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INFLUENCE OF REDUCTION IN THE THREE-DRAW SINGLE-RUN TECHNOLOGY ON MECHANICAL PROPERTIES OF DRAWN TUBES

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ABSTRACT: The paper deals with the production of cold drawn precision seamless steel tubes with the three-draw single-run technology. The aim of the experiment is to verify the possibility of drawing the rolled tubes (material E355) with three-draw single-run technology from dimension ∅ 70 x 6,3 mm without intermediate recrystallization annealing on the final dimension ∅ 44 x 3 mm in the fixed reduction and advise the impact choice of the reduction on the mechanical properties and hardness of tubes.
KEYWORDS: reduction, three-draw single-run technology, mechanical properties of tubes, hardness

❖ INTRODUCTION

Cold drawing of tubes is forming process, during which the original material (tube) forms in beams, its cross-section shrinks, thins up or the thickness of wall of pipe enlarge and length increases. The process of forming moves in several draws, depending on the original and final size of the tube. The important task is the choice of proportional reduction for the particular cross-section, because the unbalanced decomposition of reduction result into tension and deformation or cracks during the pulling, that will consequently influence on the mechanical properties and on hardness of tubes.

❖ EXPERIMENT

The experimental material is non-alloy structural steel grade E355 (see Table 1.), which was used to produce hot rolled tubes´ size ∅ 70 x 6,3 mm.

Table 1. Chemical composition of experimental material E355

C	0,1800	Mn	1,1800	Si	0,2300	P	0,0150	S	0,0140	Cr	0,0500
Ni	0,080	Mo	0,0200	Ti	0,0020	V	0,0030	Nb	0,0010	N	0,0090
Al	0,0230	Zr	0,0020	Ca	0,0022	As	0,0060	W	0,0100	Zn	0,0040
Cu	0,2000	Sn	0,0160	Pb	0,0010	O	0,0032	Sb	0,0040	Ce	0,0010

The experiment was conducted to the following technological process:
deburring → chemical treatment → drawing tube at a fixed mandrel roller → other operations.
Detailed view of the internal tube surface is shown in Figure 1.

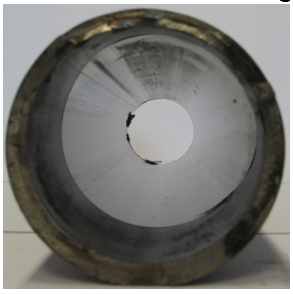
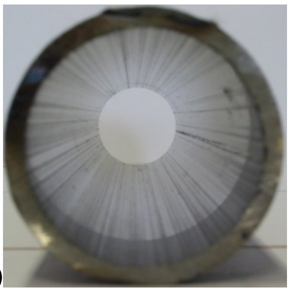

a)

b)

c)

Figure 1 Detail of inner tubes´ surface, material E355 a) Ø57x5, first draw, b) Ø50x3,75, second draw, c) Ø44x3, third draw

Determination of final reduction: Specified final reduction with three-draw single-run technology of drawing tubes from Ø70 x 6,3 mm to final diameter Ø44 x 3 mm is 69,35% which was consequently divided into three draws .

❖ EXPERIMENT EVALUATION

Figure 2 and Figure 3 shows the measured values of mechanical tests identified by basic tensile test according to STN EN 10002-1 and the values obtained from measuring of Vickers STN EN ISO 6507-1. The resultant value of the yield strength and ductility after third draw is R_m = 928 MPA and A_5 = 5,9 %. According to standards EN 10305-1, the required mechanical properties for material E355+C (C – means, that no heat treatment after the last cold forming) are R_m min. 640% and A_{min} 4 %. We can state, that the measured values meet the requirements standard EN 10305-1. Hardness of material is after third draw 222,3 HV. Since the standard EN 10305-1 does not give permissible value of hardness, as an indirect method is using the tensile strength R_m, which is determined according to EN 10305-1 at R_m min. 640 MPa was determined the minimum value of hardness 200 HV, which corresponds to the minimal strength R_m. On the basic of this indirect method, we observed, that the resultant value of hardness after third draw is corresponding to the minimum hardness.

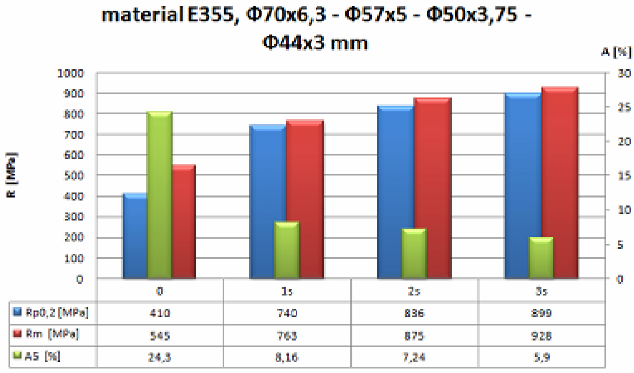


Figure 2. Graphical figuration of the values of mechanical properties obtained from the basic tensile test according to STN EN 10002-1, grade OR-1, material E355, three-draw single-run technology, where 0 – rolled tube (input semiproduct), 1s – first draw, 2s – second draw, 3 – third draw.

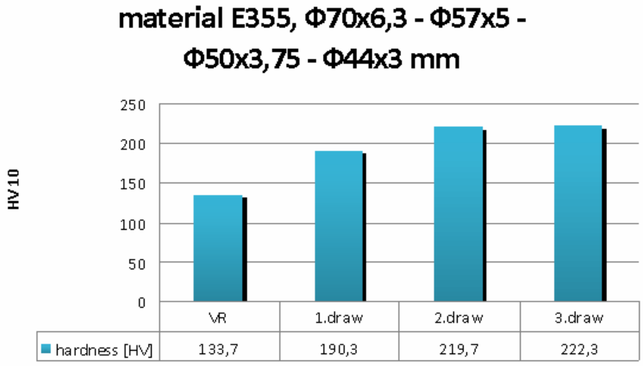


Figure 3. Graphical figuration of the measured values of Vickers hardness STN EN ISO 6507-1

❖ CONCLUSIONS

On the resultant mechanical properties and hardness of tubes surface has great influence the choice of a proportional reduction in individual sections. Inappropriate reduction setting would be reflected in the mechanical properties and hardness of the tubes surface like that values of R_m and A_5 would be smaller than is determined according to EN 10305-1. According to this standard is R_m = min. 640 MPa, A_{min} = 4% and an indirect method to determine the minimal value of hardness using min. tensile strength R_m (R_m = min. 640 MPa), was established min. hardness value of 200 HV. The graphs shows, that the experimental material had the value much higher after the first draw. It follows, that the material in terms of mechanical tests and in terms of hardness, after third draw, verifies the requirements in standard to EN 10305 and is suitable for other forming operations.

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