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Krzysztof Lukasik, Lublin University of Technology, ul. Nadbystrzycka 36, 20-618 Lublin
Volodimir Ivanovich Stebliuk , National University of Ukraine

Problems in production of uniformed, hollowed push-pull rods

The article presents the results of research on uniformed push-pull rods endings. The aim of research was the analysis of characteristics and the possibility of durability improvement, in particular fatigue durability. The research included microstructure analysis and numerical modelling of manufacturing process. The influence of technological parameters on characteristics improvement was also analysed. The obtained results will be used to develop a new method of forming, and to produce sample elements which will be subjected to verification trials.

Key Words: push pull rods, microstructure examination, computer modeling, neck forming

1. Introduction.

Many technical products require using light hollow elements. Push-pull rods belong to this group. They are connected to other elements by properly shaped endings. They are usually made as uniform elements. A typical product made from 2024 alloy is shown in fig. 1. It has a diameter dz=28mm, the wall thickness 1.5mm and the length of 350mm. During trials, fatigue caused cracking can be observed in the area where the cylindrical section changes to coned shaped threaded section fig.2.

The crack propagates from the inside wall at the border of cylindrical section and narrowing section. Thick grain structure occurs at the division surface macrostructure. The crack beginning at the interior side proves the existence of tension concentrator, the connection of cylindrical and cone sections of the rod.

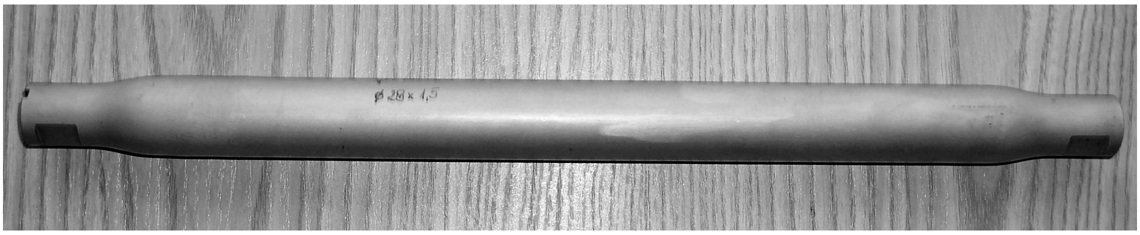


Fig. 1. Photograph of a unit

The production technology is responsible for the failure. The graph representing technological patented [1] equipment is shown in fig. 3.

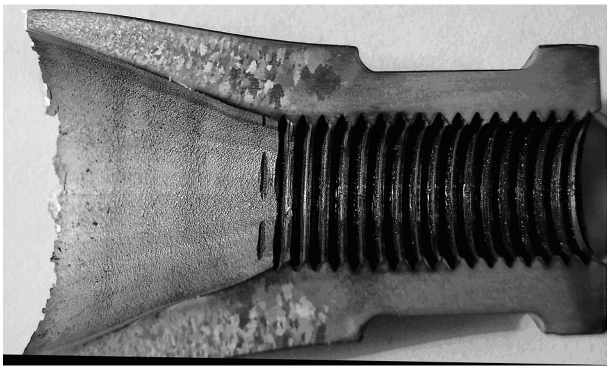


Fig. 2. Photograph of a separated part

The rod ending is formed by pushing cold pipe using P1 punch through hot matrix. During necking it heats up and the diameter is reduced. After pushing the required length of material punch P2 starts upsetting the ending. After the forming process is finished the product is pushed out of the tool. The process sequence and change of shape at this step is shown in fig 4.

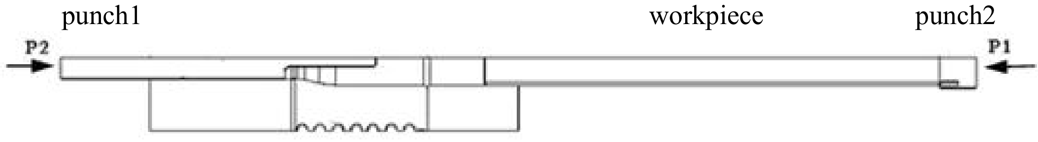


Fig. 3. Process diagram 1

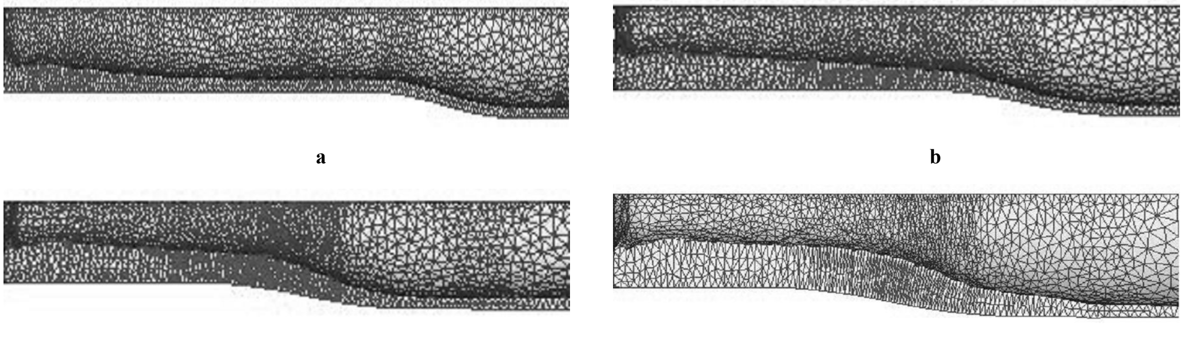


Fig. 4. Progression of the shape forming of the ends of a push-pull rod for the subsequent stages of the forming process (low forming speed): a – 15%, b – 30%, c - 55%, d – 85%

This production method leads to the creation of a specific intermittent zone. It is characterised by very small strain in the area close to the zone where the rod changes shape, between deformed and not deformed section. The material is also subjected to higher temperature which leads to the grain expansion.

