CHANGE IN MECHANICAL PROPERTIES AND MICROSTRUCTURE AFTER UNIAXIAL COLD ROLLING OF ALUMINIUM 6061 ALLOYS

[1*]DIVYANSH SHARMA
Department of Mechanical Engineering
SRM University
Ghaziabad, India
e-mail: Divyansh.sharma23@gmail.com

[2]SHUBHAM DWIVEDI, [3]ANURAG JAIN
Department of Mechanical Engineering
SRM University
Ghaziabad, India
e-mail: shubhamdwivedi747@gmail.com
e-mail: ajanurag09@gmail.com

ABSTRACT: Aluminium 6061 alloy is a very widely used alloy; it is used in various industrial applications, transportation, automobile, aerospace industries. This paper focuses on enhancing the mechanical properties and microstructure evolution of the cold rolled Aluminium 6061 along the length at various thickness reductions of 10%, 20%, 40% and 60%, then it wears out. After cold rolling the strength and the hardness of material is increased, thus we have compared the initial samples with the each cold rolled samples of reduced thickness to analyze by how much the strength and hardness is improved. For this purpose various tests such as optical microscopy, tensile test and hardness test were performed on the samples. The test result shows the change in microstructure from coarse to fine , improved hardness and tensile strength after each reduction ratio.

KEYWORDS: Cold Rolling, Hardness, Tensile test, Optical microscopy & Vickers Hardness.

I. INTRODUCTION

Aluminium 6061 is a precipitation hardening alloy, the major composition of this alloy is magnesium and silicon whereas the other constituents are Iron, copper, zinc, titanium, manganese and chromium. This paper shows the improved hardness and strength of the Aluminium 6061 after cold rolling on different reduction ratio (10%, 20%, 40% and 60%) along its length and finally it wears out. After that we have made samples for polishing to obtain the other results. Aluminium is a soft material it requires very smooth and steady polishing and hence the polishing is done firstly with polishing paper of size 600, 800, 1000, 1200, 1500 and 2000. Then we moved to double disk polishing and used alumina powder of 0.1 µm for polishing. As the polishing is done we have the sample for performing optical test.

Hardness is a characteristic property of a material, not a fundamental physical property. It is defined as the resistance to indentation or the resistance to plastic deformation. In this, we will use Vickers hardness test. It is the most commonly used hardness test method. The Vickers hardness test measures the permanent depth of indentation produced by a force/load on an indenter.

Table. 1: Composition of Aluminium 6061

COMPONENT	WEIGHT "%"
Aluminium	Balance
Magnesium	0.8-1.2
Silicon	0.4-0.8
Iron	Max. 0.7
Copper	0.15-0.40
Zinc	Max 0.25
Titanium	Max 0.15
Magnesium	Max 0.15
Chromium	0.04-0.35
Others	0.05

II. EXPERIMENTAL PROCEDURE

A. MAKING OF SAMPLES FOR COLD ROLLING

We have made rectangular cross section samples through CNC milling machine, the samples are shown in the "Fig. 1."

Fig. 1: CUT SAMPLES FOR COLD ROLLING

B. UNIAXIAL COLD ROLLING

The cold rolling is a process which occurs below recrystallization temperature (at room temperature, 25°), which increases the strength via strain hardening. The samples are cold rolled directly along the length without using any lubrication and are taken out through the outlet channel. The rolling is done at different reduction ratio 10%, 20%, 40%, 60% and then the material wears out. The parameters of cold rolling are shown in "Table. 2."

Table. 2: COLD ROLLING PARAMETERS

SAMPLE NUMBER	REDUCTION PERCENTAGE "%"	INITIAL THICKNESS "mm"	THICKNESS AFTER COLD ROLLING "mm"
1	10%	12	10.08
2	20%	11	9.6
3	40%	11.86	7.1
4	60%	11.61	4.45

C. CUTTING OF COLD ROLLED SAMPLES FOR FURTHER TESTING

The cold rolled samples are further cut into smaller pieces for polishing to obtain optical image and for Vickers hardness test. Some samples are cut for tensile test. Below is the image of tensile test sample.

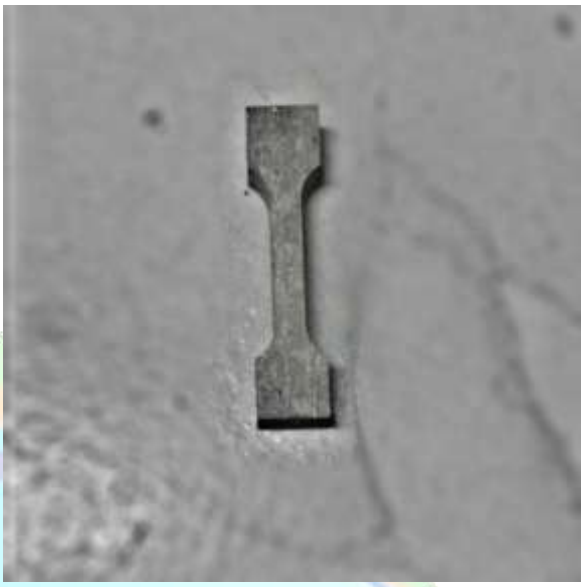


Fig. 2: TENSILE TEST SAMPLE

D. POLISHING OF SAMPLES

The polishing is done firstly with the polishing papers of size 600, 800, 1000, 1200, 1500 and 2000. And then the samples are polished on double disc polishing machine with the help of polishing cloth and 0.1 µm alumina powder. After this, etching is done to obtain the clear optical image.

