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ANALYSIS OF SAWDUST COMPOSITE BRAKE PAD USING FINITE ELEMENT ANALYSIS APPROACH

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Abstract— **The present work is concentrated on development of a particulate reinforced composite material for an automobile brake pad replacing asbestos, which is carcinogenic in nature. It is observed that composition has balanced the properties and fine element analysis shows the improvement which enables the composite to be used practically in brake pad lining.**

Keywords— **Reinforced material, properties, fine element analysis, composition.**

I. INTRODUCTION

Brakes have been advanced in recent years through many developments. Previously all those years brake pads were made of asbestos fiber which are very harmful in many ways. When vehicles apply brake, the asbestos gets wear down and releases asbestos dust in surroundings. This asbestos also gets trapped inside the brake housing which is also a vital problem. When there is requirement to open brake housing, the asbestos dust is released in to the air and humans may accidentally inhale it without consciousness. It also posed a risk during manufacturing in industries as workers are exposed to asbestos when they knowingly or unknowingly come into contact with asbestos.

Thus this work is concentrated on utilizing industrial and agricultural wastes as a source of raw materials in the area of development of asbestos free brake pads such as sawdust. Based on the tests conducted, density and coefficient of friction increased with decrease in the filler particle size. Fillers are used to maintain the overall composition of the friction material, as well as to improve morphological and tribological properties of brake pad. Fillers are also included in a brake pad to reduce the overall cost of the brake pad. The amount of filler is one of the highest constituents in a brake pad composition. Therefore, the essence of present study is to employed sawdust as fillers in a typical brake pad formulation together with epoxy resin as binder, silicon carbide as abrasive component, zinc dust as reinforcing material and graphite as friction modifier. Sawdust used in this study was found as waste from the processing of hardwood in sawmill. Sawdust is by-product from milling of wood. Therefore, utilization of sawdust as alternative filler to asbestos in brake pad formulation will help to prevent environmental degradation and pollution.

The objective is to study morphological, mechanical and tribological properties of brake pad lining. It also includes validation of studied experiments using simulation software. Here, the validation is done by fine element analysis using Ansys. It stands for Analysis Systems used method for numerically solving differential equations arising in engineering and mathematical modelling. It includes traditional fields of structural analysis, heat transfer, fluid flow, mass transport and electromagnetic potential. The method approximates the unknown function over the domain. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. Then it uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error function.

Hence the objective is to carry out different testings and to get validated using finite element method through Ansys work.

II. PROPOSED ALGORITHM

A. Materials and Methodology–

Materials

The materials required in manufacturing of brake pad lining are as follows.


Sawdust


Graphite


Zinc dust


Silicon Carbide

Epoxy resin & hardener

Fig.1 Photos of all materials

Formulation

The formulation used in the brake pad friction lining in this study was chosen based on the typical sample formulation of commercial brake pad. This combination of the composite materials in the ratio (wt%) is shown in Table 1.

Sr. no.	Materials	A	B	C	D	E
1	Sawdust	31.5	36.75	42	47.25	52.5
2	Zinc dust	21	21	21	21	21
3	SiC	21	15.75	10.5	5.25	0
4	Graphite	10.5	10.5	10.5	10.5	10.5
5	Epoxy resin	21	21	21	21	21

Table 1

Preparation

The sawdust was sun dried for about 1-3 month after collection. The dried sawdust was milled into powder and then sieved into different sieve sizes of aperture 450µm, 300µm and 150µm. Using a set of BS with different mesh sieves in the brake lining formulation. The samples were produced using a pressure gun, the piston rod was used to close the cylindrical mould after impregnated. Different composition and sieve grades (i.e. 450µm, 300µm and 150µm) of sawdust, silicon carbide, graphite, zinc dust and epoxy resin were added together.

The combinations were properly dry mixed in a mixer, to achieved a homogenous state and transferred to a mould kept in industrial oven at temperature of 90˚C at 950KN/cm² pressure for 2 minutes. After removing from industrial oven, the brake pad was cured in an oven at a temperature of 50˚C for 4hours. The photos of the produced samples are shown below.

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Fig 2. Photos of specimen prepared

B. Sample Charaterisation –

Density Test

The density of the samples was determined by weighing the sample mass on a digital weighing machine and divided by measuring their volume by liquid displacement method. The formula is below.

