J. Basic. Appl. Sci. Res., 3(8)844-849, 2013
ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Effect of Rolling and Annealing on the Hardness and Mechanical Properties of 1050 Aluminum Alloy

Ayesha Naz*

Lahore College for Women University (LCWU), Lahore, Pakistan.

ABSTRACT

In this paper, we discuss the effect of aging in AL 1050 alloys solution treated at 500ºC for 2 hours by Tensile testing, Hardness and XRD. The aging heat treated was performed at 150ºC for different aging time i.e. 2, 5, 10, 50, 150 and 300 minute followed by 20% and 26% rolling. Rolling of specimens shows a rapid increase in hardness as well as tensile properties i.e. yield strength and ultimate tensile strength, whereas aging at 150ºC for just 2 minute reduces the internal stresses produced during rolling and results in decrease in hardness and tensile properties. No variation in hardness, yields strength and we observe ultimate tensile strength after further aging for more time up to 300 min. X-rays diffraction analysis show the appearance of Si4H precipitates in Al-matrix.
INDEX TERMS— Tensile testing, Diffraction analysis.

1. INTRODUCTION

Commercial purity aluminum alloys are widely used for a large number of consumer products, e.g. beverage cans and automobile components. High demand exists for large quantities of these products. Slight modifications in the processing of these alloys to achieve even a small reduction in wastage are considered very important, and therefore huge investments – both financial and intellectual – have been made to gain a thorough understanding of the various aspects of processing and their influence on the final products. Many commercially used aluminum alloys undergo rolling (hot and cold) deformations at different stages of production. Hot-rolling operations form an integral part of the processing of rolled aluminum alloys. The microstructure and texture developed during hot-rolling strongly influences the subsequent processing and (anisotropic) properties of the final product. A large number of studies have been carried out in recent times to understand the micro structural and texture evolution during the hot-rolling of aluminum alloys [1-4]. Micro structural characteristics such as volume fraction recrystallized, interfacial area between deformed and recrystallized grains, grain contiguity ratio, etc., have been successfully used to quantify the kinetics and micro structural evolution during recrystallization of the material [5]. The micro structural and texture evolution during hot rolling of commercial purity aluminium alloy is an important influence on the final properties of cold rolled sheets and finished products during recent years, a significant number of studies have been carried out to study recrystallization kinetics and texture evolution during hot rolling[6, 7]. Other, indirect methods (hardness indentations, x-ray diffraction, neutron diffraction and electrical resistivity) have also been employed [8, 9–11] to determine the recrystallization fraction. These methods measure certain effects of microstructure changes on the properties and provide only average values including both recovery and recrystallization effects. Nevertheless, if the effects of recovery and recrystallization can be separated such techniques may provide valuable additional information regarding recrystallization behavior. In this study OIM and micro hardness measurement have been employed along with the optical microscopy techniques described above to determine the recrystallization fraction in the commercially pure AA1050 alloy.

2. MATERIALS AND METHODS

Pre-rolled sheet of AL-1050 Alloy having composition given in the Table. 1 was obtained from local market. Fifteen specimens of 1050 alloy were cut from the pre-rolled sheet of uniform thickness 1.2 mm, in rectangular shaped having dimensions 1m ×10 cm. All specimens were solution treated at 500° C for 2 hours and then rapidly quenched in water to get a homogenous solid solution.

Table I

Element	Cu	Mg	Si	Fe	Mn	Zn	Ti	Al
Wt %	0.05	0.05	0.25	0.4	0.05	0.07	0.05	99.5

***Corresponding Author:** Ayesha Naz, LCWU, Lahore, Pakistan. Email: ayesha.malik2008@gmail.com

By making two sets of specimens having seven specimens in each set, one set of specimens is rolled by 20% of the original thickness to get the final thickness of 0.96 mm. The other set of specimens is rolled by 26% to get the final thickness of 0.88 mm at room temperature. Six specimens from each set were again placed inside the furnace maintained at 150°C for isothermal aging for 2, 5, 20, 50, 150 and 300 minutes. Both sets of specimens rolled at 20 % and 26 % were then deformed in tension at a strain rate of 4.16 × 10-4 till fracture in a universal material testing machine (Model WDW 100, times group, china.) at room temperature. Both ends of the specimens were held tightly in the wedge type flat jaws attached to the upper and lower pull rods. Gauge length of the specimen was 4 cm. The tensile strain rate was 4.16 × 10-4 s-1 corresponds to the cross head speed of 1mm/min. The full scale load range used was 5 KN. Stress-strain curves were constructed from the load-extension data in the usual manner. Vicker's hardness of all the AL 1050 alloy specimens were measured at a load of 3 kgf for 10 sec. using Hardness Tester Model CV-700AT at room temperature.