E. VICKER HARDNESS TEST

The Vickers hardness test is the test in which the test material is indented with a diamond indenter, in the form of pyramid with the square base and has an angle of 136 degree between opposite faces subjected to a force between 1gf and 100kgf.

F. TENSILE TEST

Tensile test is the rudimentary material test in which a sample is subjected to a controlled tension until failure. Thus it is also referred to as tension test. The profile of tension test sample is shown in "FIG. 3."

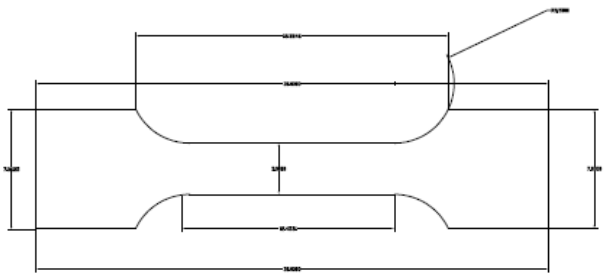


Fig. 3: TENSILE TEST SAMPLE

G. OPTICAL MICROSCOPY

The optical microscopy is done with the help of optical microscope; it helps to make fine details visible. The samples obtained after the complete

polishing and etching is placed under the microscope and the microstructure is observed by taking optical image.

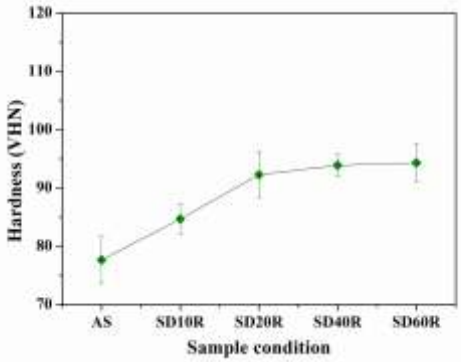
III. RESULTS AND DISCUSSION

A. HARDNESS

The Vickers hardness test is performed on the samples for different reduction ratio at different points. Then the mean is taken for the Vickers hardness number and the graph is plotted "Graph. 1." The graph shows the variation in hardness of the samples of different reduction ratio. It also shows an increase in the hardness of cold rolled Aluminium 6061 alloy with increase in reduction ratio.

TABLE. 3: HARDNESS READING FROM VICKER HARDNESS TEST

S.NO	ACTUAL SAMPLE "AS"	SD10R	SD20R	SD40R	SD60R
1	69.7	85	92.98	90.2	91.9
2	78.3	86.2	93.6	95.4	96.3
3	77.65	87.8	95.4	96.3	96.3
4	80.3	83.9	87.8	94.5	96.3
5	79	87	93.6	93.6	90
6	78.3	81	87	93.6	98.1
7	80.3	85.4	92.38	93.6	96.3
MEAN	77.65	84.66	92.98	93.88	94.32



Graph. 1: VARIATION IN HARDNESS WITH RESPECT TO REDUCTION RATIO

B. OPTICAL MICROSCOPY

The optical microscopy is performed on the test samples and the optical image is taken which are shown below "fig. 4, 5, 6, 7 and 8." The images obtained from the microscope shows the microstructure change from coarse to fine at different reduction ratio along the length in which cold rolling is performed.

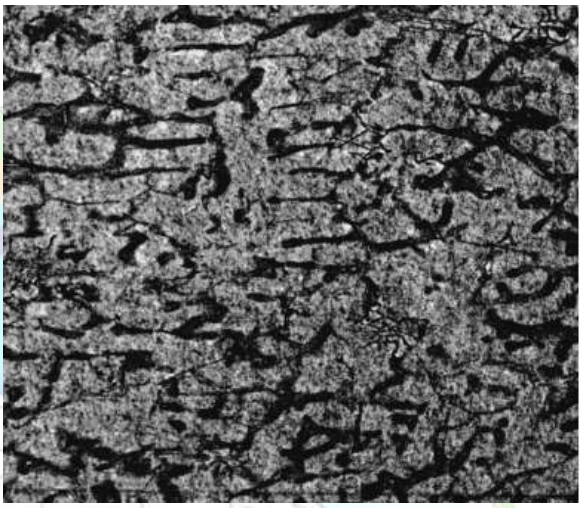


Fig. 4: INITIAL SAMPLE (ALUMINIUM 6061)