Density (ρ) = M÷V×10

where M is the mass of test piece (g) and V is the measuring volume of test piece (cm³).

Microstructural Test

The morphology of the surfaces of the brake pads also was observed by using a electron microscope. The images of the surfaces of the sample of brake pads with different percentage of filler were obtained. The analysis of samples were carried out by grinding the samples (150m,300m,450m) and the internal structures were viewed under the electron microscope.

Finite Element Analysis

This analysis is done to validate the testings done prior. To complete the process, a software is used known as Ansys. Ansys is engineering simulation software used to determine how product will with different specifications without building tests or conducting tests. It has given the comparison between the conventional fiber (asbestos, aluminium alloy) and the particulate reinforced composite material (sawdust) used in brake pad.

This is achieved by particular space variables in space dimensions, which is then implemented by construction of a mesh of the object. Then finite element method formation of a boundary value problem finally results in a system of algebraic equations. The method approximate the unknown function over the domain. The simple equations that model these finite elements are then assembled into larger system of equations that models the entire problem. The finite element method then uses variational methods from the calculus of variations to approximate a solution by minimizing an associated error.

III. EXPERIMENT AND RESULT

Density Test

Sr.no.	Sieve size (μm)	Wt. (g)	Vol. Disp. (cm³)	Avg wt.(g)	Avg Disp. (cm³)	Avg Density (g/cm³)
1	150	42	42	65.75	62	1.06
		47.5	41			
2	300	42	43	65.75	63.75	1.03
		47.5	41.5			
3	450	42	40	65.75	80.5	0.81
		47.5	40.5			

Table 2 – Density test value

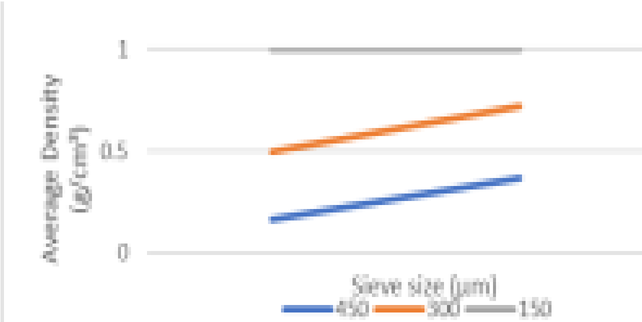

Fig 3. Graph of Density Test

Figure shows the result of the density with sieve size. It shows the density to be decreased as the sieve size of the sawdust increases in composition. The decrease in density can be attributed to increase in particle size. The 150m has the highest density which is as a result of closer packing of sawdust particles creating more homogeneity in the entire phase of composite body.

Microstructure Test

Fig. 4 Images of 150 µm specimen

Fig. 5 Images of 300 µm specimen

Fig. 6 Images of 450 µm specimen

Above figures shows the morphological (microstructural) behaviour of specimens. Microstructure of all specimens are done in x100.

Specimens with 150µm shows the densed structure and it became rarer as we increase the sieve size of sawdust.

Finite Element Analysis

Finite element analysis of brake pad lining is done with the help of Ansys workbench.

