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Silicon Carbide, Blf and Aluminium Metal Matrix Composites for Aerospace Applications

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Abstract: *Ever since the Wright brothers flew their 'heavier-than-air' machine, the aviation industry has grown in great leaps and bounds. Because aircrafts were getting faster and/or bigger, the need to develop newer materials took centre stage- the use of wood and fabric gave way to stronger metallic structures (built predominantly using aluminum and its alloys). However, ceramics and composite materials are slowly replacing these too. Since the need to develop more efficient aircraft hasn't subsided, the requirement for better materials is still in great demand. In this thesis , considers the potential of use Al-SiC metal matrix composite (MMC) with particular reference to the aerospace industry. Initially, the required properties are identified, after which, the work explores pure aluminum and its importance in the industry along with its limitations. Using these limitations, MMC's were recommended as a possible replacement for aluminum and it is seen that the exact set of properties depend on certain factors.*

Therefore these factors such as reactivity at the interface, volume fraction of the BLF material, type of the BLF material and distribution of the BLF material is reviewed using the existing literature. In this thesis, to find out the mechanical properties (Tensile strength, hardness and impact strength) at different percentages.

Keywords: Metal Matrix Composite(MMC), Aluminium, silicon carbide, aerospace

.I. INTRODUCTION

Ever since the Wright brothers flew their 'heavier-than-air' machine, the aviation industry has grown in great leaps and bounds. Because aircrafts were getting faster and/or bigger, the need to develop newer materials took centre stage- the use of wood and fabric gave way to stronger metallic structures (built predominantly using aluminium and its alloys). However, ceramics and composite materials are slowly replacing these too . Since the need to develop more efficient aircraft hasn't subsided, the requirementfor better materials is stillin great demand. This paper explores the possibilities of one such material; aluminium- silicon carbide composite (Al-SiC).

Initially, the work will look to identify the necessary properties of a material that is to be used in the aerospace industry. The reasons for aluminium's extensive application in the aircraft industry will then be identified and the use of metal matrix composites (MMC) to counter the pure element's (aluminium) shortcomings will be advocated. Once a case for Al-SiC MMC has been made, the work will look to explore and understand the different factors that could have an effect on the fabrication and the final properties of the composite.

ALUMINUM

Aluminum alloys (or aluminum alloys; see spelling differences) are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

METAL MATRIX COMPOSITES

Metal matrix composites constitute a metallic matrix that is reinforced with another material, usually in the form of fibers, particulates, whiskers etc. According to Pai et al., [10] the reinforcing material usually carries most of the load and the matrix material, by holding them together, enables load transfer. The advantages of using these materials (with metals as matrices) include high tensile and shear module, good fatigue and fracture properties, small thermal expansion coefficient, high melting point, high toughness, high ductility, high thermal and electrical conductivities, good erosion (and/or corrosion) resistance, dimensional stability and good moisture resistance .In addition, MMCs with aluminum as the

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matrix benefit from good wear resistance, high specific modulus and specific strength . A. Silicon Carbide-Aluminium MMC One such example of MMC is an aluminum matrix composite reinforced with silicon carbide (Al-Sic). The most important property of aluminum-silicon carbide with reference to the aerospace industry is its strength to weight ratio, which is three times more than mild steel[14]. In addition, composites containing SiC (reinforcing material) and Al (matrix) have high modulus, strength values, wear resistance, high thermal stability, less weight and a more effective load carrying capacity compared to many other materials [15, 16]. It is also expected that this composite will exhibit good corrosion/ oxidation properties since silicon carbide forms a protective coating of silicon oxide at 1,200°C [9] and, as discussed earlier, aluminium also displays a similar reaction. Therefore, it can be seen that this material offers considerable advantages to the aerospace industry especially in applications that require good thermal and tensile properties.

FACTORS AFFECTING THE PROPERTIES OF AL-SIC

Although the previous section briefly discussed some of the properties of Al-SiC, the composites exact set of properties depend on a number of factors. Apart from the changes in microstructure of matrix and reinforcements that could result.

from various work hardening or heat treatment processes, this work has identified four factors from the existing literature that could affect the properties of Al-SiC: Reactivity of the matrix and the reinforcing material

- Type of the reinforcing material
- Volume fraction of the reinforcing material
- Distribution of the reinforcing material
- Before we explore how each aspect affects the properties of the material, we briefly discuss certain fabrication methods of Al-SiC, since they ultimately decide the aforementioned factors.

