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Impact Testing of Al-Si Alloy in as cast and Cast aged Condition

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Abstract The objectives of the present study is to utilize the combined effects of high cooling rate solidification, unique microstructure evolution mechanism of T6 heat treatment and the advantages of hypereutectic Al-Si system alloyed with other elements such as Cu. In the present investigation, the quaternary alloy such as Al-19Si-3Cu has been selected. A systematic investigation has been carried out to explore the microstructure features, mechanical and hardness properties of as cast and T6 heat-treated alloys. Hypereutectic alloys are, in reality, in-situ metal matrix composites (MMC) of hard silicon crystals disbursed throughout an eutectic matrix; thus, like other MMCs, they combine light weight and excellent wear properties with high elastic moduli, low thermal expansion and exceptional resistance to elevated temperature service environments. The effect of aging treatment on the toughness of a near hypereutectic Al–78%Si–19%Cu–3% alloy were investigated. Izod impact tests were performed on unnotched specimen in the as- cast and heat-treated conditions. It was found that the presence of Cu-containing phase increase the alloy brittleness which reduces impact toughness. The hypereutectic Si phase also plays an important role, where the size/morphology of the Si particle controls the area of α-Al matrix available which affects ductility and toughness. Increasing the Mn content leads to an increase in the volume fraction of the α-Al15(Mn,Fe)3Si2 phase formed and to sludge formation, which facilitates crack initiation and propagation. Crack propagation occurs mainly via the Al2CU and/or α- Al15(Fe,Mn)3Si2 phases. The impact behavior of aged alloys is influenced by the amount, size and morphology of hardening precipitates formed in the alloy, depending on the aging conditions. Aging at 502 °C produces a significant increase in the impact energy values of the low Mn-content alloys, as a result of alloy softening. The high Mn-content alloys also show a similar increases in impact energy values, but at a steady level across the same range of ageing times, due to persistence of the α-Al15(Mn,Fe)3Si2 phase.

Keywords: Impact strength, solutionizing,

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1. Introduction The impact energy value obtained in the case of a notched sample is much lower than that otherwise obtained with an unnotched sample. This change implies that the impact energy is dependent upon the notch geometry, rather than on the microstructure. Similar observations have been repored elsewhere [4-6] In case of Al-Si alloys the hardening phases are beta' and beta" whereas in case of Al-Si-Cu alloys more number of hardening phases appear that makes the response to the artificial aging process more complex. In the present work, as evident from the literature review, considerable attention is being drawn to the study of the microstructural evolution and the structure-property correlation of the Al- alloys, particularly for the automotive applications. There exists knowledge about influence of alloying elements on the microstructure, mechanical and hardness properties of as cast materials. Although there are large number of investigations on Al alloys, systematic and detailed research reports on micro structural control and the effect of processing route on the properties of Al- alloys at elevated temperature for automotive applications remain to be understood clearly. Also, the study on the effect of addition of high percentage of Cu on the mechanical properties as well as elevated temperature performance will be investigated. This study will help in using the enhanced properties for manufacturing the automotive as well as some aerospace components that need elevated temperature resistance. Presently very few works has been reported in the field of elevated temperature studies on Al-19Si-3Cu alloys with Cu as alloys.

2. Experimental Description Dry abrasion tester measures index of abrasive resistance to dry sand. The Dry Sand / Rubber Wheel Abrasion test involves abrading of test specimen with a grit of controlled size and composition. The test specimen is pressed against a rotating wheel, while a controlled flow of grit abrades test surface. The rotation of the wheel is along the sand flow. The duration of test and force applied is varied. Specimens are weighed before and after the test. Loss in mass is recorded. It is necessary to convert mass loss to volume loss. due to differences in density of materials. Index of abrasion is reported as loss of volume. Wheel rim is of chlorobutyle rubber with shore hardness of A60±2.

Specifications**:** Speed : 200 RPM , Wheel diameter :228.6 mm.

