EXPERIMENTAL INVESTIGATION ON GAS TURBINE BLADES FOR SELECTED MATERIALS UNDER DIFFERENT TESTING CONDITIONS

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Abstract:
Gas turbine blades are the ones which are capable in evaluating high energy units in field of engineering. As per earlier studies it is observed that the fabricating parameters for these blades is getting into complications due to some order of casting, moulding, machining and in choose of materials where it leads the blade for cracking. To overcome these testing conditions in this blades are taken with three mixing materials like Al+SIC, SS+SIC, MS+SIC. The portion of SIC is taken 10% for every sample fabricated. The tests like tensile, hardenss and SEM is conducted to the fabricated blades. Here after the testing conditions it is observed that the testing parameters are equal and should maintain constant overall the process. It is founded that SS+SIC is giving more efficient rate in the taken samples and all samples are giving better performance rate compared to the past ones.

Keywords: Gas Turbines, SEM, Tensile test, Synthesis of blades.

1.0 Introduction:

The technical condition of turbine blades in the operating process of aviation turbojet engines is of decisive importance for the reliability and durability of a turbine and the entire engine The main reason gas turbine blades get damaged is overheating of their material as well as thermal fatigue This is caused by adverse operating conditions or manufacturing defects. Important factors causing turbine blade damage are: Insufficiently strong superalloys and protective coatings applied to the blade (vanes), and the use of fuel with decreased quality requirements. The most important factors are complex conditions of mechanical and thermal loads in the course of turbine operation. Exceeding the permissible flue gas temperature, especially over a long operation period, as well as disturbances in or lack of sufficient cooling of turbine blades are particularly dangerous. The evaluation of the technical deterioration of operated blades with non-destructive methods enables, in certain cases, the extension of the service life of an engine even after detection of a permissible defect or to decommission an engine before catastrophic turbine damage appears

Figure: Turbine blade model

Figure: Turbine blade isometric view

ANALYSIS OF TURBINE BLADE:

Boundary Conditions

For Structural and Thermal analysis Input parameters of Pressure and temperature values are taken from the "Film Cooling Effectiveness in a Gas Turbine Engine"

Pressure = 0.32364Pa

Temperature = 1500 0C

Material – SS+SIC10%

STATIC STRUCTURAL ANALYSIS:

