Studies On Aluminium Silicon Sleeve Castings Subjetced To Internal Pressures

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Abstract

Aluminium Silicon alloys are widely used to make automobile components like air brake components, valves, sleeves ,high pressure CRDi fuel lines, pulleys, gears etc. In the literature survey it is found that Aluminium silicon alloys are used to make sleeves and connectors of air braking systems, which are used in air braking systems of heavy vehicles**.** This project work is undertaken to study about the cylindrical Al-Si sleeve castings which is used in air braking systems, which are subjected to internal pressure and their corresponding mechanical properties. Cylindrical Al-Si specimens which are identical to the air brake connector sleeves are made with different silicon compositions and are studied by subjecting them to tensile tests, hardness tests, wear test etc. They are subjected to internal pressures and stresses. The ultimate stress, radial stresses, tangential stresses, critically resolved shear stress etc are studied by using maximum shear stress theory. After that a C program is generated to compute the distribution of radial, tangential stresses inside the specimen. At the end of the study it is found that, The Yield strength and ultimate tensile strength of specimens increases with the increase of weight percentage of silicon. Al-7Si can withstand a much higher amount of radial and tangential stresses without failure compared to Al-4Si of same thickness. This is due to their higher value of yield point stress and maximum possible shear stresses.

1.Introduction

Aluminium alloys are very important in engineering applications due to their low weight and high mechanical and thermal properties. The one of the most important property of aluminium is the ability of aluminium to form a wide range of alloys with different alloying elements. Other important properties of aluminium alloys include high wear resistance, high ductility and appreciable yield stress. Due to the less weight and high tensile strength aluminium silicon alloys are blessed with high strength to weight ratio, which makes them an important engineering material. The good castability, machinability,surface finish and corrosion resistance of aluminium alloys also makes them more and more important in engineering applications. In this research work, an attempt has been made to study the mechanical properties and industrial applications of Al-4Si and Al-7Si cast aluminium alloys. An aluminium silicon sleeve casting used in air braking system of heavy articulated vehicle is taken for examination and study. The specimens were made as per the dimensions of sleeve casting and is subjected to study. . For conducting experiments, hollow cylindrical castings are made using Al-4Si and Al-7Si using sand moulds. The mechanical properties are studied and analyzed using maximum shear stress theory. The hollow cylindrical castings are subjected to high internal pressures and the corresponding inner and outer diameters to withstand the pressures,shear stresses,radial stresses,tangential stresses etc are found out.

2.Experimental Methods

2.1 casting of test bars

The experiment has been conducted in different stages. In the first stage casting of the specimens were done. For casting purpose the patterns are made of wood. These patterns were used to make moulds for casting the Al-4Si and Al-7Si specimens as shown in figure 2.1

Figure 2.1 Cast test bars of Al-4Si and Al-7Si

2.2 Tensile tests on specimens

In order to find out the mechanical properties such as yield strength,ultimate strength of Al-4 Si and Al-7Si alloys,a tensile test is conducted by using a UTM. A tensile test is relatively simple but it has been around for a very long time, hence extreme care and precautions must be taken to ensure that the test will have valid results and minimum errors.The specimen is aligned vertically to avoid bending moments or torsion.

2.3 Computation of maximum permissible shear stress of specimen

Maximum shear stress theory states that failure occurs when the maximum shear stress in the component being designed equals the maximum shear stress in a uniaxial tension test.Hence form the tension tests the yield stress is found and from the yield stress,the maximum permissible shear stress is found out.The critically resolved shear stress,which is the stress responsible for the formation of slip planes is found out.

2.4 Subjecting the specimen to internal pressure

Inorder to test the pressure withstanding capacity of the specimen,it is subjected to an internal pressure by using a high pressure compressor test rig. The radial stresses and compressive stresses generated in the specimen can also be found by analysing it as a Thick walled cylinder subjected to internal pressure (lame's problem).[1]

2.5 Calculation of Minimum Thickness

Since the specimen is subjected to an internal pressure as shown in figure 2.2,the minimum thickness needed to withstand the pressure has to be found out. If 'a' is the inner radius and 'b' is the outer radius, then the maximum shear stress is given by,