III. LITERATURE SURVEY

Shabeer KP, Murtaza MA, "Optimization of aircraft wing with composite material", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, June 2013.

Shabeer KP and others [1] have created a model of wing which is made by a combination of composites and isotropic materials. They then changed the orientation of composite ply orientation in skin and compared the results. Stress and displacement of both designs were analyzed. They concluded that the leading and trailing edges showed von-mises stress distribution. This was due to the variation in fibre orientation.

INTRODUCTION TO FEA

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

INTRODUCTION TO CAD

Computers are being used increasingly for both design and detailing of engineering components in

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the drawing office. Computer-aided design (CAD) is defined as the application of computers and graphics software to aid or enhance the product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system.

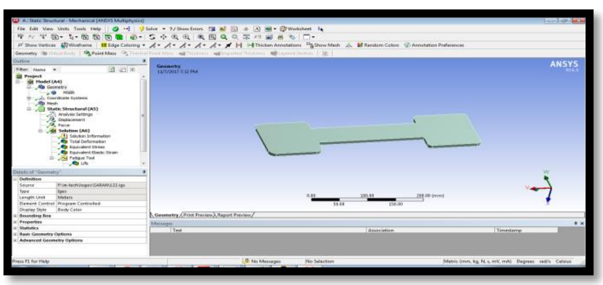
INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER, PTC's parametric, integrated **3D CAD/CAM/CAE solution**, is used by discrete manufacturers for mechanical engineering, design and manufacturing. This powerful and rich design approach is used by companies whose product strategy is family-based or platform-driven, where a prescriptive design strategy is critical to the success of the design process by embedding engineering constraints and relationships to quickly optimize the design, or where the resulting geometry may be complex or based upon equations. Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform.