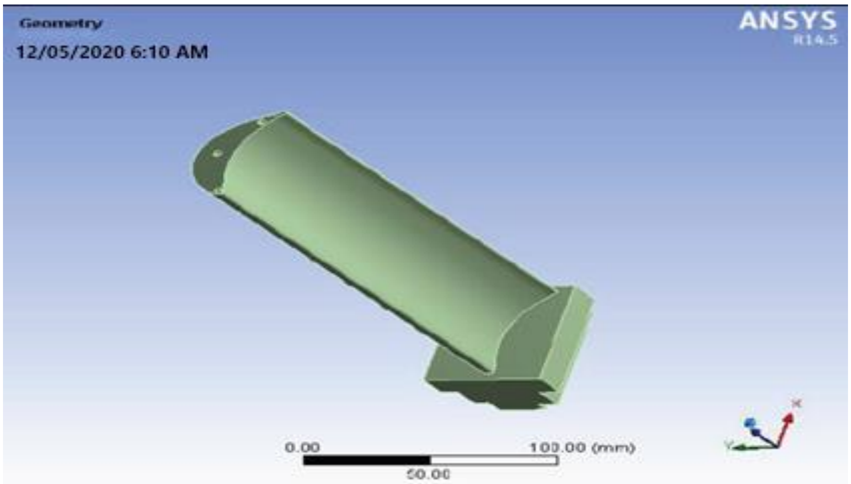

Figure: Imported model from Creo 2.0

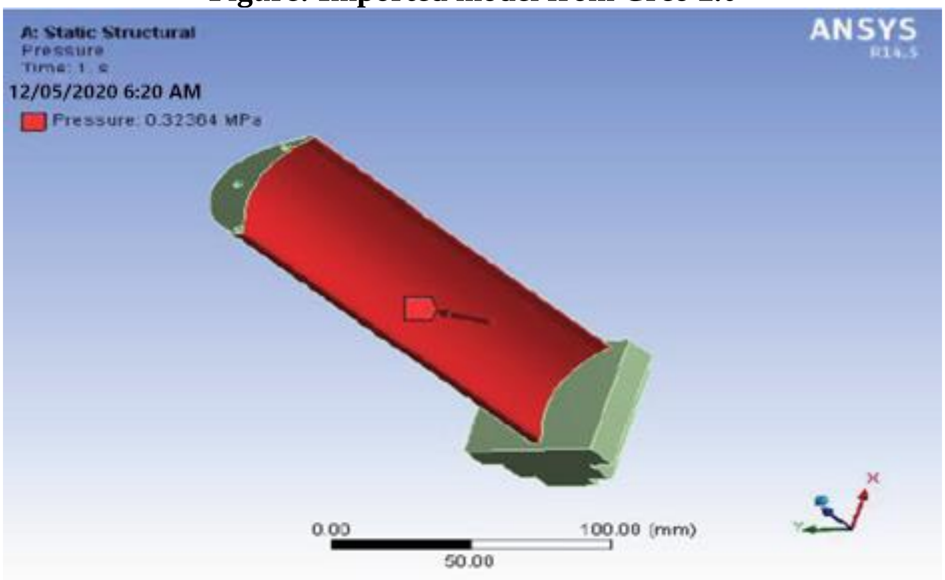

Figure: pressure

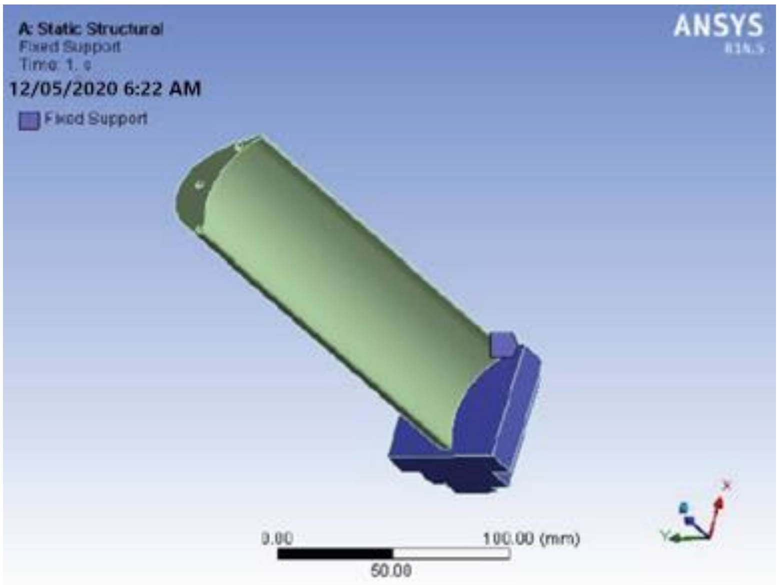

Figure: Fixed support is applied at inside the shaft

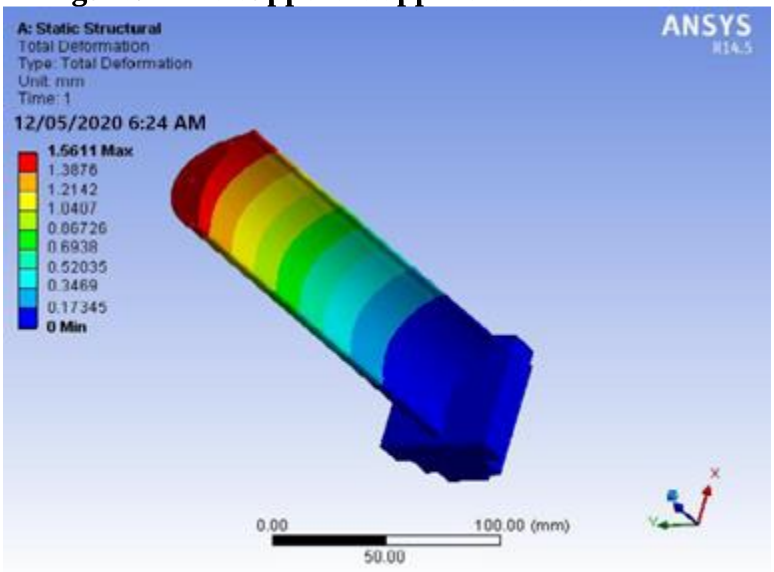

Figure: Total Deformation for SS+SIC(10%)

