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HYDROFORMING OF WELDED AND SEAMLESS TUBES

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ABSTRACT

The process of plastic forming of metals and alloys has a significant place in machine engineering industry and can be conducted using conventional and unconventional techniques and methods. Tubes are frequently used elements in mechanical engineering, as part of certain constructions, which are intended to transfer a variety of fluids. Seamless tubes are significant in transferring fluid with high pressure, while the fluid with a bit lower pressure are transferred using welded tubes. Opinions that were valid until recently, and which were based on experience, state that the choice of technology in tube production has an impact on the further process of forming the tube by a deformation. The paper presents the experimental analysis of hydroforming of welded and seamless tubes, with the aim of determining the value of the necessary working pressure of fluid for hydroforming a T-shape.
Key words: *hydroforming, fluid, pressure, welded tube, seamless tube.*

1. INTRODUCTION

Tube production is divided in the production of welded tubes and the production of seamless tubes. Seamless pipes are in a relatively short period of time had a wide application in tubular structures. The reason for this were many previous beliefs, which have been limiting the application of welded tubes, and which were based on the compromised integrity of the surface area of the weld, its orientation, the heat affected zone, less homogenous structure of grain, lower corrosion resistance, etc. Seamless tubes can also have defects arising from the manufacturing process, and refer to the base of metal. Due to constant improvements in production and cost-effectiveness of technology in the production of welded tubes, more than 80% of all tubes are welded. Nowadays, they are applied in almost every aspect of industrial production. Seamless tubes are used for installation exposed to high loads, while welded tubes are used for the installation with slightly lower fluid pressure (about 20%). Further use of tubes– in constructions

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with a complex shape– requires the use of one or more conventional or non-conventional methods for their formation. Taking into account aforementioned characteristics of welded tubes, it is assumed that there are differences in the subsequent formation of tubes by deformation. For the purposes of analyzing plastic forming of welded and seamless tubes in the paper, an example of T-shape hydroforming has been provided [1-12].

2. TUBE HYDROFORMING

One of the main goals of metal industry is the optimization of forming process, as well as the minimization of costs, with the possibility of obtaining products of good quality and functionality. Hydroforming is a procedure of cold forming, through which geometrically highly complex tubular elements can be obtained, although recent research have also confirmed the application of hot forming process. The procedure of hydroforming tubes takes place through synchronized action of a fluid under pressure (expansion) and axial punch (compression) on the workpiece (tube), **Fig. 1** [1,2].

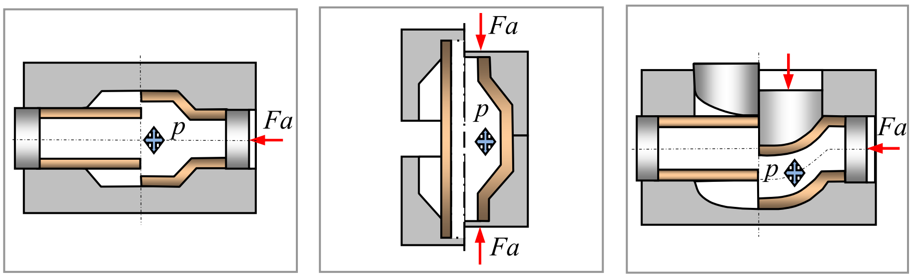

***Fig. 1** - Hydroforming of tubes*

The requirement set for the product is a high quality, which includes the manufacture of a product with the least number of components as possible, as well as less amount of material as possible (thin-walled elements). Automobile manufacturers are faced with this problem, where safety and ergonomic requirements are set for the product, in addition to functional requirements. This explains ever increasing application of hydroforming process in the production of parts of welded and seamless tubes for the automotive and aerospace industry. Hydroforming gives a possibility to achieve better quality (of mechanical and structural properties of a workpiece), as well as saving material and energy [5,6,7].

3. EXPERIMENTAL MEASUREMENT OF FLUID PRESSURE AND AXIAL FORCE OF A PUNCH

The experimental analysis aims to determine the impact of technology of tube production (welded and seamless tubes) on its subsequent plastic forming in certain forms of tubular elements. Hydroforming technology has been selected for the production process. During the experiment performance, we measured the value of the working fluid pressure to create T-shape [2].

3.1. Resources of conducting the experiment

During the experiment, the following was applied: machine for hydroforming tubes, measuring equipment and a workpiece. Experimental hydroforming of a T-shape has been performed on the hydroforming machine, **Fig. 2**.

Fig. 2 - *A machine and tool for T-shape hydroforming*

The tool for T-shape hydroforming is made of Č.4732 (DIN-42CrMo4) with N5 quality of processing. Measuring equipment, **Fig. 3**, consists of a measuring amplifier device, inductive pressure transducer (1), sensors for measuring axial force-dynamometer (2) and inductive displacement sensor (3).