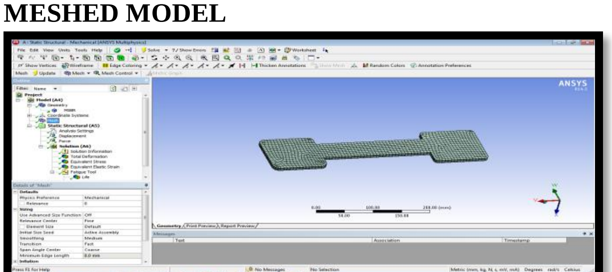
STATIC ANALYSIS

MATERIAL- PURE ALUMNIUM ALLOY

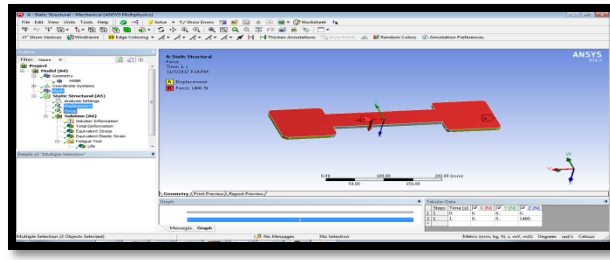
IMPORTED MODEL



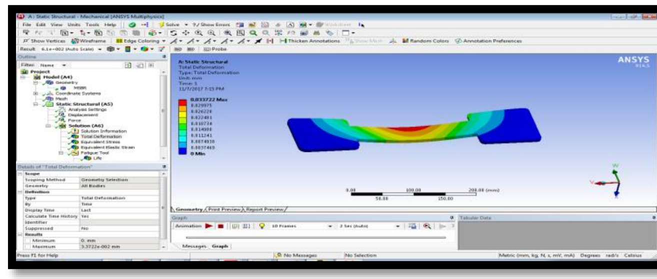
MESHED MODEL



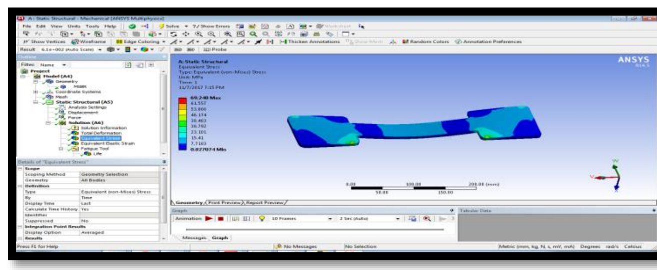
BOUNDARY CONDITIONS



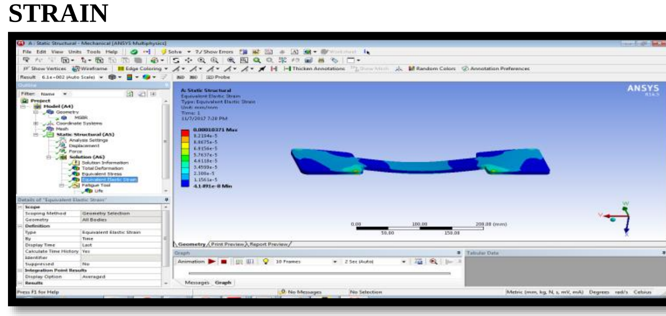
DEFORMATION



STRESS



STRAIN



MATERIAL- PURE ALUMNIUM ALLOY WITH SILICON 10% AND BLF 55

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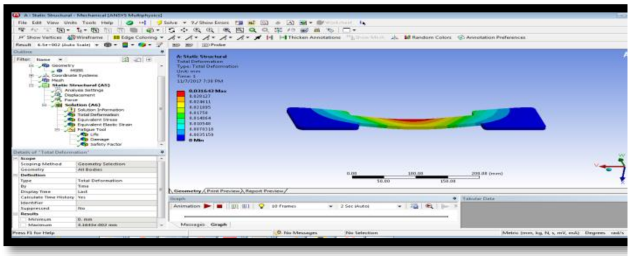
DEFORMATION



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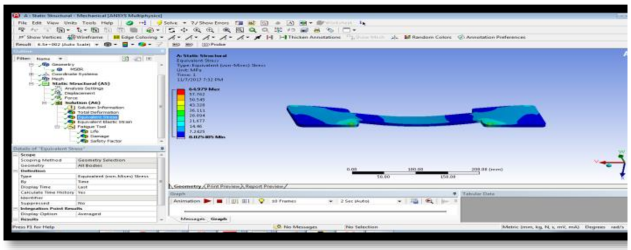
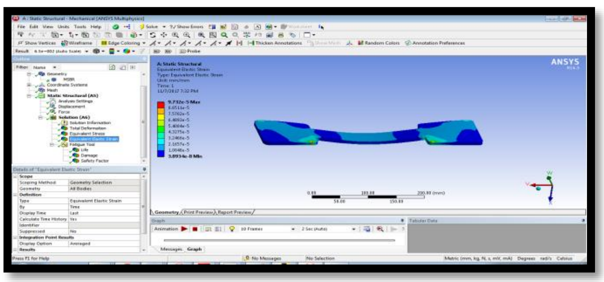
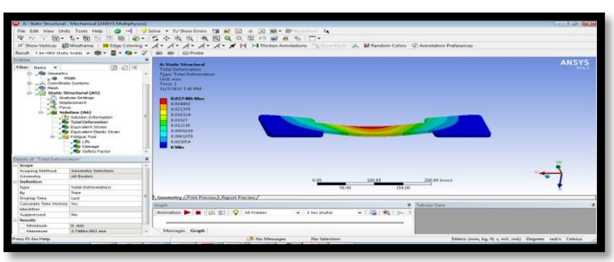


