SURFACE FINISH AND TENSILE STRENGTH OF Cu/Nb SHEETS

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ABSTRACT:

As it is rather not very obvious or intuitive, the relationship between sample thickness, surface finish, and tensile strength of metallic materials was studied. The selected material was cold rolled alloy and layers of CuNb sheet metal. Several samples of different thicknesses were produced by slowly removing metallic material with 4000 grade sandpaper. The Mechanical testing was made and the data was analyzed to attempt to find a trend and finally discover if there is a relationship.

INTRODUCTION:

Although a study of the impact on specimen thickness and its tensile strength of several metals is already out in the scientific community, there had been no research in the impact of the surface finish of very thin specimens and the tensile stress changes that it made. To attempt to solve this problem a research in this subject was started, several samples of different thicknesses and surface finishes that range between 2500 and 4000 grade paper were tested.

The samples then were tested in a 250N Axial tensile test machine, pulled and given a gradually increasing amount of stress to its cross sectional area, the data was then analyzed and put into tables and graphs, the results confirmed that there is actually a change in the mechanical properties of the material the thinner they get, the samples required less stress in their cross sectional areas in order to fracture. The final goal was to obtain a trend that could predict or at least suggest that there is an optimal thickness and surface finish that yields the greatest amount of stress applied to the sample before it fractured.

PROCEDURE:

To obtain good samples with small variations of thickness through their length very careful polishing was used. The samples 20 mm in length and 2 mm in width were glued with cyanoacrylate to a glass slide cover to insure a flat surface for the polishing procedure then the system was glued to a metal disk that assembled into a device to measure the thickness that one needs to be removed, after a certain thickness the sample was removed with Acetone and then flipped.

