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METAL CLOTH FROM WOLFRAM WIRES AS PART OF COMPOSITES

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ABSTRACT
At present there is vast scope for metal textiles, welded nets and other special products applied in practically all branches of industry (the automobile, aviation, foodstuffs, chemical, rubber and building industries). Metal textiles are also used for decorative purposes (Dancing House and the National Theatre in Prague, etc.). As in all branches of industry we need unconventional materials for the best application. The producers must be sure that all their products have no defects, faults or other undesired properties. Our research work was devoted to the new application of wolfram wires. We solved a possibility to create cloth from wolfram wires. The best property of wolfram is its thermal resistance and high strength. These properties are needed for application in cosmos industry. Wolfram wire finds the usage especially in composites as is for example the composite where wolfram fabric is an armature and copper is matrix. For development and effective usage of composites it is necessary to recognize the properties of wolfram and possibilities to create cloth by weaving. This paper is therefore devoted to wolfram wires and their characteristics and possibility how to weave and how to use them as composites.

Keywords: wolfram, wolfram fabric, composite with copper matrix

1. INTRODUCTION
Our contribution is devoted to the new application of wolfram wires. Wolfram (Fig. 1) is a very heavy metal and is difficult to melt. Differences in parameters of wolfram and common textile fibres are in:

o diameter of mono fibres	~ 0,05 a 0,1 mm	3 - 8x larger
o density	~ 19 250 kg/m^3	14 - 20x larger
o small tensile strain	~ 2 %	2 - 50x smaller
o modul of elasticity	~ 270 GPa	27x larger
o small strength	~ 0,14 N/tex	
o large bending in resistance		800 – 14000x larger

- inception of plastic deformation already upon first loading
- damage of surface → downgrade all properties.

We solved a possibility to create cloth from wolfram wires. It is essential to study the mechanical properties of wolfram wires before developing fabric.

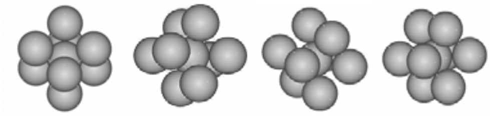


Figure 1. Basic atomic unit of wolfram

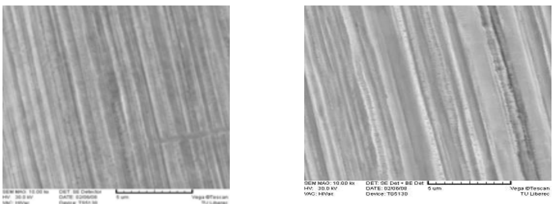
It has the highest temperature of melting among all metals (about 3422°C) and therefore, it is used for the production of fabrics, used as reinforcement of composites for cosmic industry. A composite material should have certain important features, that it should have dimensional stability at higher temperatures and at the same time it should have high thermal conductivity along with high modulus of elasticity [2].

2. EXPERIMENT

For this research purpose, wolfram wires with diameter 50 μm and 100 μm were used. They were woven into metal fabrics. These were investigated with respect to characteristics like: surface and cross section of W-wire, strength and extensibility under tension, strength and extensibility in bundle, cyclical straining and adhesion of metal fabrics [1].

2.1. Surface of W-wire (longitudinal section)

The surface structure of wire was analysed on scanning electron microscope, which is fully managed with computer.



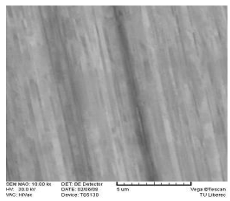


Figure 2. Detail of surface wire, 50 μm and 100 μm, MAG. 10 000x

Figure 3. Detail of surface wire 100 μm after winding, MAG.10 000x

The W-wire has characteristic streak, namely knurled surface. The wire of average 100 μm (Fig. 2) has markedly bigger knurling than softer wire), which results from the method of production. If we compare surfaces of wires of equal diameter, but before winding (i.e. in original state) and after winding (i.e. after deformation, Fig. 3), we find the wire after winding markedly loses knurling. During winding a permanent elongation or nonreversible deformation occurs.