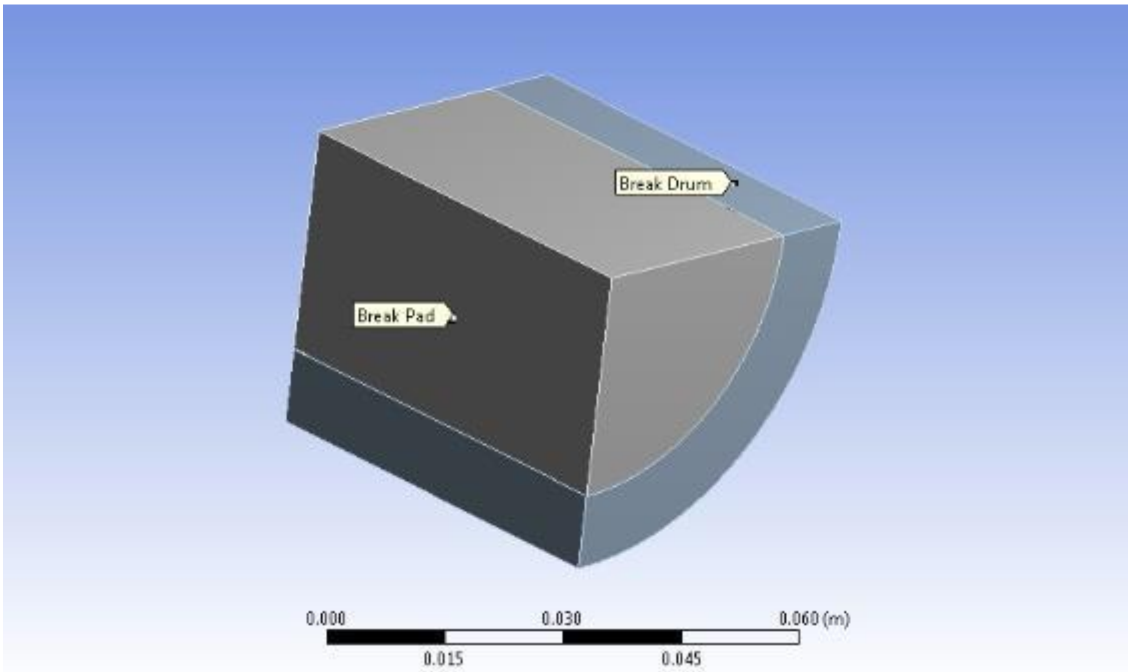

Fig 7. Geometry of brake pad

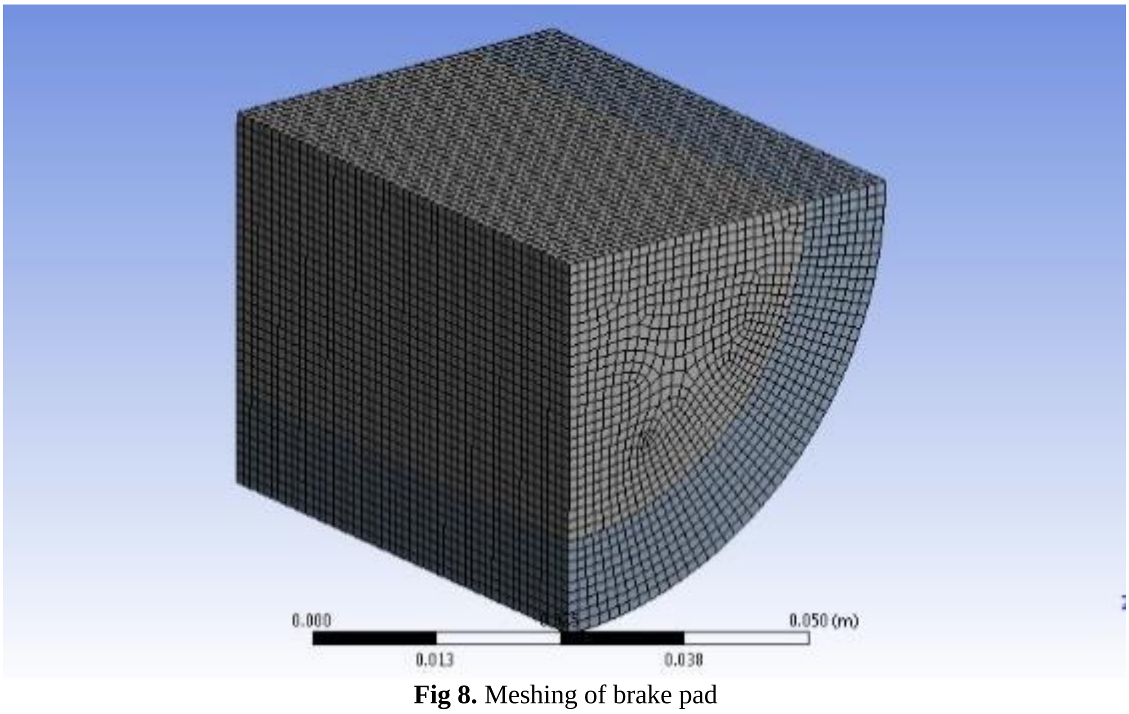

Fig 8. Meshing of brake pad

The above figures show the desired design of brake pad lining. The geometry of specimen is designed in a way with the help of software to apply the boundary conditions to get the possible effects on the specimen.

After designing, the specimen needed to be meshed which is also shown in above figure.