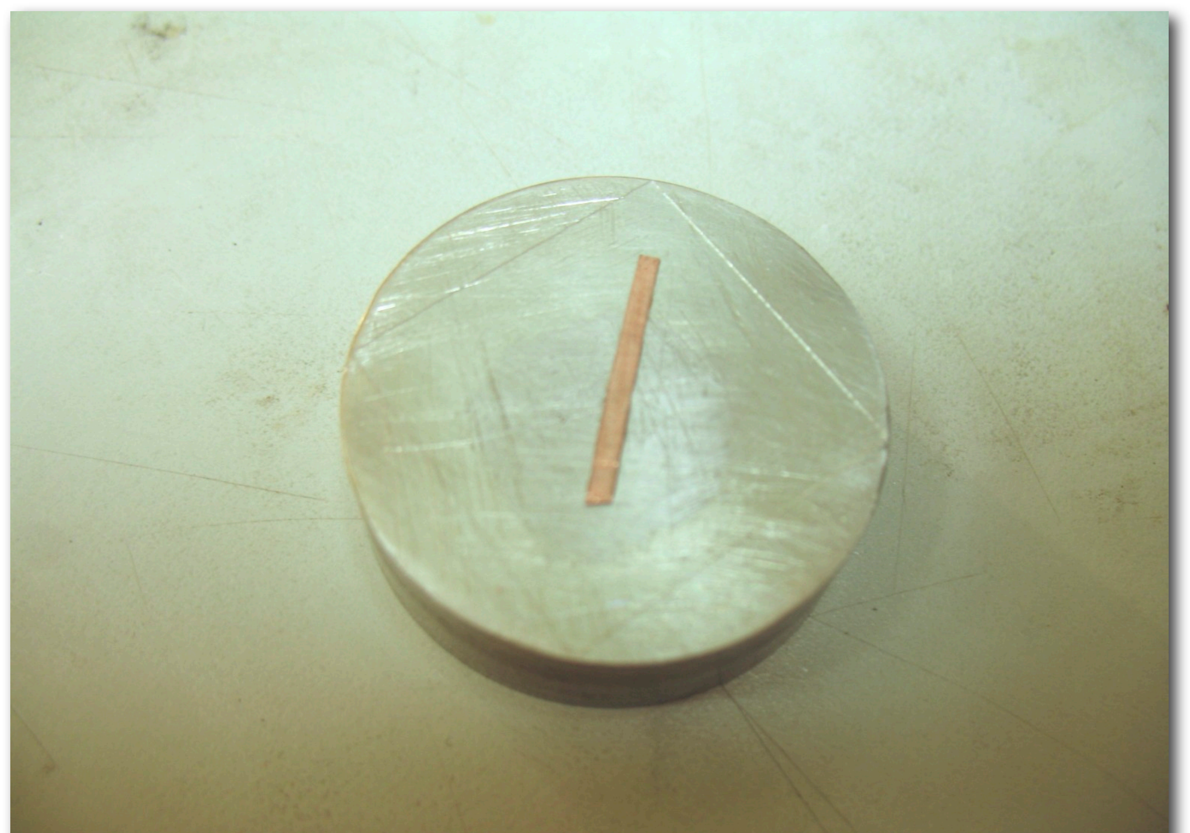

FIGURE 1 - SAMPLE POLISHER HOLDER WITH CuNb SHEET

Fig 1. -The above picture depicts the method of making the very thin samples by slowly polishing them with different sand papers to thicknesses ranging from 50 µm to 110 µm.

After this procedure was repeated several times, and sometimes starting all over again the time came to obtain information. The samples were tested for their tensile strength in a MTS MicroTester. Wedge grips were used to hold the sample in place and put it under Axial stress, the data gathered created a tensile stress graph that aided in the visualization of the forces involved in all the phases of elastic modulus of the metal, the ultimate yield strength and the fracture point.