X-ray technique was used to examine the nature of alloy. X-ray diffraction studies of phase analysis and lattice parameter measurement were performed using D8 DISCOVER. X-ray diffraction pattern were obtained by utilizing CuKα radiation with a wavelength λ 1.5406. For phase identification, measurements were scanned for a wide range of diffraction angles (2θ) ranging from 15-85° with a scanning rate of 4°/min with a increment of 0.1degree.The lattice parameters were determined from the index planes reflections of aluminum alloy 1050.

3. RESULTS AND DISCUSSIONS

Fig. 1 shows the dependence of hardness of solution treated specimen as well as 20% & 26% rolled specimens aged at 150ºC for different aging time i-e. 0, 2, 5, 20, 50, 150 & 300 min of Aluminium alloy 1050 on aging time. Each point denotes an average value of five measurements for a given aging time. It is representing from the graph that rolling either at 20% or 26% increases the hardness value from 25 HV to 32 & 27.6 HV. But as process of aging starts at 150°C, curve shows a sharp decrease in hardness due to removal of internal stresses produced during rolling. After 2 min of aging, there is no considerable change in hardness even up to 300 min of aging time. It can also be seen from the hardness vs. aging time curve that the higher rolling percent (26%) results in the high value of Hardness for all aging times then specimens rolled at 20 % for all aging time.

Referring to Fig. 2 triangles denotes yield strength of 26% rolled + aged specimens and square denotes 20% rolled + aged specimens. It is clear from the fig that rolling results in an increase in yield stress but aging at 150ºC for just 2 min effect in decrease in yield stress values. Further aging for more time up to 300 min. shows that the yield strength values are almost constant as shown in table 1.

Similar behavior to Fig. 2 is also visible in the curve obtained between ultimate tensile strength and aging time in Fig 3. rolling of the specimens at 20% and 26% result in increase in UTS due to the generation of internal stresses during rolling. But as rolled specimens are aged for 2 min at 150ºC, these stresses are almost removed which results in decrease in UTS values as shown in table 1. Further aging for 5, 20, 50, 150 and 300 min shows that there is no change in ultimate tensile strength values. The lines drawn through the data points in ultimate tensile strength vs aging time curves represent that the ultimate tensile strength for 26% rolled specimens is 12 % more than the specimen rolled at 20% which may be due to the consequence of production of internal stresses produced during rolling. There internal stresses are responsible for increasing the strength of the material and also effect on the percentage elongation of the specimens. As there are more stresses, more will be the ultimate tensile strength and less will be the percentage elongation which is clear from the Fig 4.

X-rays diffraction measurements were performed at room temperature after quenching the specimen and aging at 150°C for different aging time i.e. 2, 5, 20, 50,150 & 300 min followed by 20 % & 26 % rolling. The recorded patterns are presented in fig 5 & 6. A comparison of pattern rolled at 20% & 26% and then aged at 150ºC for different aging time i.e. 0, 2, 5, 10, 50,150 & 300 min is made with the reference specimen solution treated at 500ºC for 2 hrs. All the Bragg's diffraction peaks were analyzed for interplaner spacing d and then compared with d-values and hkl values. In comparison, main peaks are identified as AL (cubic) peaks along with progressive appearance of Si4H (tetragonal) phase.

Table II: Data sheet of the specimens rolled at 20%

Specimen	Ref	1a	1b	1c	1d	1e	1f	1g
Ageing time (min.)	-	0	2	5	20	50	150	300
%Elongation	24	10.75	16	16.75	15.2	19.4	18.5	17.75
Yield strength (MPa)	46	76	67	72	67.5	68	67.5	73
Ultimate tensile strength (MPa)	51	78.8	74	77	78	80	82	79
Hardness (HV at 3kgf for 10 sec.)	25	35.15	27.6	28.6	29.5	29.92	29.05	30.5

Table III: Data sheet of the specimens rolled at 26%

Specimen	Ref	2a	2b	2c	2d	2e	2f	2g
Ageing time (min.)	-	0	2	5	20	50	150	300
%Elongation	24	5.75	13.6	11.5	13.4	11.5	13.75	14
Yield strength (MPa)	46	83	59	66	69	69	71	70
Ultimate tensile strength (MPa)	51	89.2	86	89	86	89	88	90
Hardness (HV at 3kgf for 10 sec.)	25	38.37	32	31.2	33.3	32.6	33.8	33.57

