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DESIGN OF THERMAL EXPANSION AND FINITE ELEMENT ANALYSIS IN COMPOSITES CIRCULAR BARS

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ABSTRACT:

Composite materials are being more frequently used in a wide variety of industries. Their high strength to weight ratio makes them a desirable material in many applications. In some specific cases, polymer based composites can be subjected to large changes in temperature causing undesirable amounts of expansion. To reduce the composite's thermal expansion, materials that have negative coefficients of thermal expansion are used as a filler material. Aluminium Silicon Carbide is a metal oxide which exhibits thermal behaviours not seen in most other materials. When subjected to a positive temperature change, Alsic will decrease in volume as opposed to most other materials which show an increase in volume. This makes Alsic an ideal candidate to be used as filler material in these polymer composites to reduce their overall thermal expansion. This research looked at the finite element modelling of these composite materials and tried to gain a better understanding of their possibilities. In the models, the bond between the two was considered perfect, with no voids or separation, leading to the filler material having more effect on the overall properties of the composite. In this project, Aluminium Silicon Carbide (AlSiC), an aluminium matrix composite is used for composite bars A 3D model was made using CATIA and finite element, Structural and thermal analysis was done on ANSYS AlSiC has better abrasion resistance, creep resistance, dimensional stability, exceptionally good stiffness-to-weight and strength-to-weight ratios and better high temperature performance.

Keywords: composite circular bars, Aluminium Silicon Carbide, catia, thermal analysis, ansys.

1. INTRODUCTION

A composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct

within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, which are known as Robotic Materials.

1.1 Natural composites:

Natural composites exist in both animals and plants. Wood is a composite – it is made from long cellulose fibers (a polymer) held together by a much weaker substance called lignin. Cellulose is also found in cotton, but without the lignin to bind it together it is much weaker. The two weak substances – lignin and cellulose – together form a much stronger one. The bone in your body is also a composite. It is made from a hard but brittle material called hydroxyapatite (which is mainly calcium phosphate) and a soft and flexible material called collagen (which is a protein). Collagen is also found in hair and finger nails. On its own it would not be much use in the skeleton but it can combine with hydroxyapatite to give bone the properties that are needed to support the body.

1.2 Typical engineered composite materials include:

- mortars, concrete
- Reinforced plastics, such as fiber-reinforced polymer
- Metal composites
- Ceramic composites (composite ceramic and metal matrices)

Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite and cultured marble sinks and countertops. The most advanced examples perform routinely on spacecraft and aircraft in demanding environments.

1.3 Why use composites:

The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive.

1.4 Al-SiC Metal Matrix Composite Ceramic Material:

metal matrix composites feature take advantage of various material mixes to deliver unique material properties and performance characteristics. The material properties of Aluminum—Silicon Carbide metal matrix composites make it a good solution for large size products. Al-SiC metal matrix materials are good for contributing to weight reduction and provide excellent damping for high speed and precise equipment motion applications like robot parts.

Benefits

- Light weight
- High stiffness
- Low thermal expansion
- High thermal conductivity
- Excellent mechanical damping
- Facture toughness
- Near net shape process allowance

Applications

- Semiconductor equipment parts
- Semiconductor inspection parts
- Display equipment parts
- Precision equipment parts

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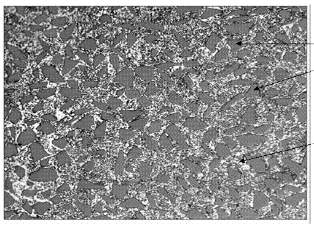
- Heat sinks

Microscopic picture of Al-SiC composite:



AlSiC:

AlSiC, pronounced "alsick",[1] is a metal matrix composite consisting of aluminium matrix with silicon carbide particles. It has high thermal conductivity (180–200 W/m K), and its thermal expansion can be adjusted to match other materials, e.g. silicon and gallium arsenide chips and various ceramics. It is chiefly used in microelectronics as substrate for power semiconductor devices and high density multi-chip modules, where it aids with removal of waste heat.

1.5 Problem of statement:

Composite materials are being more frequently used in a wide variety of industries. Their high strength to weight ratio makes them a desirable material in many applications. This research looked at the finite element modeling of these composite materials and tried to gain a better understanding of their possibilities.