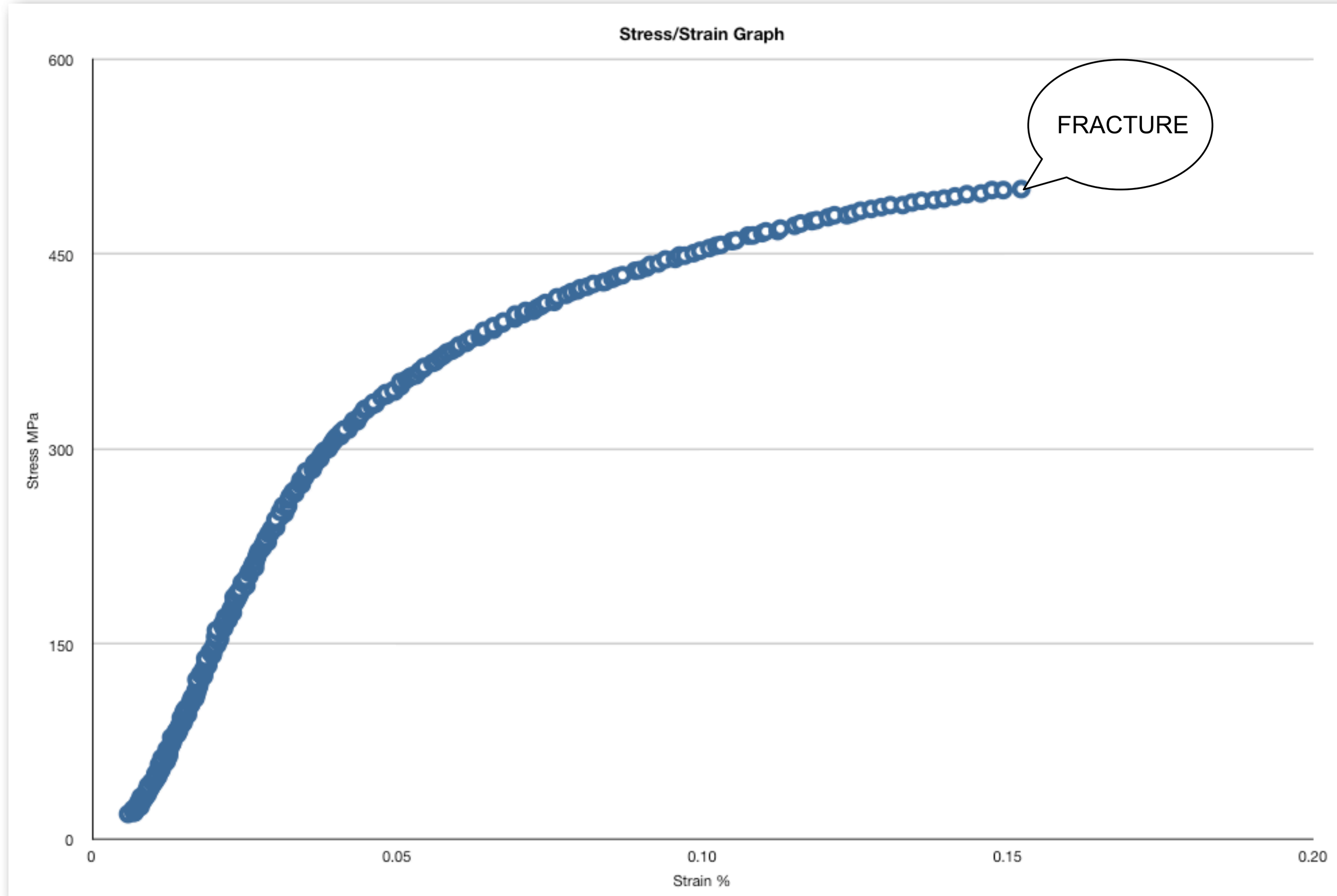

FIGURE 2 - EXAMPLE OF THE STRESS/STRAIN GRAPH OF THE 55 µm SAMPLE

The samples, had to be photographed before and after the fracture happened, so that a comparison between the 2 states could be done. Two marks 5 mm apart were put on the surface of the samples and then photographed with a microscope, the samples were then photographed after the fracture and then it was attempted to do compare and measure the elongation of the sample due to the application of the axial force.

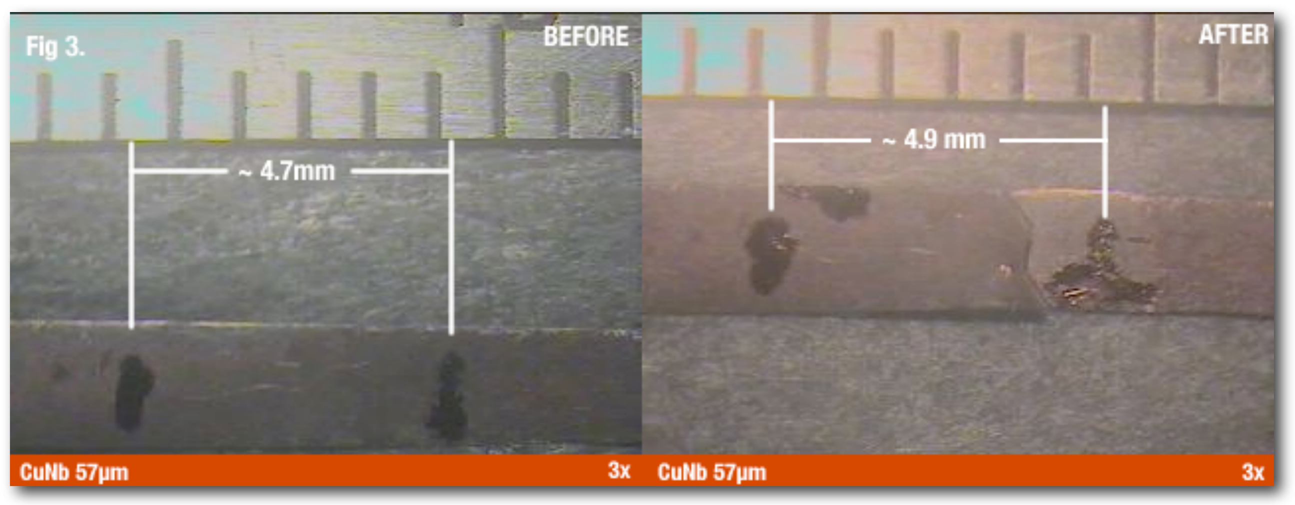

Fig. 3 - The two sample pictures before and after the testing in order to make a comparison.

