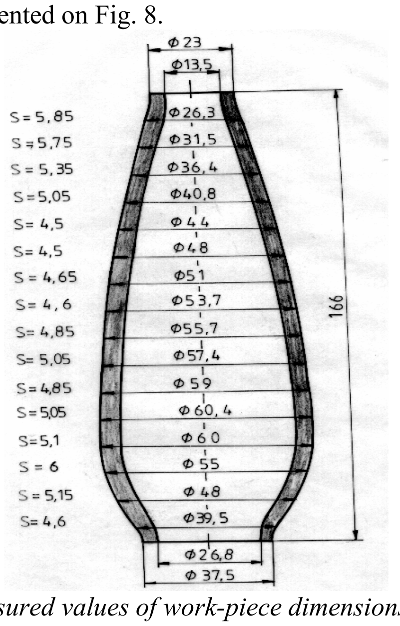


Fig. 8 – Measured values of work-piece dimensions in meridian section

Preparatory sample necking-in has also caused a wall thickness change and hardness increase, Fig. 8.

Values of calculated force according to equation (2) have amounted to:

F_{s1} = 595 kN, one side

F_{s2} = 247 kN the other side.

Measured values have been significantly greater and amounted to:

F_{s1} = 873 kN i

F_{s2} = 356 kN

Greater difference of measured and calculated force values refers to the fact that it is necessary to do corrections within the used equation for the force (2).

4. CONCLUSION

Successful production of axial-symmetrical work-piece out of preparatory sample made of steel seam tube is acknowledged. Necking-in process has been performed within two phases through necking-in from both ends separately of the tube-like preparatory sample that has been performed from the internal side in the tool. Optimization of the process requires respect for the following influential factors:

- Stress-strain state within forming zone
- Forming zone form and size,
- Work-piece geometry,
- Friction factors of tool-material contact layer.

5. REFERENCES

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RAZVOJ PROIZVODNJE JEDNOG OSNOSIMETRIČNOG IZRATKA IZ ŠAVNE CIJEVI METODOM SUŽAVANJA

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REZIME

U okviru israživanja stabilnosti procesa sužavanja izradaka iz čeličnih šavnih cijevi, u Laboratoriji za tehnologiju plastičnosti Mašinskog fakulteta u Banja Luci, razvijena je proizvodnja jednog osnosimetričnog izratka iz šavne cijevi primjenom metode sužavanja.

Cilj je da se dokaže da li je proces sužavanja stabilan kada se pripremak koristi iz šavne cijevi.

Šavna cijev je proizvedena iz čelične trake kvaliteta materijala St 37-2 postupkom valjanja sa nizom poredanih valjaka u liniju i visokofrekventnim zavarivanjem krajeva sa naknadnim kalibriranjem.

Deformacija sužavanja je realizovana u dvije faze sa dva alata, a pripremak je prethodno podmazan sa Zn-fosfat + suspenzija molibdendisulfida.

Potvrđena je uspješnost proizvodnje osnosimetričnog izratka iz pripremka urađenog od čelične šavne cijevi.

Optimizacija procesa zahtijeva uvažavanje sledećih uticajnih faktora:

- *naponsko stanje u deformacionoj zoni*
- *oblik i veličina deformacione zone,*
- *geometrija obratka,*
- *tribološki uslovi u kontaktnom sloju alat-materijal.*