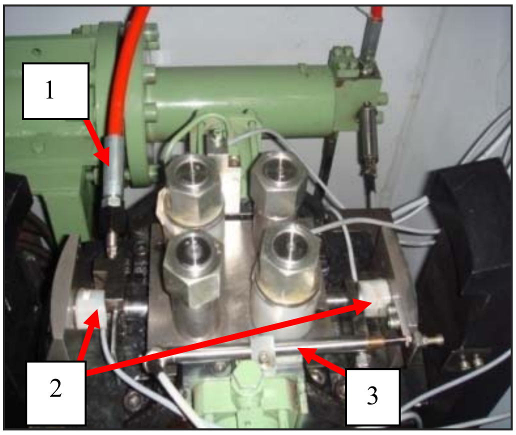

Fig. 3 - *Measuring amplifier device "Spider 8" and measuring sensors*

The initial piece is a tube 80x20x2 mm. Materials for tubes are AlMgSi0,5 (EN AW- 6060 T66) and steel tube E235 (EN 10305-1). The working fluid is oil INOL HIDROL – X46.

3.2. Measurement results

Experimental measurement has been conducted on 21 samples. Successful hydroforming of T-shape has been carried out on 8 welded and 8 seamless tubes, for both types of material, **Fig. 4**.

Fig.4 *- The samples of the hydroformed T-shape*

The results of measurements of fluid pressure for 16 successfully formed samples are given in **Fig. 5**.

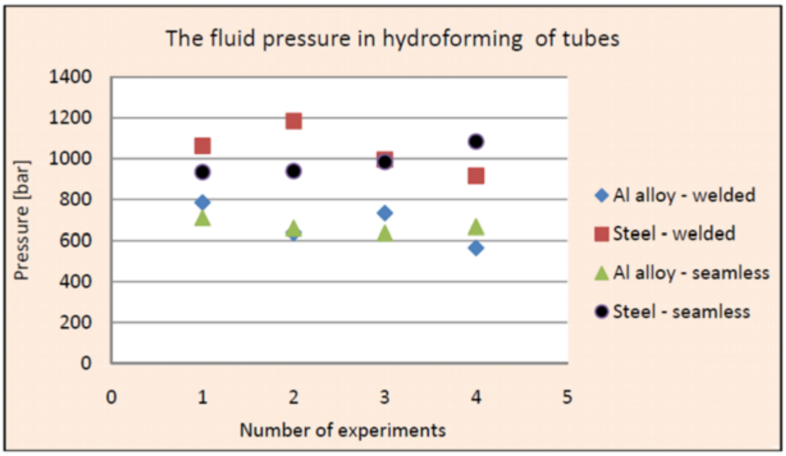

Fig. 5 *- The working fluid pressure in hydroforming welded and seamless tubes made of aluminum and steel*

Graphical representations of the measured values for the two samples of hydroformed welded and seamless tubes made of aluminum are given in **Fig. 6**.

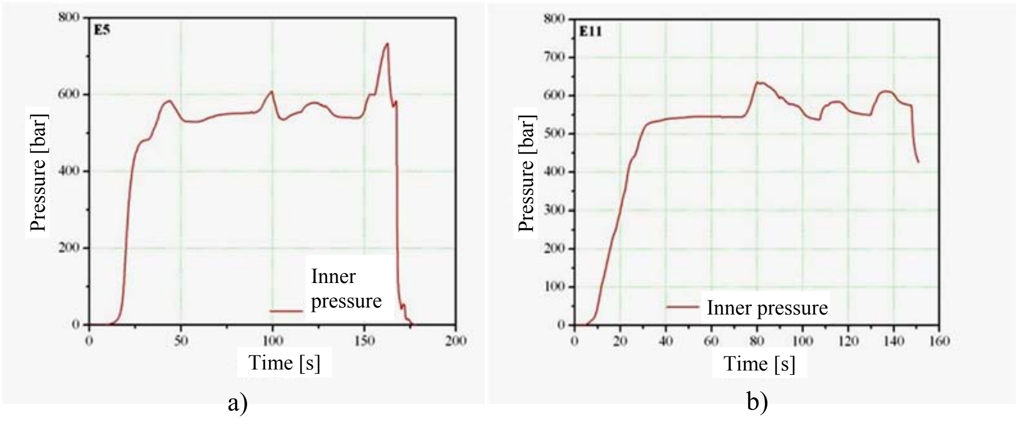

***Fig. 6** - Working fluid pressure for hydroforming (a) welded and (b) seamless aluminum tubes*

Working fluid pressure for hydroforming welded and seamless steel tubes are given in **Fig. 7**.