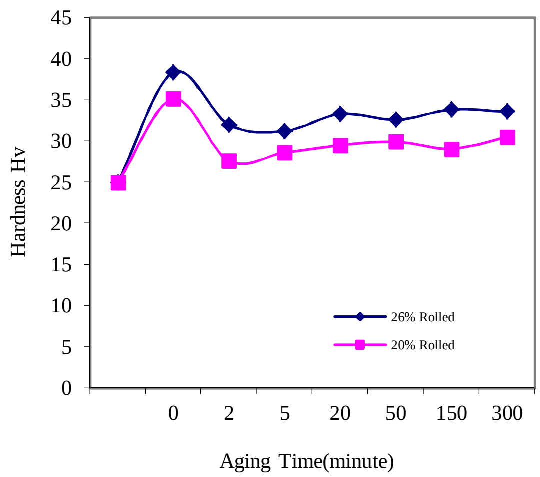

Fig. 1: Graph b/w aging time and hardness

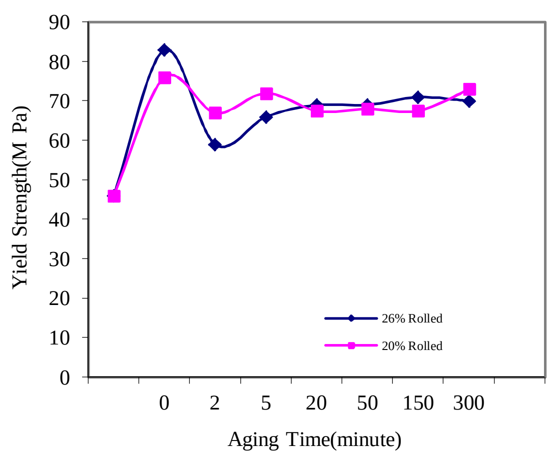

Fig 2: A graph b/w aging time and yield strength

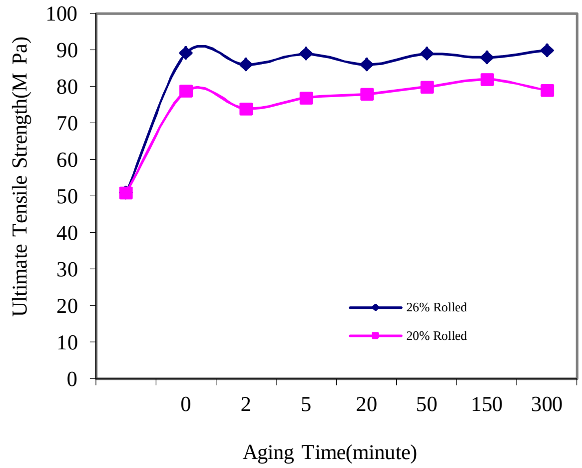

Fig. 3: Graph b/w aging time and ultimate tensile strength