STRAIN

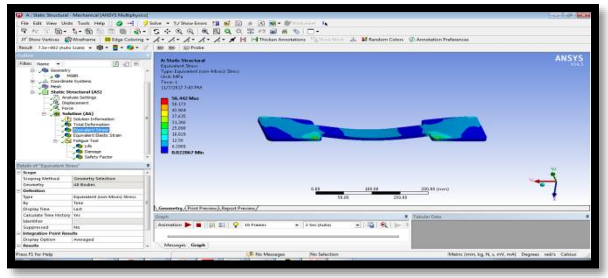


MATERIAL- PURE ALUMNIUM ALLOY WITH SILICON 20% AND BLF 15%

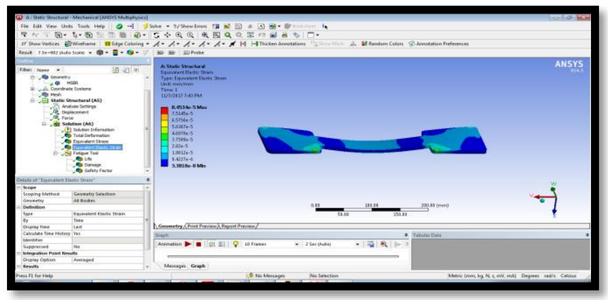
DEFORMATION



STRESS

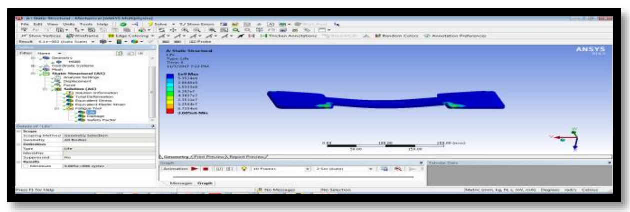


STRAIN

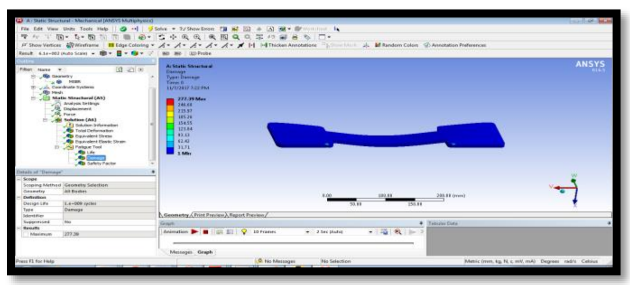


FATIUGE ANALYSIS

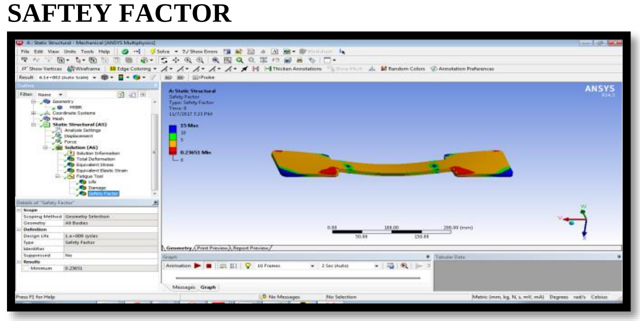
MATERIAL-ALUMNIUM ALLOYLIFE



DAMAGE



SAFTEY FACTOR



MATERIAL- PURE ALUMNIUM ALLOY WITH SILICON 10% AND BLF 5%

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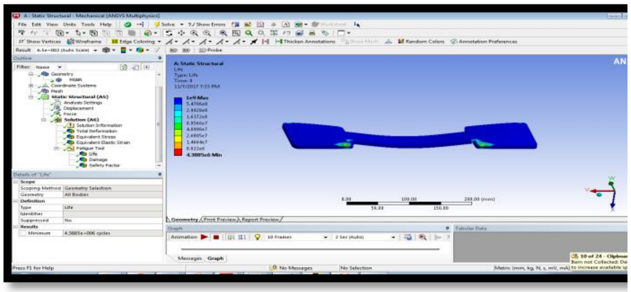
LIFE



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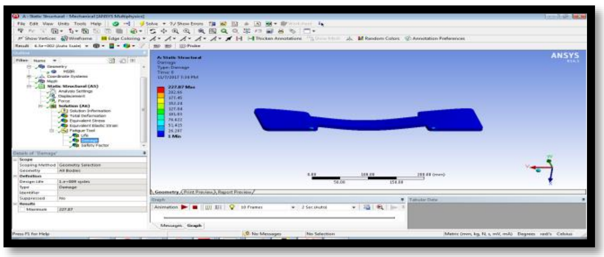