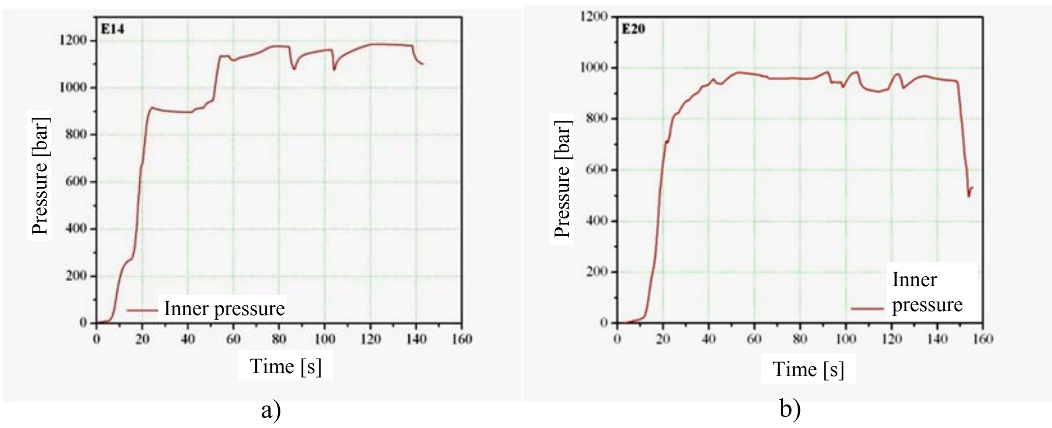

***Fig.7** - The working fluid pressure for hydroforming (a) welded and (b) seamless steel*

To compare the measured experimental values of working fluid pressure, the mean value of fluid pressure (p_{sr}) has been used. Analysis of the results indicates that the values of working fluid pressure in hydroforming T-shape from aluminum alloy for samples obtained from a welded tube (p_{sr}= 680 bar) and seamless tubes (p_{sr} = 668 bar) showed deviations around 2%, while the deviations in used samples from steel for fluid pressures of welded (p_{sr}= 1040 bar) and seamless (p_{sr}= 985 bar) tubes was approximately 5%.
In the analysis of experimental results for aluminum and steel alloys, it is evident that about 35% higher working fluid pressure is required for the design of welded and seamless steel tubes, in comparison with welded tubes from aluminum alloy. About 32% higher working fluid pressure is required for hydroforming seamless steel tubes, in comparison with seamless aluminum tube.

4. CONCLUSION

Analysis of the obtained experimental values of the working fluid pressure in T-shape hydroforming for both types of materials showed that somewhat higher fluid pressure values are necessary for the formation of welded tubes in relation to seamless tubes. A change in the structure and mechanical properties of materials in the seam area, created by the welded tubes technology, can be seen as the reason for these differences. Considering the continuous development and progress of welding technology, as well as types of materials for the tubes production, it is expected that the resulting differences in the measured values of the working fluid pressure for T-shape hydroforming will be reduced. As it has been expected when it comes to the T-shape forming, it turned out that there was no difference in the values of the working fluid pressure for both types of materials in the hydroforming of certain samples of welded and seamless tubes, so that aforementioned differences that have been obtained can be neglected. In addition, this experimental analysis has confirmed that just over 30% higher values of working fluid pressure are necessary for the hydroforming of steel T-shape (E235), when compared to a tube from aluminum alloy (AlMgSi0,5).

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HIDROOBLIKOVANJE ŠAVNIH I BEŠAVNIH CEVI

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REZIME

Hidrooblikovanje se smatra naprednom tehnologijom procesa plastičnog oblikovanja, koja ima širu primenu u auto industriji. Eksperimentalna istraživanja u ovom radu fokusirana su na određivanje vrednosti radnog pritiska fluida potrebnog za hidrooblikovanje šavne i bešavne cevi u račvu T oblika. Analizom su obuhvaćene dve vrste materijala, aluminijska legura (AlMgSi0,5) i čelik. Izmerene vrednosti pritiska fluida u cevi pokazale su da je za hidrooblikovanje cevi od čelika (šavne i bešavne) potreban veći radni pritisak u odnosu na cevi od aluminijumske legure, što odgovara razlici u njihovim mehaničkim osobinama. Takođe su za hidrooblikovanje šavnih cevi potrebni nešto veći radni pritisci fluida u odnosu na bešavne cevi oba materijala (od 2-5%). Razlog tome, je moguća promena u strukturi materijala zavarene cevi. Svakodnevni razvoj tehnologija zavarivanja pruža mogućnost uklanjanja eventualnih nedostataka nastalih procesom zavarivanja, čime se postiže uspješno hidrooblikovanje šavnih cevi.
Key words: hidrooblikovanje, fluid, pritisak, šavna cev, bešavna cev.