Microstructure analysis confirms the presence of thick grain structure zone (point P in Fig.5) in the area of fatigue cracking. It proves deterioration of material's mechanical properties [2]. Microhardness distribution shown in fig. 6 suggests its diversification.

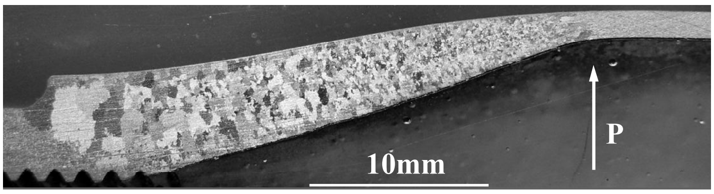


Fig. 4. Microstructure of a push-pull rod cross with a marked P point of a fatigue fracture, digested with a Keller reagent

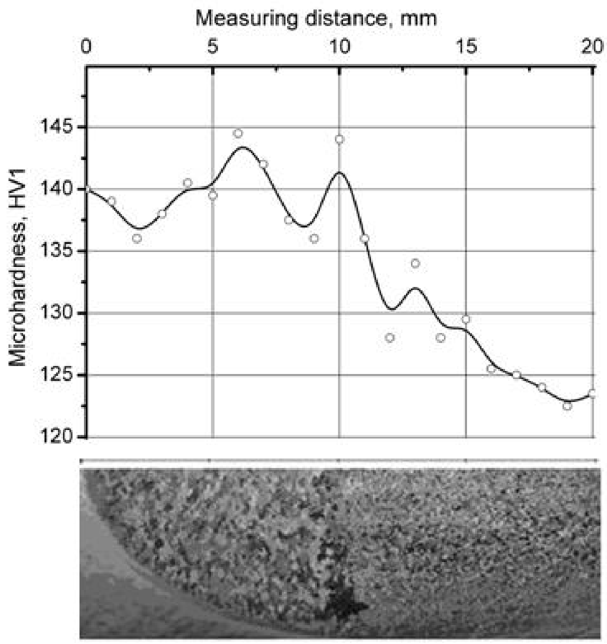
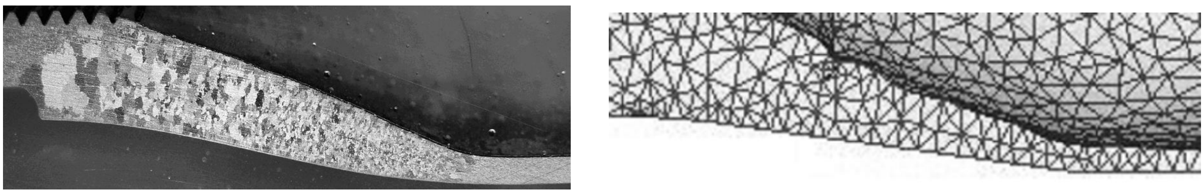


Fig. 6. Microhardness distribution in a transition zone

2.Computer simulations.

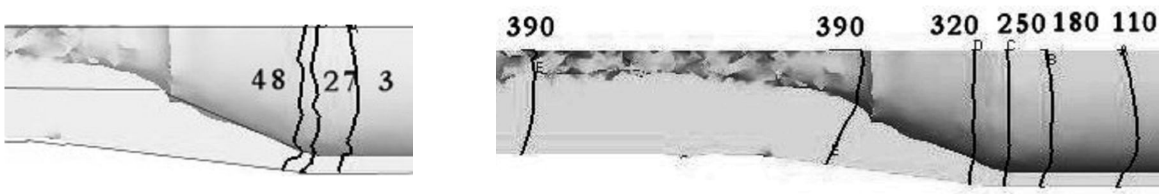
Deform 3D was used for numerical modelling . Contact heating for the material and the tools was assumed. The process is of closed type, hence the heat exchange with the environment was ignored. The proprietary material properties model for the temperature range 20-450^{o}C for 2024 alloy was used. Friction coefficient was assumed to be μ=0,4.

Numerical analysis was conducted according to the process shown in fig.3. During the first phase of forming the pipe is pushed into the narrowing die through the punch P1 with variable speed (1 to 25mm/s). Hot die temperature is 460 ^{o}C. After creating the smaller diameter of a tube punch P1 is stopped, and punch P2 is started. The upsetting of the ending is performed with the speed v_s=50mm/s. The appropriate choice of temperature, speed of forming is important not only because of the process itself but also because of the final shape of the intermittent zone of the rod (fig.7), and because of temperature and mechanical condition of the material (fig.8). Small deformations and increased temperature lead to decreased mechanical properties.



a b

Fig.7. Comparison of a push-pull rod transition: a – photograph, b – computer simulation



a b

Fig. 8. Fial stage distribution of: a – total strain in %, b – temperature in ^{o}C

3. Podsumowanie.

The results of performed simulations show that the shape of the rod in the intermittent zone is strongly influenced by the heat state of material (temperature distribution). It is the result of the time of forming with a hot tool which is influenced by the speed of tools, temperature of a tool, time of the process and workpiece cooling after forming.

Because the durability of parts produced with this method is decreased it is important to change the method of forming. Because it is not possible to completely remove the intermittent zone, the change in the final location would be beneficial. The beneficial factors for this process are these that cause the intermittent zone to move towards the cylindrical section, outside the present intermittent. In this case it will be subjected to smaller bending forces what will increase its durability and reliability.

Literatura

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