1.6 Objective

1.3.1 Study and analysis the alsic composite bars verify using ansys Simulation.

1.3.2 Analysis the thermal effect of impact force on alsic composite bars system.

Chapter-2

LITERATURE REVIEW

2.1 INTRODUCTION:

Aluminium is the most widely used metal in engineering apart from iron. It has good electrical and thermal conductivities and high reflectivity to both heat and light. It is highly corrosion resistant under a great many service conditions and is nontoxic. Aluminium alloys offer a combination of mechanical and tribological properties and low density that makes them highly suitable for composite manufacturing.

2.2 matrix material:

Several metals and alloys have been used as matrix materials; however, most Research and Development has been concentrated on aluminium and its alloys. Aluminium has a unique combination of properties among its class, i.e., light metals. It is not only less expensive than titanium and magnesium but also easier to fabricate. To tailor its properties such as strength, stiffness, hardness, wear resistance, thermal expansion etc., a suitable alloy of aluminium can be paired with appropriate reinforcement. In recent years, aluminium alloys have attracted attention of many researchers, engineers and designers as a promising structural material in different industries like aerospace and automotive. Special 2xxx series of Al alloys have been studied extensively because of their high strength to weight ratio, good formability, age hardenablity and other appropriate properties. The major characteristics of the 2xxx series are:

- Heat treatable

- High strength, at room and elevated temperatures
- Typical ultimate tensile strength range: 190 to 430
- Usually joined mechanically, but some alloys are weldable

The 2xxx series of alloys are heat treatable and possess good combinations of high strength (especially at elevated temperatures), toughness, and, in specific cases, weldability. Among Al alloys, 2024 Al has the highest hardness (Hudaa et al 2009). The use of A2024, therefore, has been growing gradually in industry as a material of aeroplane constructions, automobiles, and pulling wheels (Malas et al 2004). AA 2024 alloy is the most widely used aluminium–copper alloys in forging as well as rivets for aircraft industry.

Cheng et al (2007) developed an effective approach in achieving both high strength and high ductility in a 2024 Al alloy. The approach involves solution-treatment to partially dissolve T-phase particles, cryorolling to produce a fine-structure containing a high density of dislocations and submicrometer subgrains and aging to generate highly dispersed nanoprecipitates. Such a high density of precipitates enabled effective dislocation pinning and accumulation, leading to simultaneous increases in strength, work-hardening ability and ductility.

Mazahery et al (2012) investigated the optimal solidification conditions to manufacture AA 2024 alloy with minimum wear and maximum strength. Mechanical and wear properties of unreinforced AA 2024 alloy andits composites with different vol. % of coated boron carbide particles were also experimentally investigated. It was seen that the incorporation of hard particles to

2024 aluminium alloy contributes to the improvement of the mechanical properties and wear resistance of the base alloy to a great extent.

Chapter-3

ANALYSIS OF COMPOSITE BAR

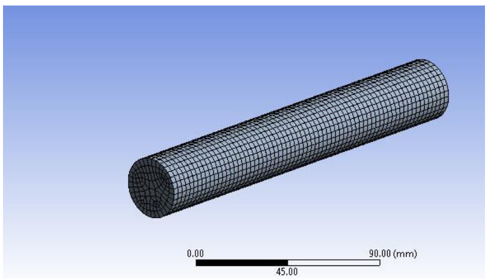
ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.

5. A typical ANSYS analysis has three distinct steps.

6. Pre Processor (Build the Model).

Mesh:



- **Material Data**

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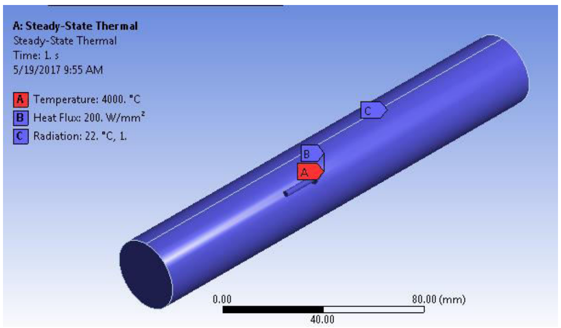
AlSiC