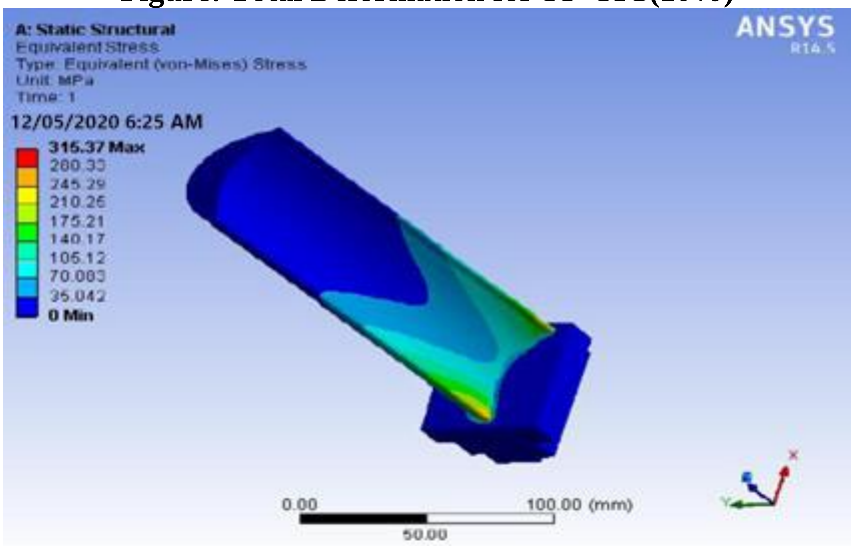

Figure: Equivalent Stress for SS+SIC(10%)

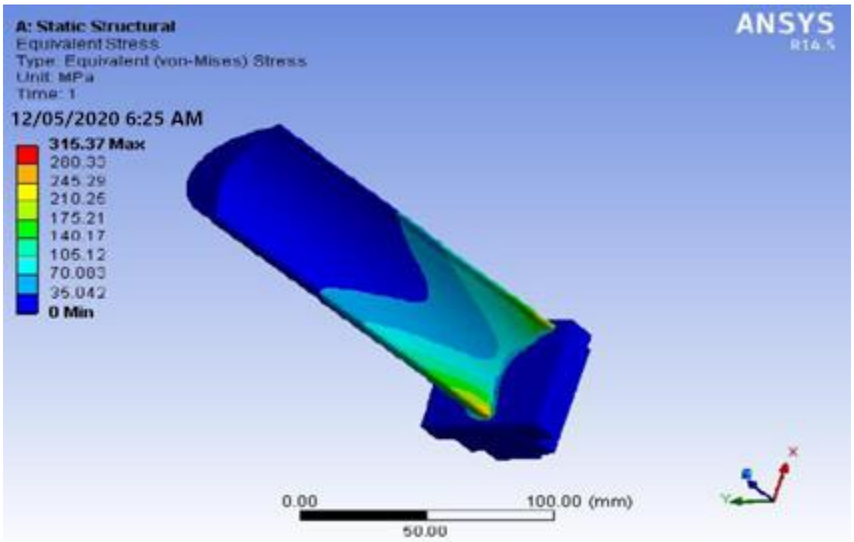

Figure: Equivalent Elastic Strain for SS+SIC(10%)

THERMAL ANALYSIS:

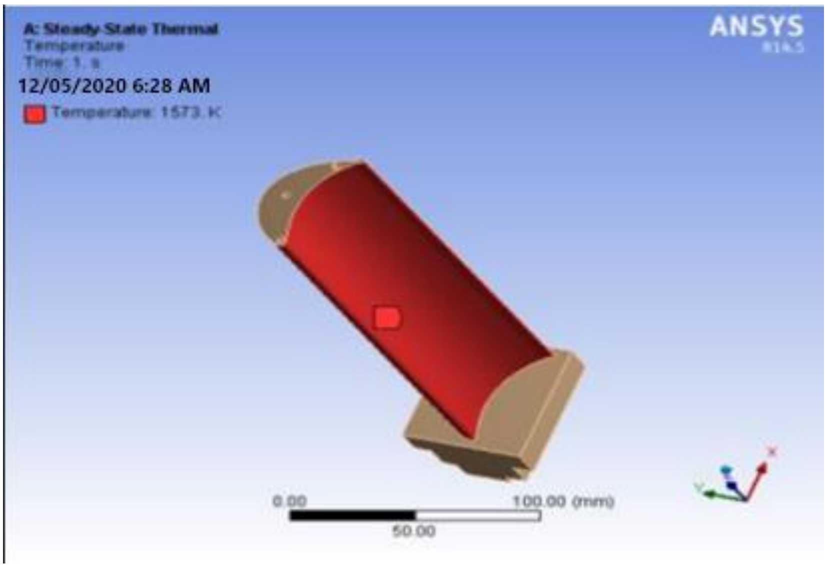

Figure: Temperature

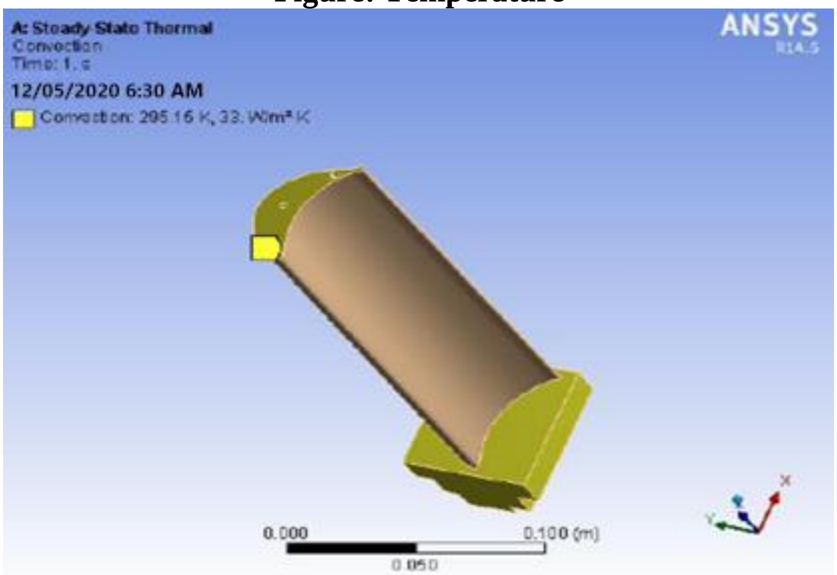

Figure: Convection

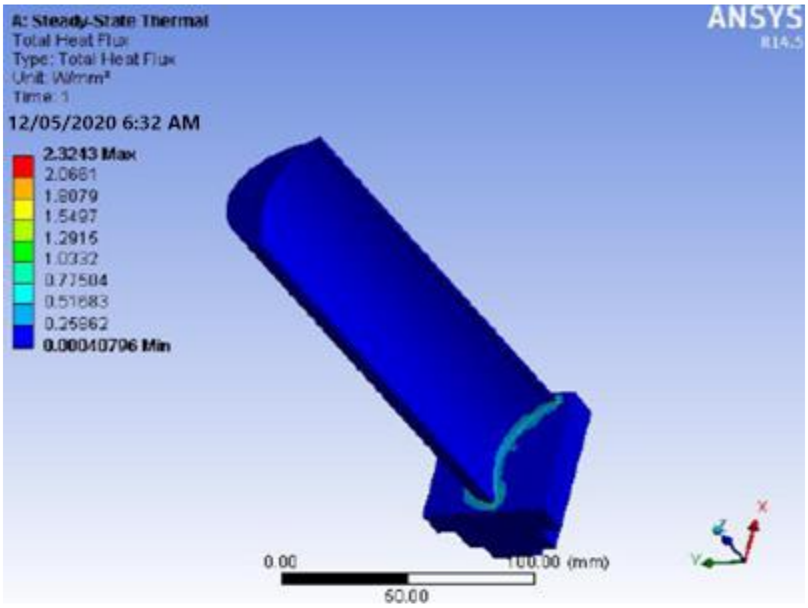

Figure: Heat flux

FATIGUE ANALYSIS:

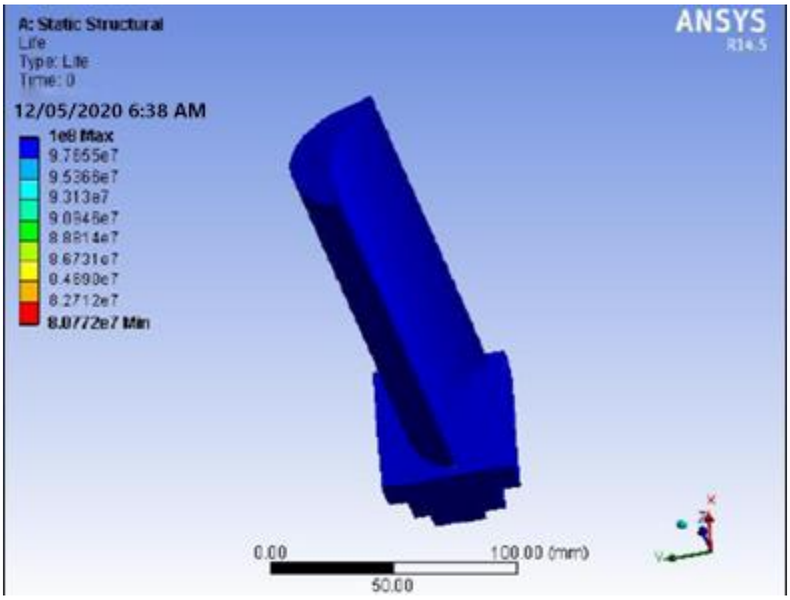

Figure: Life

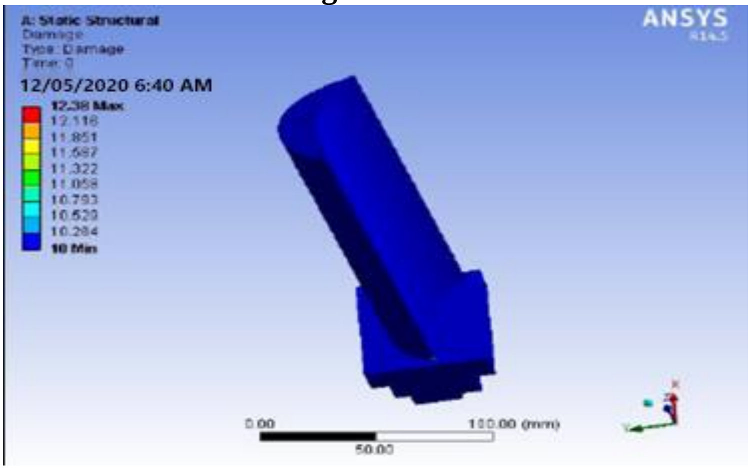

Figure: Damage

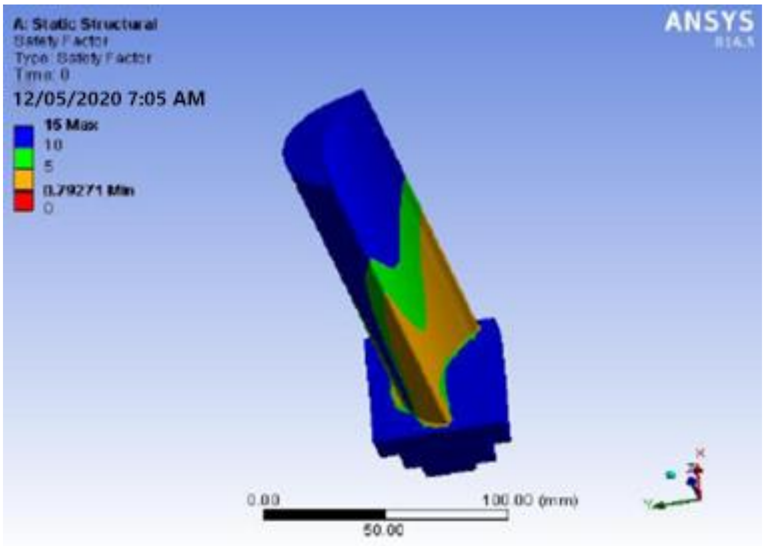

Figure: Safety Factor

FRACTURE ANALYSIS:

FRACTURE CREATED AT THE MIDDLE OF THE BLADE:

Select Crack Shape – Semi Elliptical
Enter major radius →5 mm
Enter minor radius→2 mm
Enter Fracture affected zone Height – 13.55mm
Enter largest contour radius – 5 mm