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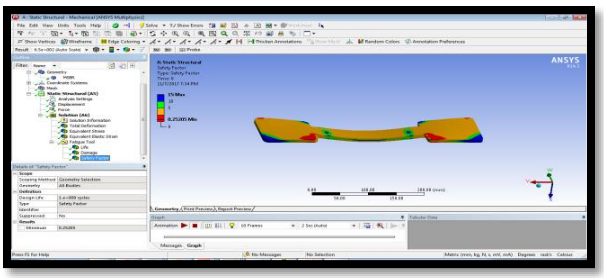
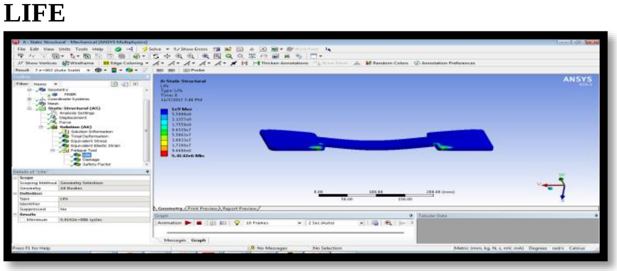


MATERIAL- PURE ALUMNIUM ALLOY WITH SILICON 15% AND BLF10%

LIFE



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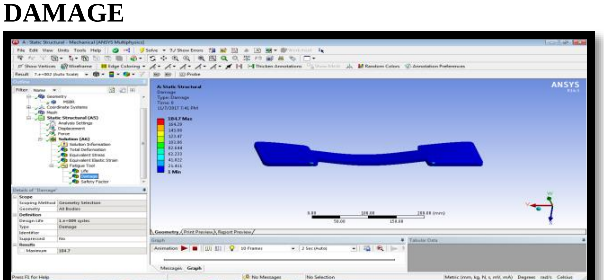

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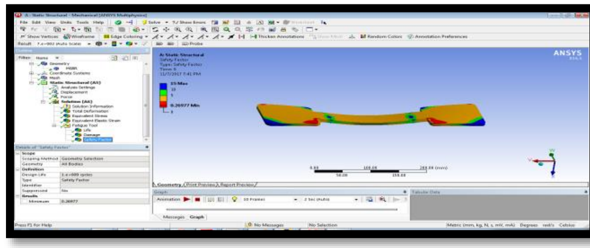
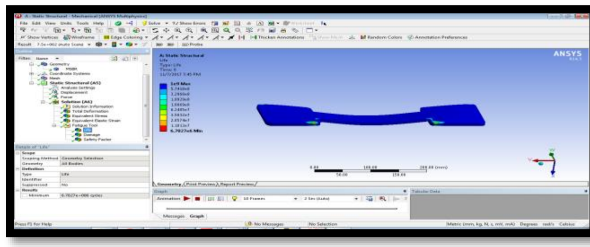


MATERIAL- PURE ALUMNIUM ALLOY WITH SILICON 15% AND BLF 10%

LIFE



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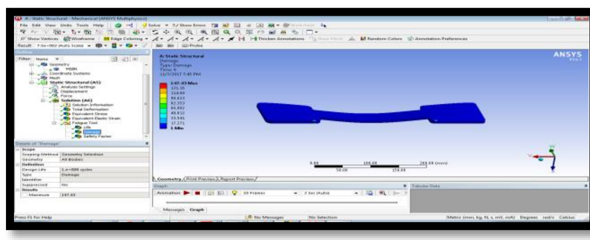
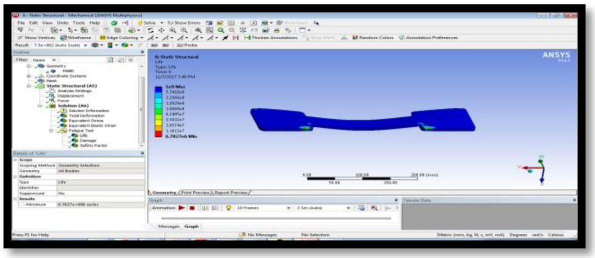