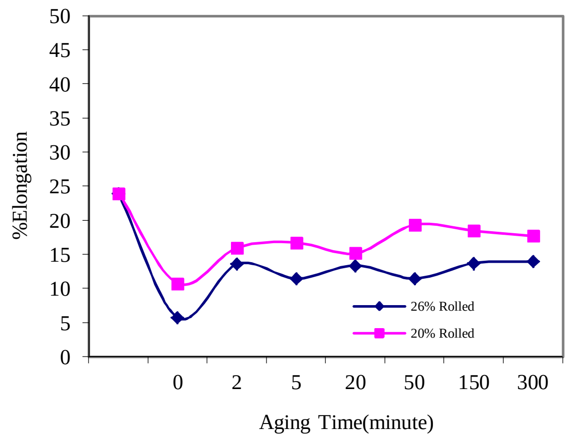

Fig 4: Graph b/w aging time and % elongation

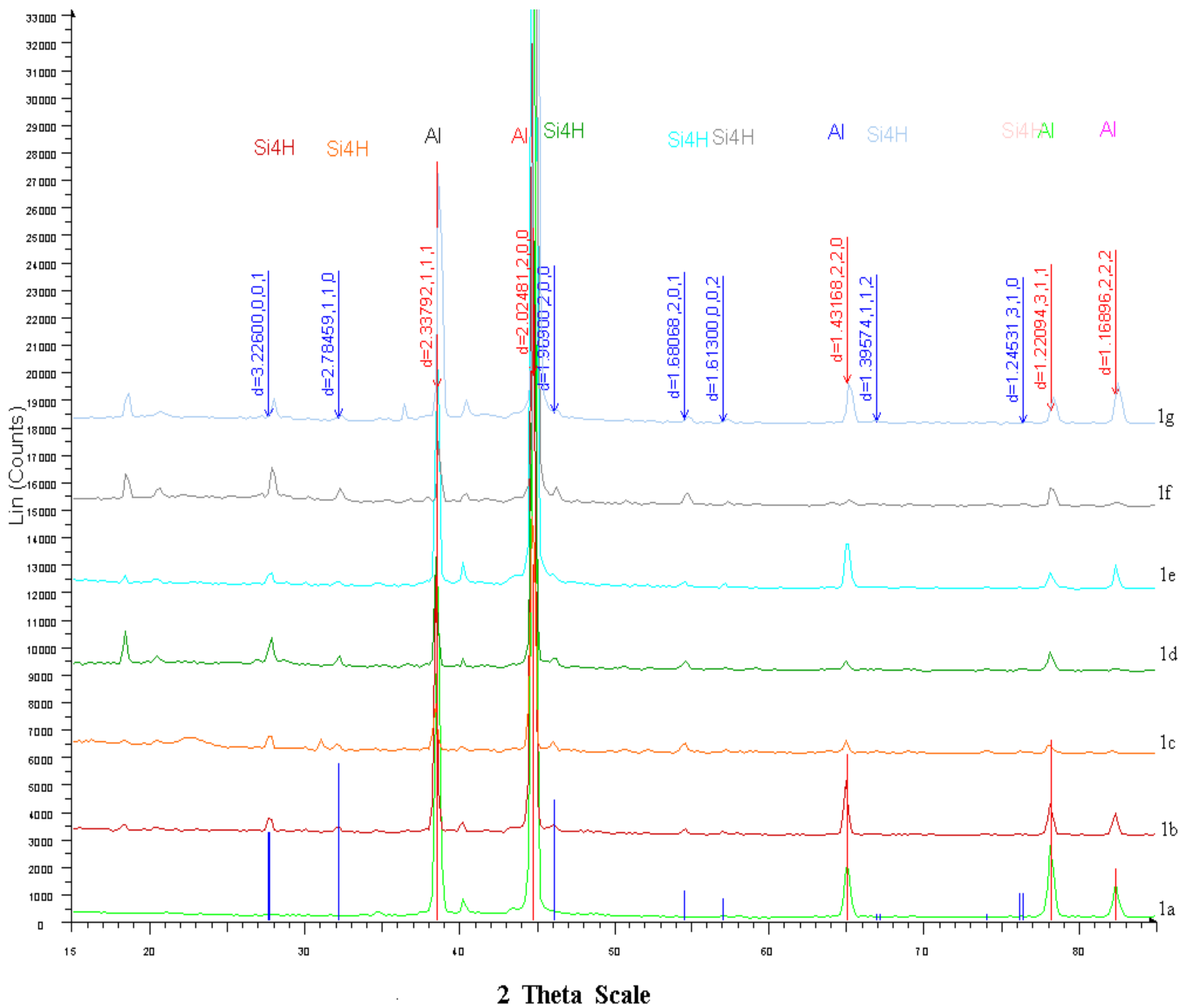

Fig. 5: XRD pattern of aluminum alloy 1050 20% rolled & aged at 150°C for (1a) unaged, (1b) 2 min, (1c) 5 min, (1d) 20 min, (1e) 50 min, (1f) 150 min & (1g) 300 min.