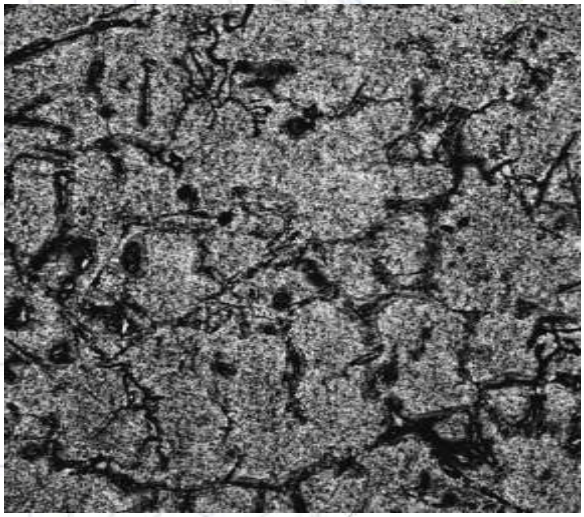


Fig. 5: 10% REDUCTION SAMPLE

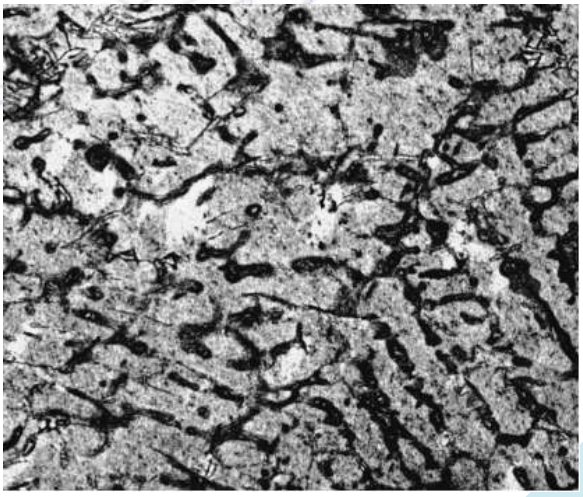


Fig. 6: 20% REDUCTION SAMPLE

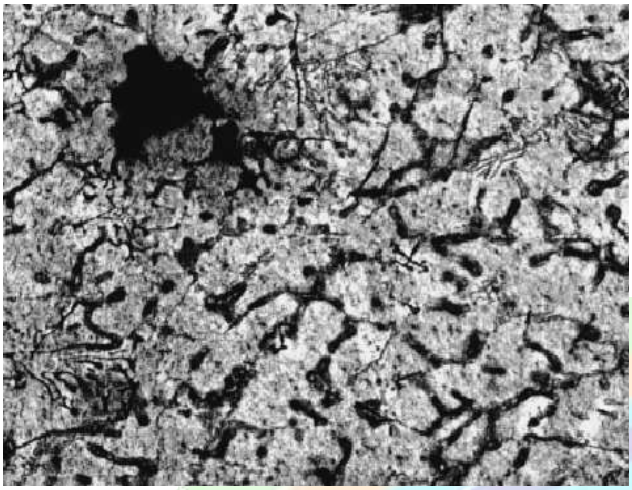


Fig. 7: 40% REDUCTION SAMPLE

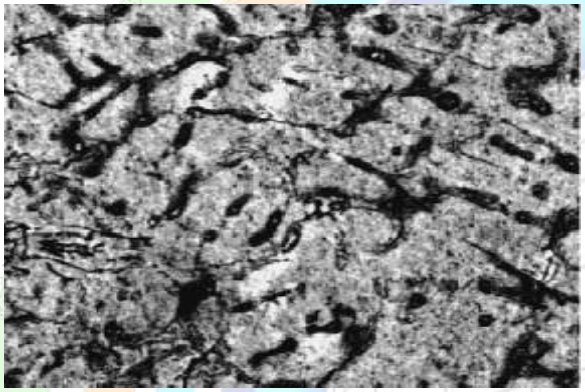


Fig. 8: 60% REDUCTION SAMPLE

C. TENSILE TEST

The tensile test is performed on the test samples which are cut into specific profile and the test is performed at room temperature for different samples. The result obtained is tabulated in the "Table. 4." The result shows that the tensile strength of the material increases as the cold rolling ratio is increased.

Table. 4: TENSILE TEST READING

SAMPLE	MAXIMUM LOAD "N"	MODULUS (E-MODULUS) "MPA"	TENSILE STRESS AT YIELD (OFFSET 0.2 %) "MPA"	TENSILE STRESS AT BREAK (STANDARD) "MPA"
Standard	2209.87	7207.63	63.37	28.75
SD10R	2356.47	7456.98	87.65	41.96
SD20R	2478.32	7724.65	105.63	98.63
SD40R	2920.16	7147.95	109.66	108.47
SD60R	2976.49	8946.09	116.84	115.93

IV. CONCLUSION

The test result shows the change in microstructure from coarse to fine, improved hardness and tensile strength after each reduction ratio.

As the cold rolling is done along the length in the single direction, the strength of the material increases. The hardness of the material is also increased from 77.65 VHN TO 94.32 VHN "Table. 3". The grain structure of the material has also changed from coarse to fine after each rolling "Fig. 4, 5, 6, 7 & 8.

The tensile strength of the material has also increased and the material can finally withstand the maximum load of 2976.49N "Table. 4."

V. REFERENCES

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