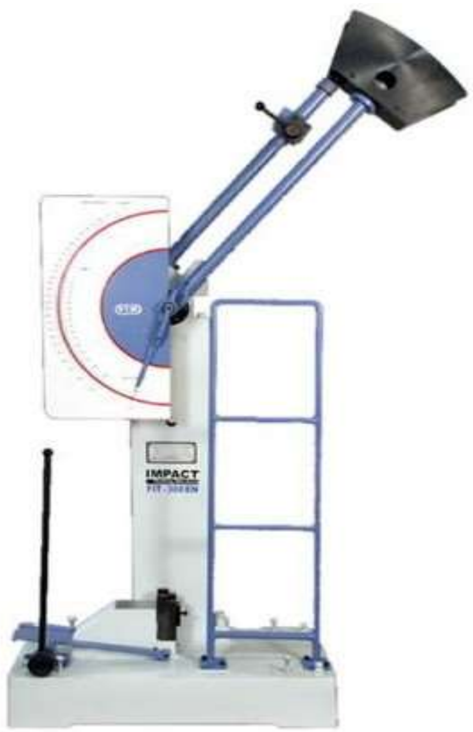
Test Load: 4.5 to 13.25 kgf, Instrumentation: 4 digit preset counter to stop test after preset revolution count. Power: 230V / 50Hz/ Single phase / 1.5 KVA

3. Methodology Al-19Si-3Cu alloys in as cast condition is machined into six pieces of 10mm diameter and 30mm length for wear and six pieces for micro structure study each for each alloy having dimensions 10mm×10mm×55mm.

- These samples will be heat treated (solutionizing) and subjected to age hardening.
- Following are the samples details with the type of heat treatment that will be done over the samples.

Table No: 2

Sample Number	Heat-treatment operation details
1	As cast subjected to heat treatment
2	Heat treated at 512°C for 1 hour and then water quenched
3	Heat treated at 512°C for 1 hour and then water quenched, latersubjected to heat treatment for 1 hour at 210°C
4	Heat treated at 512°C for 1 hour and then water quenched latersubjected to heat treatment for 3 hours at 210°C
5	Heat treated at 512°C for 1 hour and then water quenched againreheat treated for 5 hours at 210°C



Impact test

An impact blow is delivered to a test specimen by means of a pendulum-type hammer. The impact value of the material is determined from the energy required to break the specimen. Izodtests were carried out using a universal impact testing machine. A 10×10×55mm samples for metallographic study were sectioned off from the impact-tested bars of all the alloys tested in the present work at a point approximately 10 mm below the fracture surface. The samples werethen mounted and polished to a 1 µm fine finish.

4. Results and discussion The alloy used in the present work is Al-19Si-3Cu and its chemical composition as shown in theTable1.

Table 1 Chemical composition (wt %) of Al-19Si-3Cu alloys

Sr. no	Alloy	%Al	% Si	%Cu
1.	Al-19Si-3Cu	78%	19%	3%

Impact Test observations & calculations on heat treated specimens:

Sl.	Initial reading, J	Final reading, J	Energy absorbed, J	Impact strength, J/m^2
1.	170	90	80	800.000
2.	170	90	80	800.000
3.	170	91	79	790.000
4.	170	82	88	880.000
5.	170	82	88	880.000

Impact Test observations & calculations on as cast specimens:

Sl.	Initial reading, J	Final reading, J	Energy absorbed, J	Impact strength, J/m^2
1.	170	71	99	990.000
2.	170	77	93	930.000
3.	170	71	99	990.000
4.	170	74	96	960.000
5.	170	70	100	1000.000

It is observed from the above that the unnotched as cast specimen of Al-19Si-3Cu performs better by 13.63%comparatively compared to 1hour cast aged.

5. Conclusion

- A chosen alloy Al-19Si-3Cu was machined to specimens are test as per ASME standards with the help of lathe and milling machine
- The specimen are heat treated followed by solutionizing at 512 °C for 1 hour
- The results of as cast and 1 hour caste aged specimen of Izod impact test are compared which shows that the as cast specimen performs better by 13.63% so it concludes that as cast specimen is suitable at this study
- Future test may be carried out for different heat treatment hours like 3hr, 5hr, 7hr. also it can be compared.

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