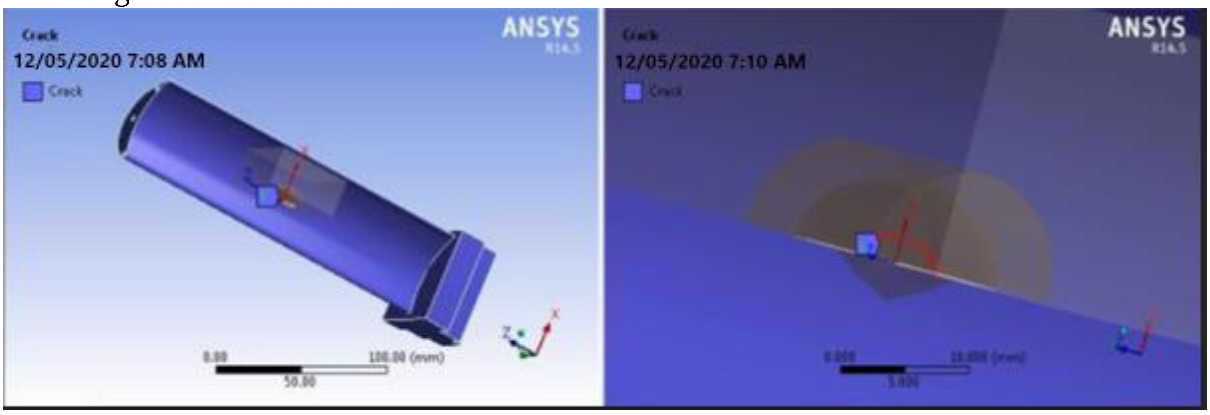

Figure: Crack on blade

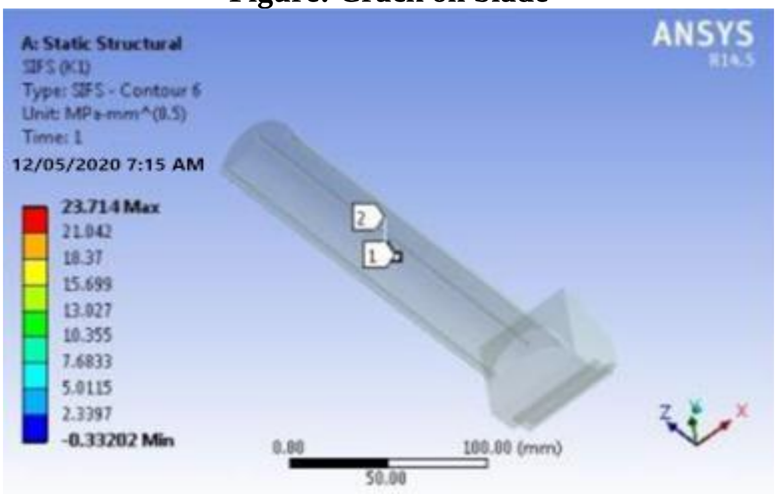

Figure: Stress Intensity Factor

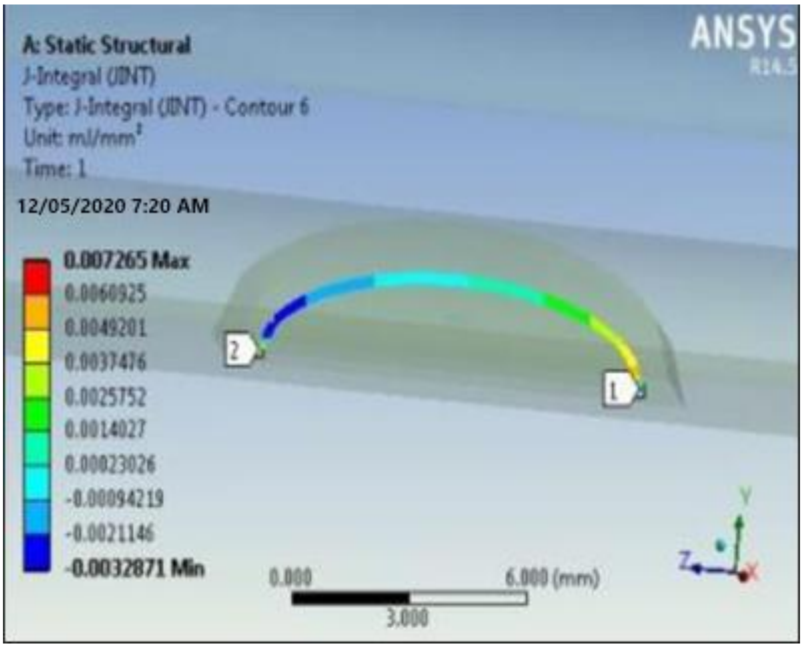

Figure: J-Integral

RESULT & DISCUSSIONS:

STATIC STRUCTURAL ANALYSIS:

MATERIAL	Deformation (mm)	Stress (MPa)	Strain
SS+SIC(10%)	0.93587	313.94	0.00158
AL+SIC(10%)	1.5611	315.37	0.002644
MS+SIC(10%)	0.91394	315.66	0.001549

THERMAL ANALYSIS:

MATERIAL	Temperature (K)	Heat Flux (W/mm^2)
SS+SIC(10%)	1573	1.1732
AL+SIC(10%)	1573	2.3243
MS+SIC(10%)	1573	2.6478

FATIGUE ANALYSIS:

MATERIAL	Life	Damage
SS+SIC(10%)	$1e^{8}$	34.958
AL+SIC(10%)	$1e^{8}$	12.38
MS+SIC(10%)	$1e^{8}$	13.566

FRACTURE ANALYSIS:

MATERIAL	SIFS K1 (MPa.mm^0.5)	SIFS K2 (MPa.mm^0.5)	SIFS K3 (MPa.mm^0.5)	JINT (mj/mm^2)
SS+SIC(10%)	23.711	17.576	19.478	0.0043697
AL+SIC(10%)	23.714	17.413	19.611	0.007265
MS+SIC(10%)	23.714	17.381	19.638	0.0042506

SEM Results:

The results of the SEM analysis are represented in the Figure shows the optical micro structure of Aluminium and 10% of Sic alloy, the microstructure of the sample indicates that the homogeneity of Al grain was observed. Figure shows the microstructure of stain less steel and 10% of Sic and Figure shows the micro structure of mild steel and 10% of Sic particles. You can see from the chart that the cluster particle increases, which lead to an increase in temperature. Although the particles clustering has been increased with an increase in processing temperature, the tendency to form particles clusters was higher in higher holding time than in low holding time. The growth of porosity is not restricted by low viscosity liquid.