AlSiC

Density	2.95e-006 kg mm^-3
Specific Heat	7.4107e+005 mJ kg^-1 C^-1
Thermal Conductivity	0.18 W mm^-1 C^-1
Coefficient of Thermal Expansion	7.5 C^-1

AlSiC > Isotropic Elasticity

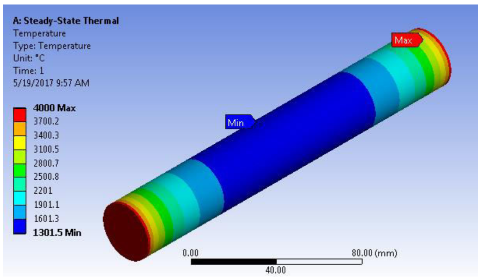
Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	2.3e+008	0.154	1.1079e+008	9.9653e+007



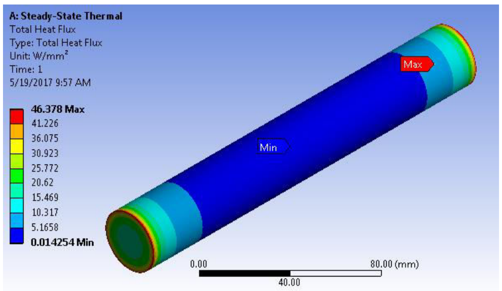
Loads

Object Name	*Temperature*	*Heat Flux*	*Radiation*
Geometry	1 Body		2 Faces
Type	Temperature	Heat Flux	Radiation
Magnitude	4000. °C (ramped)	200. W/mm²	
		(ramped)	
Suppressed	No		
Correlation			To Ambient
Emissivity			1. (step applied)
Ambient Temperature			22. °C (ramped)

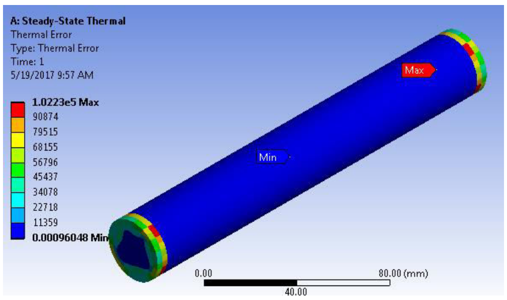
Temperature



Total Heat Flux



Thermal error:



Object	*Temperatu*	*Total*	*Thermal*

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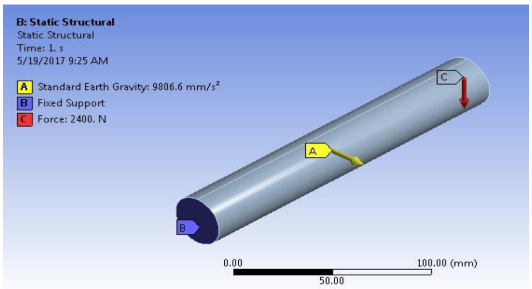
Name	*re*	*Heat Flux*	*Error*
Results			
Minimum	1301.5 °C	1.4254e-002 W/mm²	9.6048e-004
Maximum	4000. °C	46.378 W/mm²	1.0223e+005

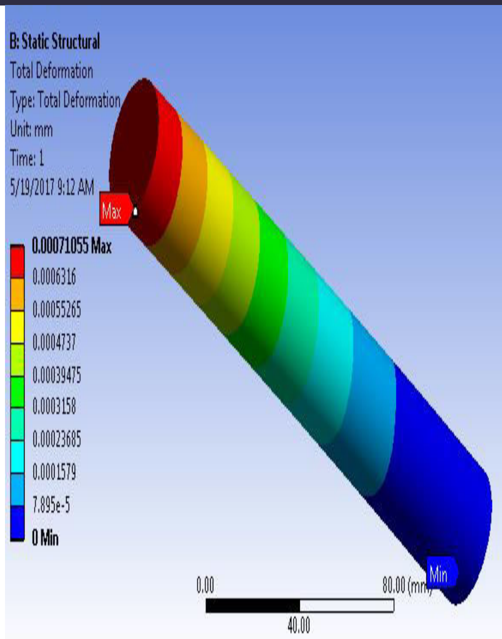
Structural analysis:



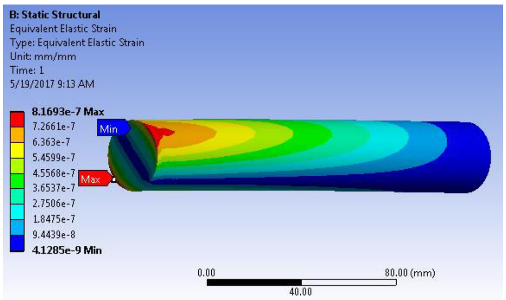
Loads

Object Name	*Fixed Support*	*Force*
Geometry	1 Face	
Suppressed	No	
Define By		Vector
Magnitude		2400. N (ramped)
Direction		Defined

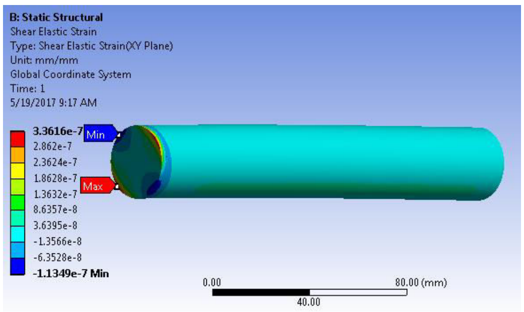
Total deformation:



Equivalent elastic strain



Shear elastic strain



Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Shear Elastic Strai*	*Vector Principal Elas*	*Equivalent Plastic Strain*

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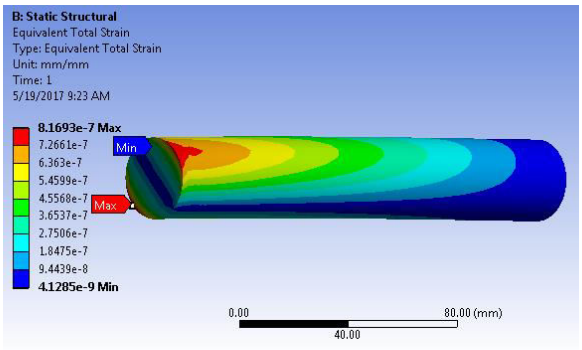
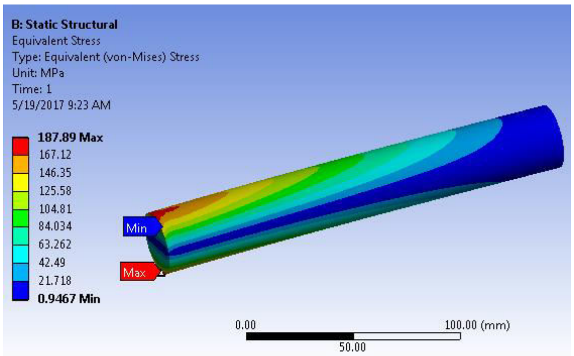
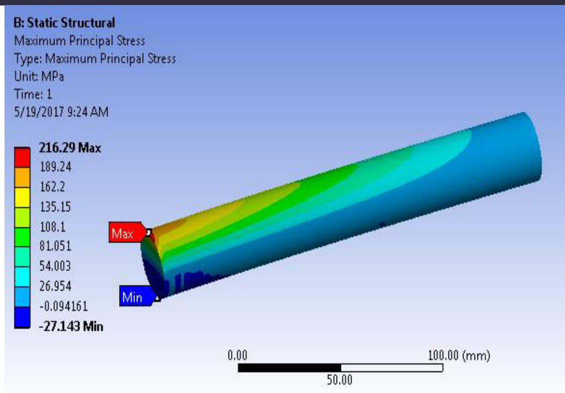
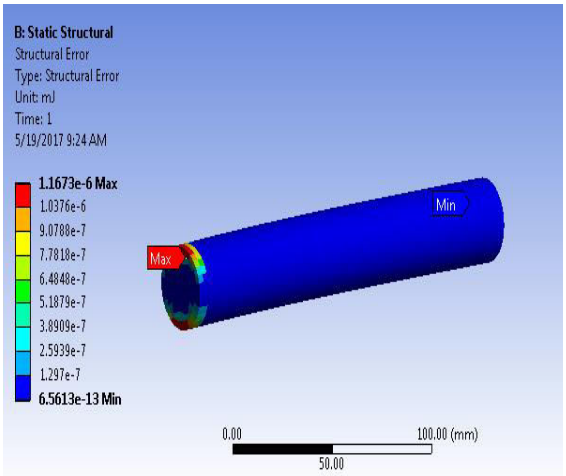
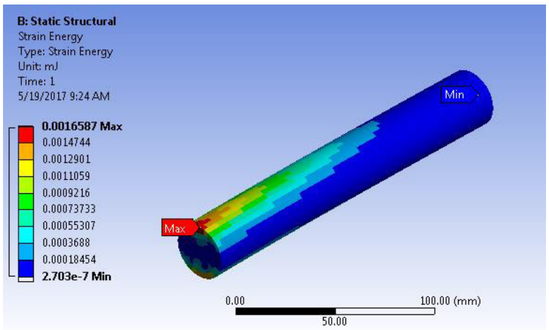
			n	*tic Strain*	
Results					
Minimum	0. mm	4.1285e-009 mm/mm	-1.1349e-007 mm/mm		0. mm/mm
Maximum	7.1055e-004 mm	8.1693e-007 mm/mm	3.3616e-007 mm/mm		0. mm/mm