A) Boundary Conditions:

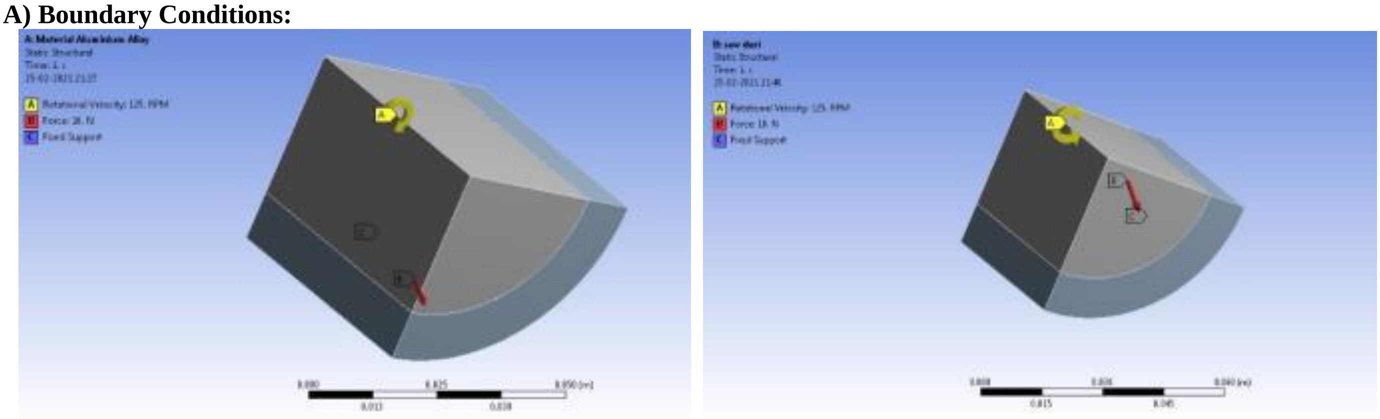

Fig 9. Comparison of boundary conditions of conventional and sawdust brake lining

B) Equivalent Stresses (von mises stress):

