MECHANICAL PROPERTIES OF WIRES FOR MEDICAL USE MADE FROM MODIFIED 316LVM STAINLESS STEEL

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Introduction

Stainless steel is a material commonly used for medical implants used in orthopaedics and traumatology [1]. This steel is used for the production of unblocked nails for bone osteosynthesis [2]. Current solutions used in bone osteosynthesis can be either external or internal. In the case of the internal technique, implant-assisted anastomosis blocks the possibility of bone elongation, which is especially important for patients in the growing phase [3]. Hence, the production of 316LVM steel wires with modified properties will make it possible to introduce them into the production of bone nails/wires to treat patients in the growth phase. The work aimed to produce charging wires for the production of implants made of 316 LVM steel and characterize their mechanical properties.

Materials and Methods

The elemental chemical composition of stainless steel 316LVM. for intramedullary nails/wires, was prepared based on the requirements of ISO 5832-1. The ingots were made in the Valbruna steel plant using an electric arc furnace (EAF). Then they were remelted in a vacuum arc furnace (VAR) followed by hot forged. Hot forging was applied to produce a rod with a diameter of 5,5 mm. Their surface was etched with a mixture of sulfuric acid, hydrogen peroxide, and Cleanox and Brightner prepare. Then, in the BHH Mikrohuta Sp. z o.o., they were drawn into the form of wires with a final diameter of 1,2 mm.
The mechanical properties of rod/wires were determined based on the results of static tensile tests performed using the Inspekt table 50-250 kN machine (Hegewald und Peschke MPT) following the standard PN-EN ISO 6892.

Results and Discussion

Characteristics of the stages during the wire production were made based on measurements of its diameter. In FIG. 1, the relationship between wire diameter and total reduction (Z) as well as the total deformation (ε_s) were summarized. In the applied technological process, the total maximum reduction of 95% was obtained with a wire diameter of 1,2 mm. This reduction in wire diameter resulted in a total deformation of 3.
However, the most important aspect of plastic working was to obtain information on the mechanical properties of the wires. Based on the results from the static tensile test, the yield point ($R_{0,2}$) and the ultimate tensile strength (R_m) were determined for each wire (FIG. 2).
It can be seen that as the total reduction of the wire diameter increases, both the yield point and the ultimate tensile strength increase. It is a consequence of the change in grain morphology - their fragmentation and elongation in the direction of wire drawing as well as an increase in the density of dislocations generated in cold working.

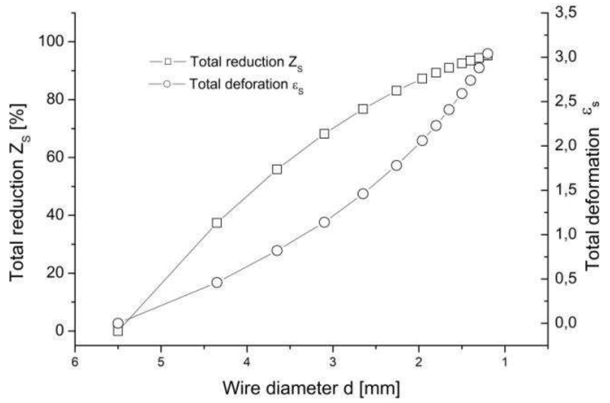

FIG. 1. Relationship between wire diameter d and total reduction (Z) and deformation (ε_s).

From the point of view of the applicability (of the wire for intramedullary nails and wires), the requirements of the standard, regarding ultimate tensile strength, must be met. In FIG. 2, the requirements for wires and nails were marked depending on the diameter of the wire. These conditions are met for wires with a diameter of 2,0 - 1,8 mm and 1,5 mm. In the case of nails, these conditions are met by all produced wires with a diameter less than 3 mm.

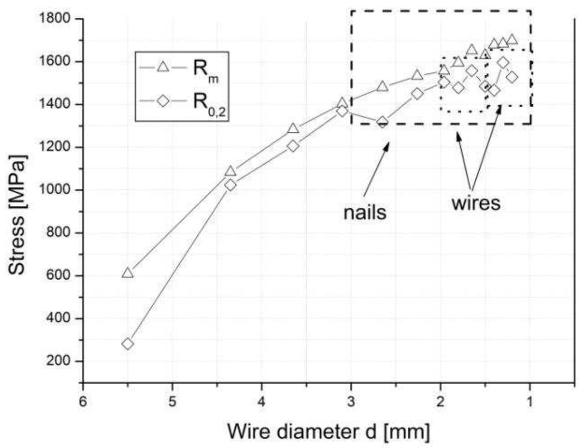

FIG. 2. Relationship between total reduction (Z) and yield point ($R_{0,2}$) and the ultimate tensile strength (R_m).

The mechanical properties of the wire with a diameter of 2.6 mm are noteworthy. The difference between the tensile strength and the ultimate tensile strength is 162 MPa. Such conditions increase the possibilities of cold plastic processing.

Conclusions

The applied methods of producing modified stainless steel 316 LVM and the ingot processing enable the production of the starting material for the manufacturing of rods and wires that meet the requirements of standards for medical devices. In addition, this material can be successfully used for the production of intramedullary wires and pins.

References

[1] T. Hanawa, Mat. Trans. 62 (2021) 139-148.
[2] K.S. Stiffler DVM, Clinical Tech. in Small Animal Pract. 19 (2004) 105-113.
[3] B.B. Franssen, A.H. Schuurman, A.M. Van der Molen, M. Kon Acta Orthop Belg. 76 (2010) 1-6.