Type	Equivalent Total Strain	Equivalent (von-Mises) Stress	Maximum Principal Stress	Structural Error	Strain Energy
Results					
Mini	4.128	0.946	-	6.561	2.70

mum	5e-009 mm/mm	7 MPa	27.143 MPa	3e-013 mJ	3e-007 mJ
Maximum	8.1693e-007 mm/mm	187.89 MPa	216.29 MPa	1.1673e-006 mJ	1.6587e-003 mJ

Conclusions

Composite materials are being more frequently used in a wide variety of industries. Their high strength to weight ratio makes them a desirable material in many applications. In some specific cases, polymer based composites can be subjected to large changes in temperature causing undesirable amounts of expansion. The main goal of this research was to determine the effect of circular bar geometry on the finite element modeling of Alsic alloy Composite materials have

interesting properties such as high strength to weight ratio, ease of fabrication, good electrical and thermal properties compared to metals. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibers. Each layer may have similar or dissimilar material properties with different fiber orientations under varying stacking sequence by above comparison we conclude that composite bar have good thermal properties. While comparing analysis obtained results composite bar have very low deformation factor at same factor of ordinary bar which have large deformation factor in thermal factors composite bar has good factors when compared to ordinary bar.

Future Work

This research looked at the finite element modeling of these composite materials and tried to gain a better understanding of their possibilities. Composite materials are being more frequently used in a wide variety of industries. In future this paper is used for develop the Alsic alloy materials strength and thermal expansion values for further investigation, the composite bar can be analysed with structural and thermal analysis. It is possible to do the regression analysis for same work. For the same geometry modal analysis to find the performance results of Alsic alloy composite bar is possible.

References

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ranging from 0 to 16% manufactured by a PM technique

- Rao et al (2011) investigated the effect of applied pressure on the tribological behaviour of SiCp reinforced aluminium.

- Al-Rubaie et al (1999) observed the effect of three-body abrasion of aluminium matrix composites reinforced with silicon carbide particles (SiCp). MMCs were fabricated by a powder metallurgy route involving a final hot extrusion step.

- Rahimian et al (2011) observed the effect of production parameters on wear resistance of Al–Al2O3 composites. Alumina powder with a particle size of 12, 3 and 48 μm and pure aluminium powder with particle size of 30 μm were used.

- Kwok and Lim (1999) investigated the friction and wear behaviour of four Al/SiCp composites over a wide range of sliding conditions by the use of a specially adapted high-speed tester of the pin-on-disk configuration.

- Abarghouie and Reihani (2010) investigated the friction and wear behaviours of artificially aged 2024 Al and 2024 Al/20 vol.% SiC composite prepared by powder metallurgy method in the temperature range 20–250 °C.