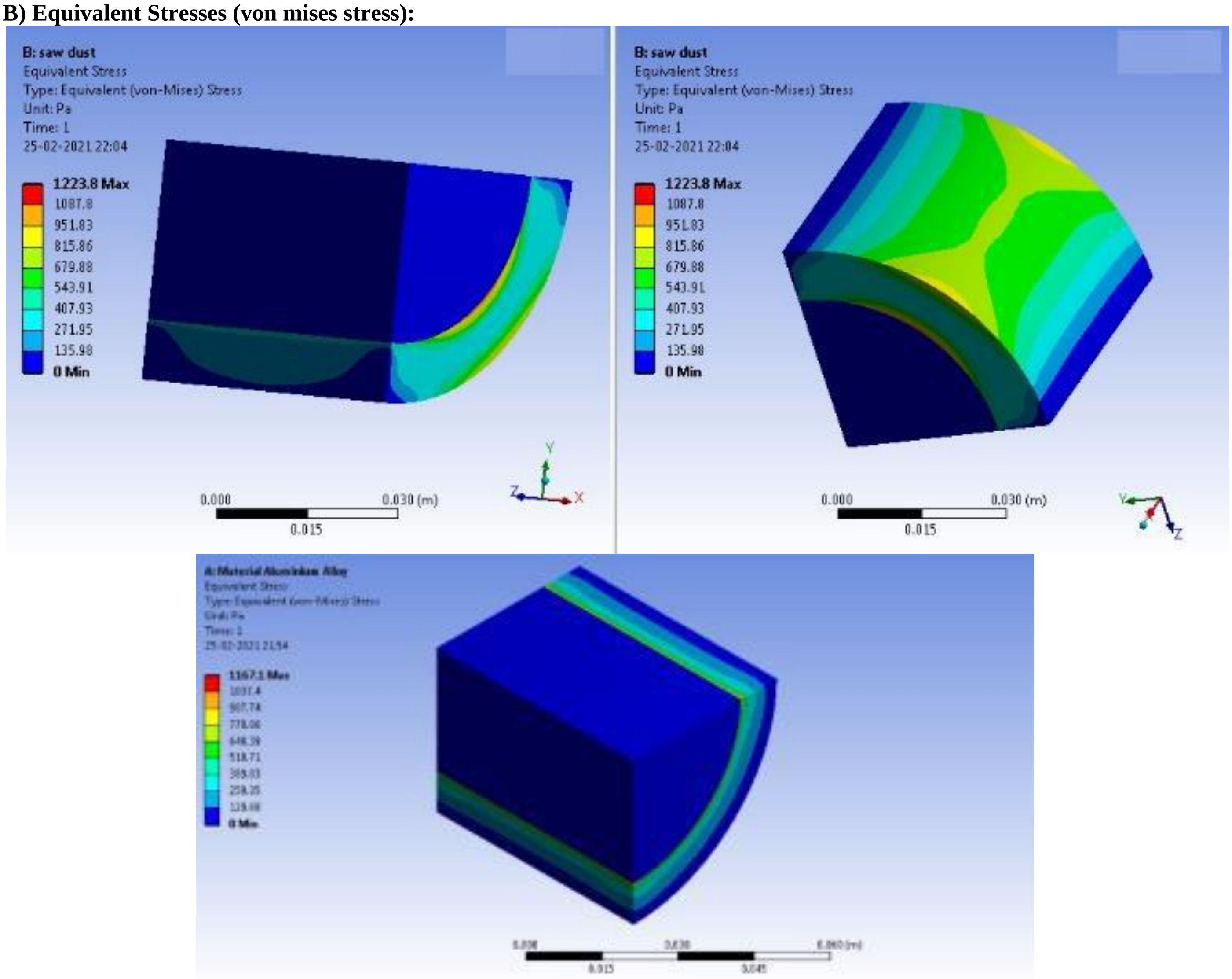

Fig 10. Comparison of equivalent stresses in aliminiun alloy and sawdust brake lining

C) Frictional Stresses:

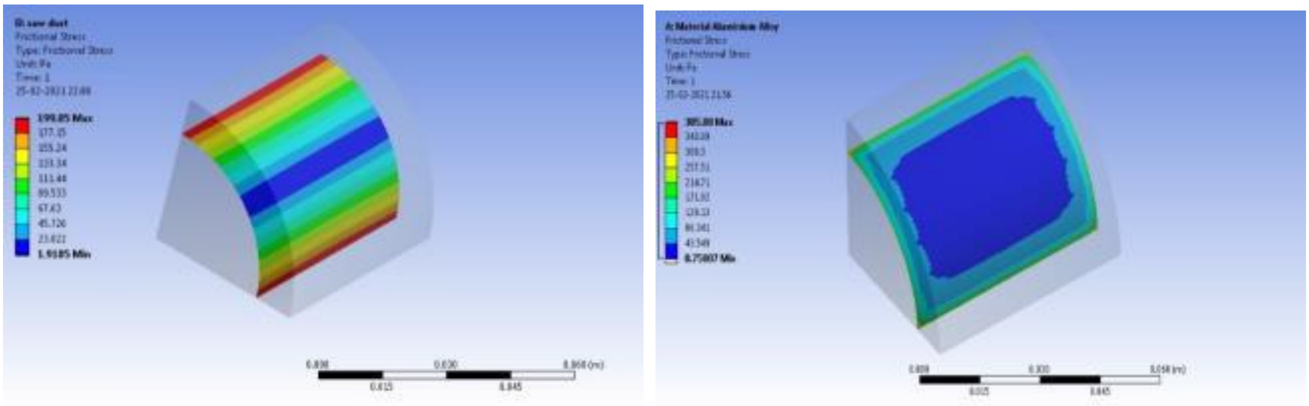

Fig 11. Effect of frictional stresses on different brake linings

D) Total Deformation:

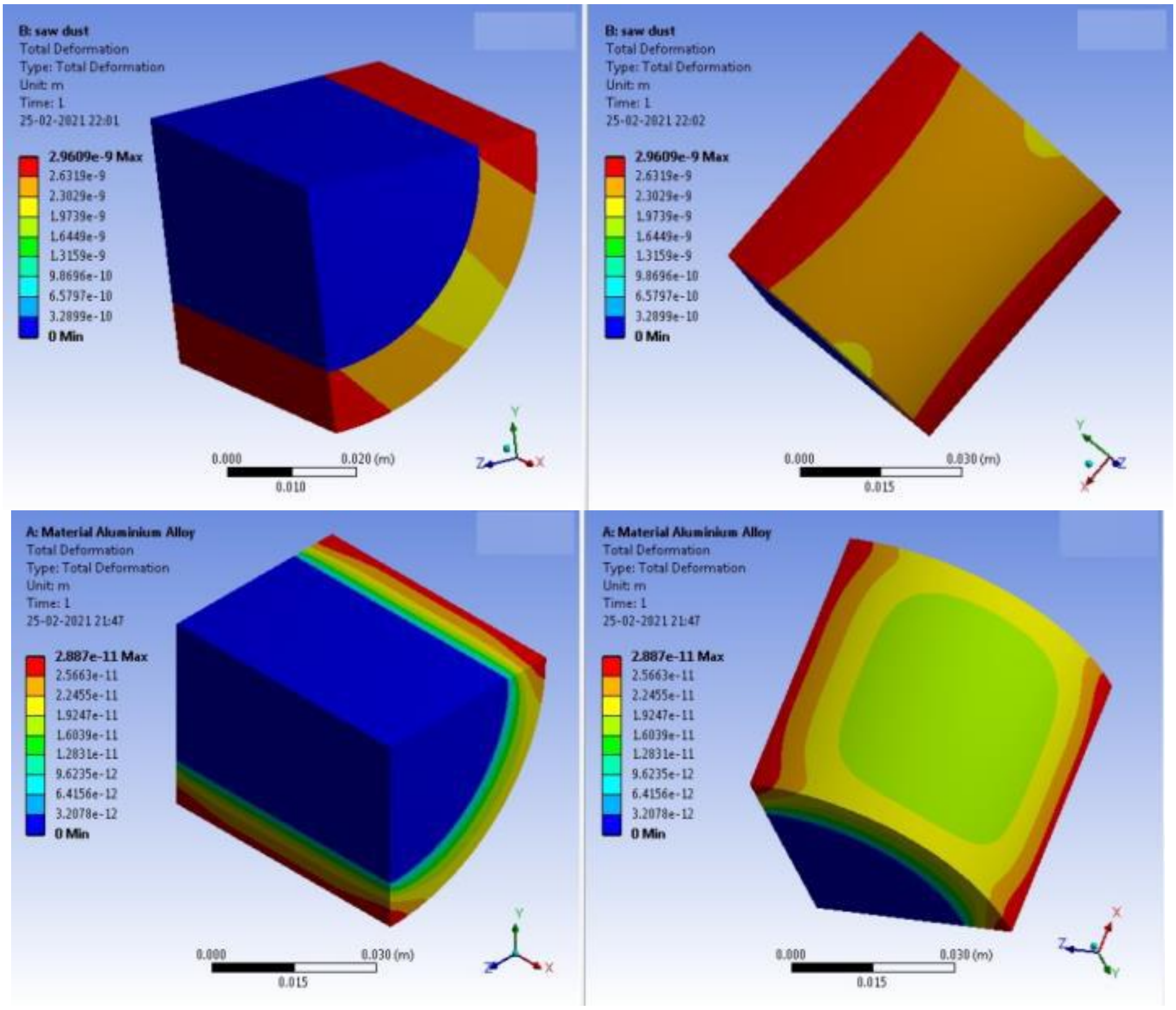

Fig 12. Deformation in brake lining after applying stresses on conventional and sawdust composite

In above conditions, for stress analysis, pressure is applied on external surface of brake pad lining. It is observed from analysis that the deformation in sawdust composite lining is less than that of the conventional lining. It also gives maximum possible von mises stress values under favourable conditions.
The result shows that the specimen with 150µm gave better properties than other specimens with 300µm and 450µm sieve size. Hence lower sieve size of sawdust, better are the properties. Fine element analysis is done with the comparison of conventional lining to the sawdust composite lining tested under similar conditions where sawdust composite gives better properties as compared to the other composites such as aluminium alloy, asbestos etc.

IV.CONCLUSION

1. The specimen of 150µm sieve size give better properties among all specimen sizes.
2. The density of 150µm composite size is highest among all composites.
3. Beside general materials such as aluminium alloy or asbestos, sawdust show less value of deformation as well as maximum von mises stresses under structural stress analysis.
4. In addition to above conclusions, sawdust has very less weight compared to conventional material and hence asbestos can be replaced by reinforced composite (sawdust) in brake pad lining.

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