$$(\tau_{max}) = b^2 P_i / (b^2-a^2)^{[2]}$$

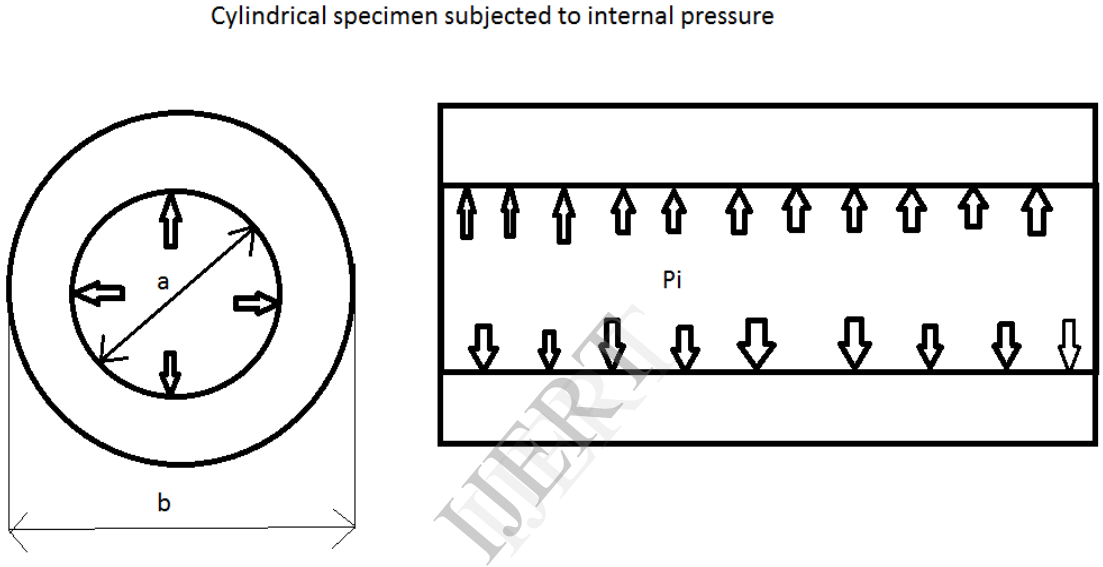

Figure 2.2 The specimen subjected to internal pressure

2.6 Analysis of Radial and Tangential stresses

The distribution of radial and tangential stresses are analysed by assuming the situation as in the Lame's Problem,where a thick walled cylinder is subjected to internal pressures.

2.7 Development of a C program

As a part of analysing stresses and the corresponding thickness needed for the sleeve casting, a C program is generated. After that the relationships between the internal pressure and the thickness of the sleeve casting needed is analysed and the characteristic graphs are drawn.

3. Results and Discussions

3.1 Strength properties

The strength properties of aluminium silicon alloys for various compositions of silicon content are found out and tabulated.It is found that the increase in silicon content increases the tensile properties of alloys.This may be due to the presence of silicon in fine dentric form.The hardness number is also increasing with increase in silicon content.The properties are shown in table 3.1 and the corresponding weight percentage of silicon and the maximum permissible shear stresses are given on tables 3.2 and 3.3

Table 3.1 mechanical properties of alloys

Composition	Ult.Stress (MN/M^2)	Density kg/m3	Hardness VHN	% elongation
Al-4Si	144	2.56	45.63	9.8
Al-7Si	180	2.60	54.45	9
Al-11Si	188	2.62	63.00	8.1
Al-12 Si	191	2.66	71.1	6.3
Al-14 Si	199	2.70	72.27	4.59

Table 3.2 Max.Permissible shear stress for the alloys

Alloy	Max permissible shear stress MN/M^2
Al-4Si	72
Al-7Si	90
Al-11Si	94
Al-12 Si	95.5
Al-14 Si	99.5

Table 6.3 weight composition of alloys

Alloy	Al (g)	Si(g)
Al-4Si	500	20
Al-7Si	500	35
Al-11 Si	500	55
Al-14Si	500	70

3.2 Variation of hardness in alloys

Correspondingly the variation of Vickers hardness number with different amounts of silicon are as shown below in figure 3.1