2.2. Cross section of W-wires

Cross section of W-wire was also analysed on scanning electron microscope.

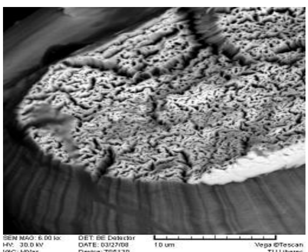


Figure 4. Cross section of wire 50 μm, MAG. 6000x

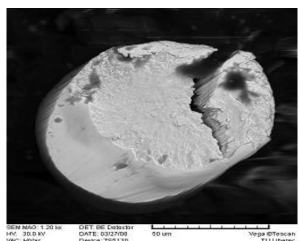


Figure 5. Cross section of wire 100 μm, MAG. 1200x

If we compare the cross section of wire with diameter 50 μm (Fig. 4) and 100 μm (Fig. 5) it is perceptible that the stronger wire has rather entire structure, whereas weaker wire, which is more fragile, has the structure highly disturbed. The scratches are seen on its surface that may be incurred already during production of wire.

2.3. Stress - strain

For tensile testing of wires, dynamometer was used. The setting of dynamometer was done as follows:

- fixative length of sample 500 mm,

- o feed speed of chops 60 mm/min,
- o direction: unbiased.

It was derived from hypothesis, that with increasing the fixative length of wire, the investigated strength will decrease. Therefore the further setting of breaker was kept with fixative length 250 mm.

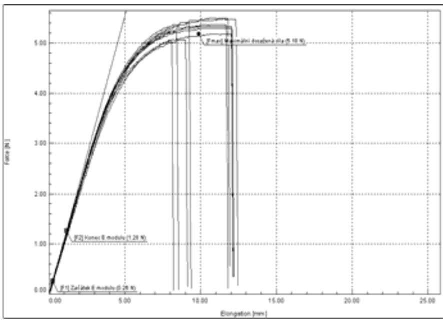
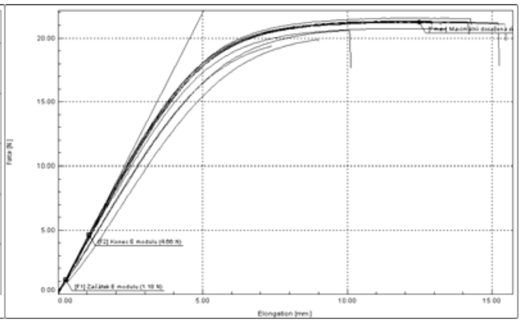


Figure 6. Load-elongation curve for 50 µm wire



F igure 7. Load-elongation curve for 100 µm wire

Stress-strain [2] behaviour was investigated on short and long abscissa. It was derived from hypothesis that with increasing fixative length, the strength will fall down [2]. This hypothesis was confirmed. With the analysis of load-elongation behaviour of wire it is perceptible that almost all wires have identical working behaviour under examination of strength. From graphs it is again perceptible that the breakage of particular wire happens in different time intervals, with different tensile elongations.

For investigation of knot strength, again dynamometer was used. Examination was effected on fixative length 250 mm on equal terms as with previous study of stress-strain behaviour. For better understanding and comparison purpose, the stress-strain, tensile-strain and knot strength [2] were investigated [Fig. 8 and 9].

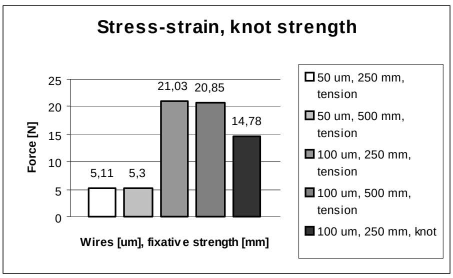


Figure 8. Stress-strain and knot strength

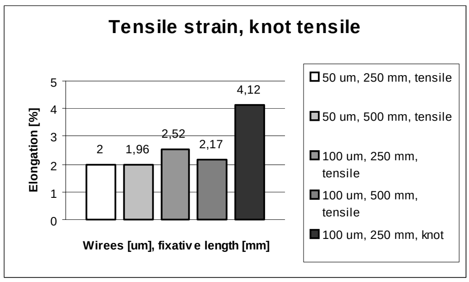


Figure 9. Tensile strain and knot tensile

By analysing, it was found that the knot strength behaviour matches approximately 70 % of stress-strain behaviour. This hypothesis has also been confirmed.