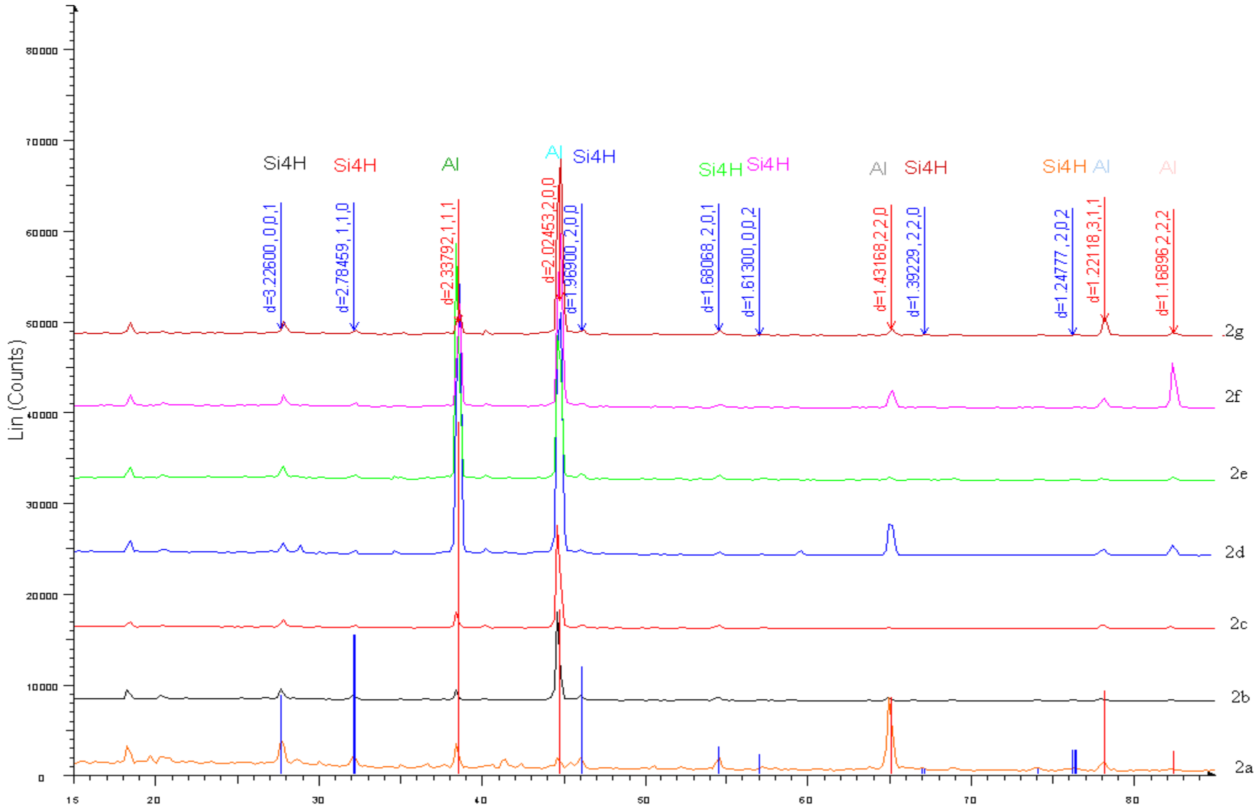

Fig. 6: XRD pattern of aluminum alloy 1050 26% rolled & aged at 150°C for (2a) unaged (2b) 2 min, (2c) 5 min, (2d) 20 min (2e) 50 min, (2f) 150 min & (2g) 300 min.

CONCLUSION

In this paper, we discussed that the higher rolling percentage, higher will be the hardness value. The yield strength and ultimate tensile strength of Al 1050 alloy is increased as rolling percentage is increased. Ageing for only 2 min at 150°C is enough to remove the internal stresses produced during rolling. Further ageing up to 300 min has no effect on the hardness as well as tensile properties. The record patterns of XRD show that only two phases Al (cubic) and Si4H (tetragonal) are indicated. No new phase is visible after rolling and annealing at different temperatures.

REFERENCES

1. R.A. Vandemeer and D.J. Jensen, Acta Mater 51 (2003), p. 3005.
2. R.A. Vandemeer and D.J. Jensen In: T. Bieler, J. Zin, A. Beaudoin and B. Radhakrishnan, Editors, Hot deformation of aluminum alloys III, TMS, Warrendale, PA (2003), p. 13.
3. I. Samajdar, P. Ratchev, B. Verlinden and E. Aernoudt, Acta Mater 49 (10) (2001), p. 1759.
4. R.A. Vandemeer and D.J. Jensen, Texture Microstruct 27 (1996), p. 263.
5. R.A. Vandermeer, Acta Mater 55 (3) (2005), p. 1449.
6. R. A. Vandermeer and D. Juul Jensen: Acta Materialia Vol. 51 (2003), p 3005-3018
7. I. Samajdar, P. Ratchev, B. Bacrix: Acta Materialia Vol. 49(10) (2001), p 1759-1769
8. E. C. W. PERRYMAN, Trans. AIME, J. Metals (1955) 1053.
9. T. FURU, R. ORSUND and E. NES, Acta Met. Mater. 43 (1995) 2209.
10. D. BOWEN, R. R. EGGLESTON and R. H. KROPSCHOT, J. Appl. Physics. 23(6) (1952) 630.
11. K. MUKUNTHAN and E. B. HAWBOLT, Metall. Mat. Trans. A 27 (1996) 3410.