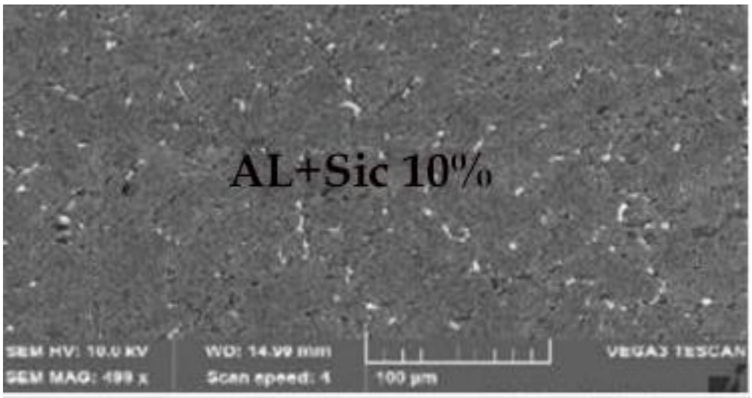

Figure: Micro structure of Aluminium and 10% of Sic

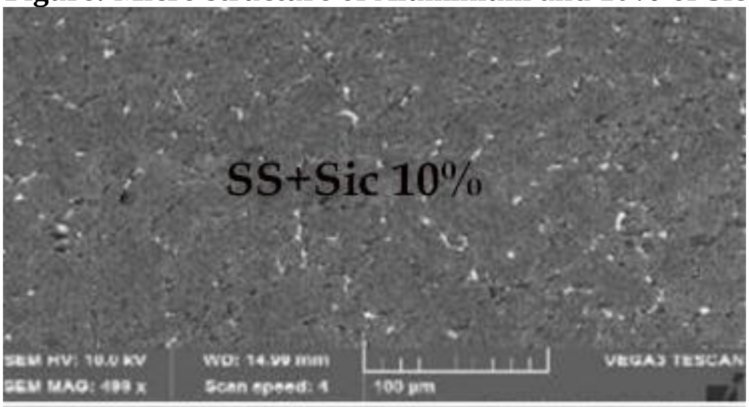

Figure: Micro structure of SS and 10% of Sic

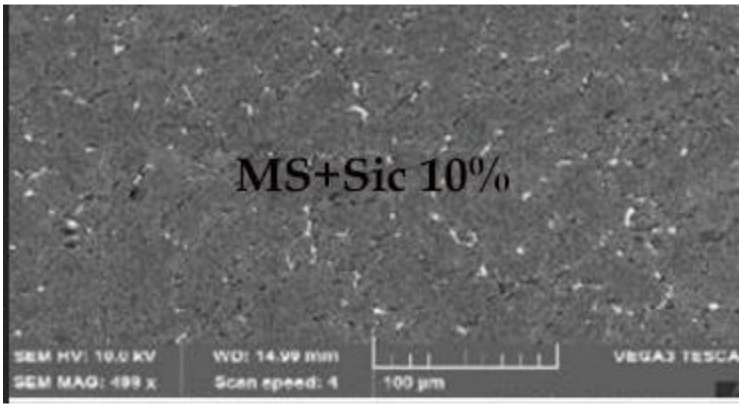

Figure: Micro structure of MS and 10% of Sic

Ultimate tensile strength (UTS):

Ultimate tensile strength variation (UTS) of the base alloy when reinforced with, 10 wt. TiB2 particulates percentage. In contrast with alloy cast Al+Sic, the ultimate tensile strength of Mild steel and 10% of Sic increases. The composites are regulated with the microstructure and properties of the hard-ceramic tin particles. Due to the strong relation of the interface, the load from the matrix to the arming results in increased tensile strength. This improvement in ultimate tensile strength is primarily due to the presence of Tin particles that avoid micro-structure dislocations.

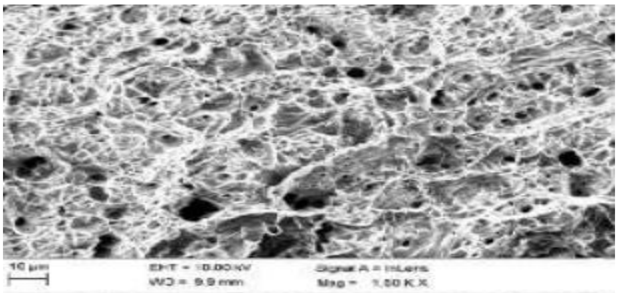

Figure: SEM image of ultimate tensile strength sample Aluminium and 10% of Sic

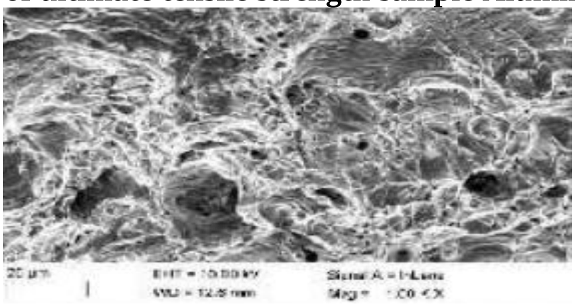

Figure: SEM image of ultimate tensile strength sample SS and 10% of Sic

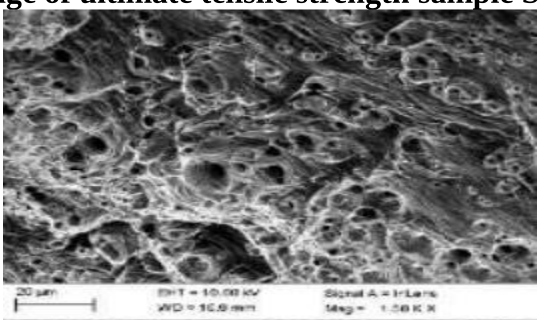

Figure: SEM image of ultimate tensile strength sample MS and 10% of Sic

CONCLUSION:

It is seen from above results both the materials are giving the considerable results; finally the conclusion can be done on the basis of the cost and the availability of the materials.

- If cost of the materials is not a primary issue we can select the AL+SIC(10%) which have lesser density, lesser value of deformation at a same time it will have lower value of yield strength and young modulus at higher temperature, which will have a lower strength.
- On the other hand if cost of the material is a primary issue then we can select SS+SIC(10%), it will have little higher deformation at high temperature as compare to AL+SIC(10%). But at the same time it will have higher value of elastic strength, higher values of yield strength which will induce lesser value of the stress on the blade.
- It is also seen SS+SIC(10%)have good material properties at higher temperature has compare to that of the AL+SIC(10%) and MS+SIC(10%).

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