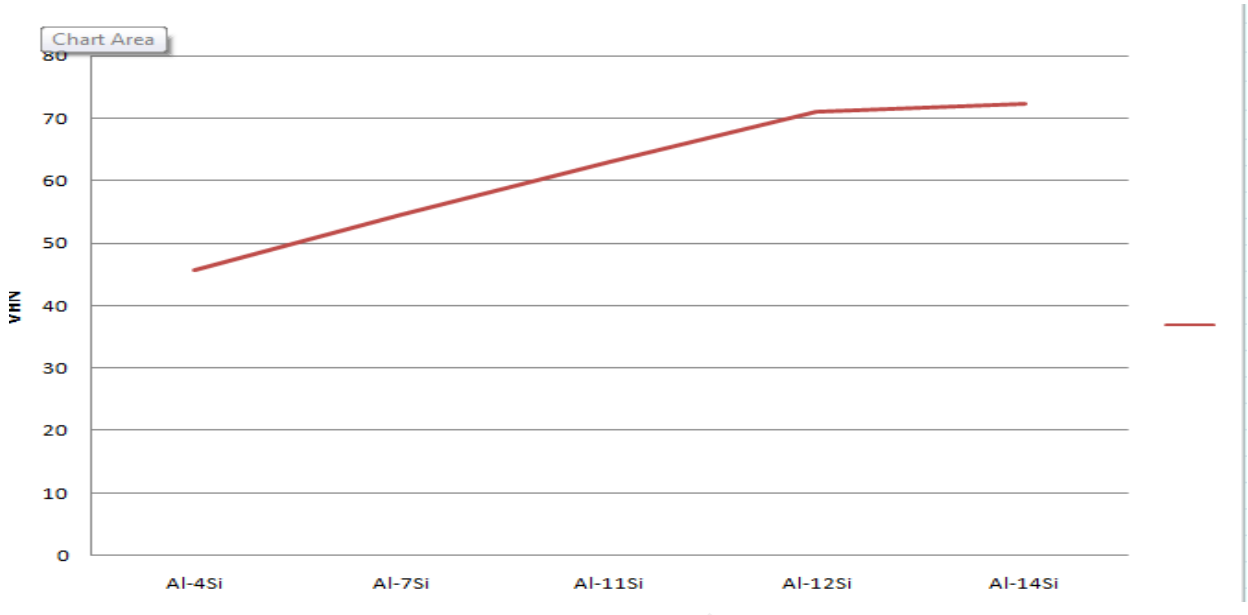

Figure 3.1 Variation of Vickers hardness number

3.3 Variation of thickness needed with internal pressure

The variation of thickness needed for sleeve casting to withstand the pressure is shown in figure 3.2

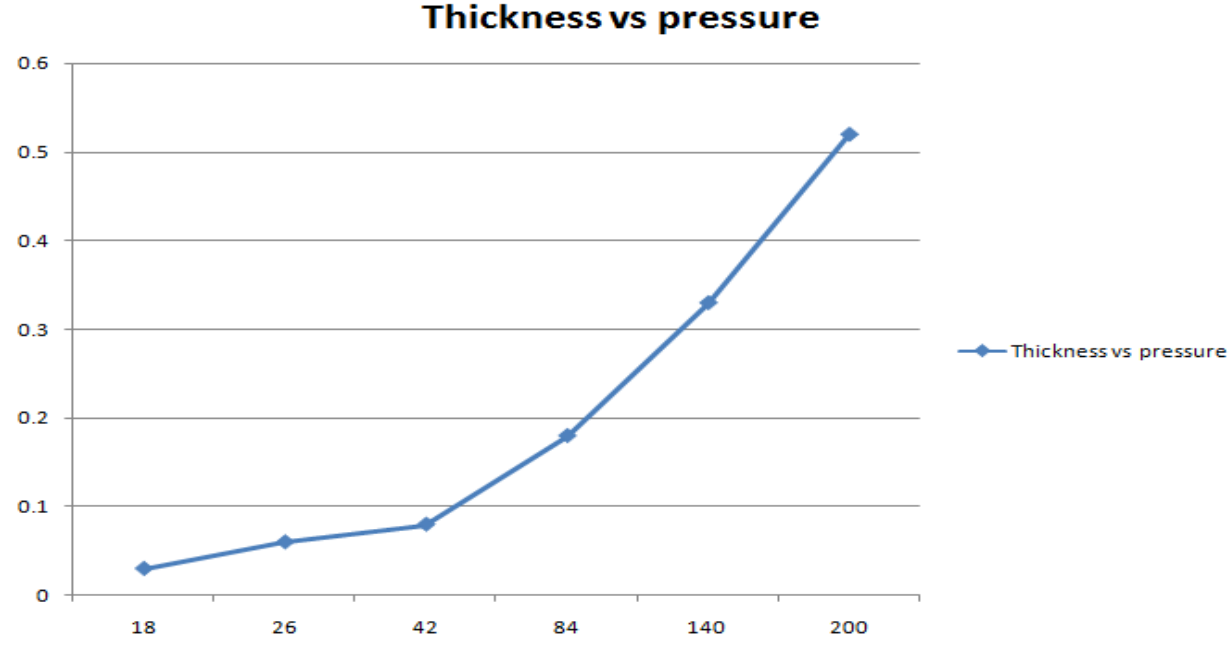

Figure 3.2 Variation of thickness with internal pressure

4. Conclusions

From the experimentation and studies on the sleeve aluminium casting made of different compositions of silicon the following conclusions were made.

- The Yield strength and ultimate tensile strength of specimens increases with the increase of weight percentage of silicon.
- Al-7Si can withstand a much higher amount of radial and tangential stresses without failure compared to Al-4Si of same thickness. This is due to their higher value of yield point stress and maximum possible shear stresses
- The thickness needed for the cylinder varies proportionally with the increase in internal pressure
- The magnitude of radial and tangential stresses are found to be maximum at the inner radius and gradually decreases towards the outer radius
- Al-Si alloys can be employed to make high pressure fuel lines,air brake components, thickwalled cylinders, pressure vessels due to their high strength to weight ratio and mechanical properties.

5. References

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