SAFTEY FACTOR

MATERIAL- PURE ALUMNIUM ALLOY WITH SILICON 20% AND BLF 15%

LIFE



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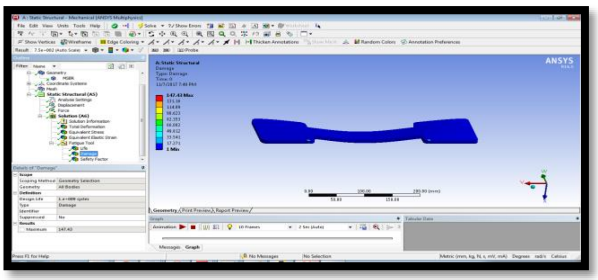
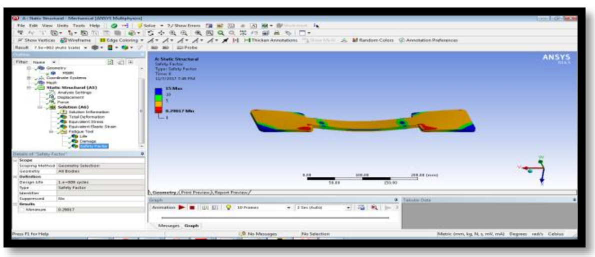


SAFTEY FACTOR



EXPERIMENTAL INVESTIGATION

Materials - 1. Aluminum alloy 7075 SiC 10% + BLF 5%

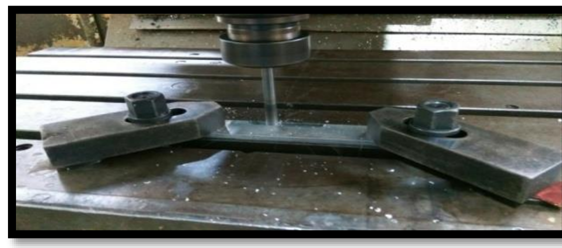
2. Aluminum alloy 7075 +SiC 15% + BLF 10%

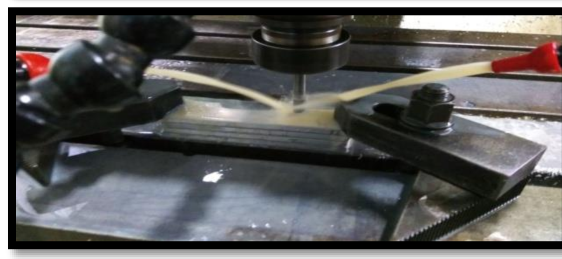
3. Aluminum alloy 7075 + SiC 20% + BLF 15%

4. Aluminum alloy 7075 + SiC 25% + BLF 20%

CASTING COMPONENT

MACHINING PROCESS FOR DOUMBLE SHAPE





FINAL DOUMBLE SHAPE

TENSILE TEST

Type of test – Tensile

Machine Model – TUE-C-600

Ultimate tensile testing machine

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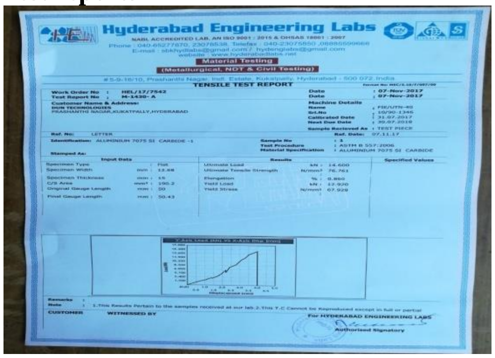
Test reports


Hyderabad Engineering Labs
Material Testing
(Metallurgical, NDT & Civil Testing)
TENSILE TEST REPORT

To attain more tool life, the optimal parameters are
HARDNESS TEST REULTS

MACHINE DETAILS

Name –HARDNESS

TEST DETAILS

Test Reference – IS 1586:2000

Type of Hardness – HRC

Machine Model – 2008/073, MRB 250
Sample ID – Hardness Test at Weld Zone


Hyderabad Engineering Labs
Material Testing
(Metallurgical, NDT & Civil Testing)
HARDNESS TEST REPORT

IMPACT TEST


Hyderabad Engineering Labs
Material Testing
(Metallurgical, NDT & Civil Testing)
IMPACT TEST REPORT

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