Graphs and Spreadsheets were created to compare the samples and obtain information about the relationship between thickness and its tensile strength properties. Fig 2. is an example of a graph that was created by a spreadsheet by using a scatter plot graph, where all the data obtained was plotted in a graph.

Cu/Nb 55 micron sample tensile Test

TIME (sec)	AXIAL FORCE (N)	AXIAL DISPLACEMENT (mm)	STRESS (MPa)	SAMPLE PARAMETERS		
				LENGHT (mm)	THICKNESS (mm)	WIDTH (mm)
				20	0.055	1.1
0.22167969	0.018901318	-0.00069816597	0.3124184793388			
0.421875	0.048599113	-0.00028669368	0.8032911239669			
0.62207031	0.031924702	-0.00044591958	0.5276810247934			

Figure 3. Example of a spreadsheet for sample comparison.

After putting the data together in a spreadsheet a calculation of the stress was needed in order to get the ultimate stress of the sample. Stress comes from the equation:

$$\sigma = \frac{F}{A}$$ Stress = Axial Force (N)/Cross Sectional Area (mm^2)

$$\varepsilon = \frac{\delta \ell}{\ell_o} = \frac{\ell - \ell_o}{\ell_o} * 100$$ = Strain = %ΔL

The Stress is the amount of force that a material is sustaining per unit area, and the Ultimate Stress that was obtained was by looking at the trend and watching the biggest amount of stress that the material could sustain during all of the testing. The samples were then measured by hand and the change in length was compared to the % Strain that was reported in the graphs

TABLE 1. - SAMPLE THICKNESS, SURFACE FINISH AND MECHANICAL PROPERTIES

1	55µm	W: 1.1 mm - L: 16.5 mm	U.S: 500.61 MPa	~0.16% ΔL
2	57µm	W: 2 mm - L: 20 mm	U.S: 527.89 MPa	~0.17% ΔL
3	76µm	W: 2 mm - L: 20 mm	U.S: 637.46 MPa	~0.42% ΔL

CONCLUSION:

The mechanical properties of metals change in a great deal whenever the piece of such metal is analyzed in small scales, in larger scales changes in the material such as its thickness or surface finish do not make a noticeable effect in their properties. The world of variables and changes that making smaller pieces of things and smaller things every time make a gargantuan difference out a very small amount of change in the original material.

It was shown during the experiment that thickness does make a change in the mechanical properties of a metal, more data, time, techniques, experiments and equipment are needed to determine whether there is a mathematical trend which can model such changes in the properties of metallic materials. Regarding the question of whether surface finish of such metals make an effect it is still unknown due to the short term nature of the program that organized this investigation; but it was very substantial for me and the parties involved in the learning that we obtained from this investigation. Only this part was not clarified, and the effects of surface thickness were confirmed and analyzed.

As I stated before, the other conclusion that I have is the following: I learned a lot with this investigation, even with the relatively small amount of time that was given, a great wealth of knowledge and passions were revealed. I feel that this program has given me the opportunity to look to the present, see and appreciate what things have been accomplished and what is currently being done, it has given me the opportunity to look beyond to the future and watch with great emotion and excitement to what there is that will come. It has helped me learn how to use several skills and it has refined and taught me many things that will serve me forever through the rest of my life. It has reinforced my love for science and engineering and has prompted me to try to do even greater things in the future for the advancement of mankind in its quest to reach the ultimate knowledge; to make even greater things, accomplish greater and more difficult undertakings, and live in peace among nations in balance with our environment. It has taught me most of all that science is a human necessity that unites and intrigues people from every country making it the thing that is the most essential to our nature and what is making better, every single day.

Special Thanks to Dr. Ke Han and Dr. Yan Xin for helping me in everything.

[1] E. Aghion, N. Moscovitch, A. Arnon, The correlation between wall thickness and properties of HPDC Magnesium alloys, Materials Science and Engineering: Volume 447, Issues 1-2, , 25 February 2007, Pages 341-346.