2.4. Cyclical straining

First of all, the orientation metering was realized on dynamometer. One cycle on each wire was effected. Fixative length was 250 mm and feed speed was 20 m/min. The loading force was always selected corresponding to 70 % of average strength of a given wire. Further metering was done on dynamometer. A programme for cyclic straining was used. Setting of breaker was as follows: fixative length 250 mm, feed speed of chops 60 mm/min, unbiased, total no. of cycles -10.

With cyclic straining [2], it was ascertained that once the wire is applied with tension force, it never attains the original status back and there is plastic deformation, which appears already under the initial strain. The permanent deformation of wire afterwards almost remains constant (Fig. 10).

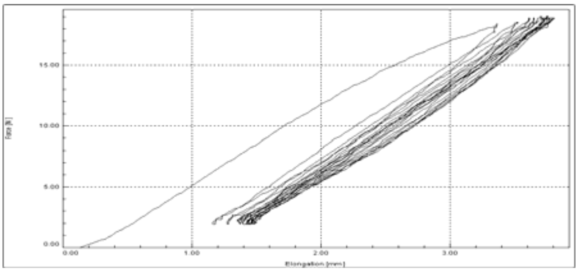


Figure 10. Stress-strain curves of wire 100 μm, in loading and unloading, at 18 N loading

2.5. Adhesion of metal fabrics

From previously characterized wolfram wires, metal fabric was woven, which would serve as reinforcement of composite with copper matrix. Therefore, the adhesion of wolfram with copper was monitored. Fabric was electroplated by galvanic coppering (electrolysis) under following conditions: flow cca 0.25 A, tension cca 1.95 V for a period of 30 minutes. Investigation of adhesion of copperized wolfram fabrics was done again on scanning electron microscope.

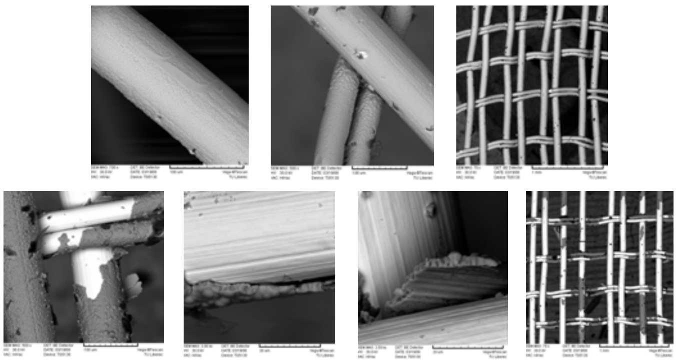


Figure 11. Adhesion of wolfram with copper

The adhesion of wolfram with copper [Fig. 11] was experimented in two parts of copperized fabrics. One part was electroplated only for the short time duration; in this case good results were not obtained. Fabricated lamina of copper did not adhere on wire and was exfoliated. The second part of fabric was copperized for a longer time and was better electroplated. The wire was almost compactly coated with layers of copper. But, if there is any irregularity on wire, or the wire is damaged, it leads to uneven electrolysis and adverse results. It is correct to state that wolfram is not suitable to be electroplated by electrolysis. But, it is necessary to avoid any defect on wire surface.

3. CONCLUSION

With the experiment it is found that:

- it is possible to produce fabrics from wolfram wires,
- optimal results were obtained with same fineness of wires both in warp and in weft,
- wires with diameter 100 μm are better for processing.

Acknowledgement

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4. REFERENCES

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