Analysis of Adhesive Joint of Brake shoe to Reinforce its Structural Strength while Sustaining Shear Load using FEA Approach

***Abstract*— The braking system in an automobile experiences shear loads at the junction of the linear with the base of the shoe typically joined by high performance adhesive. The subject matter of this work is to study the variants of adhesive material for determining the level of stress induced for each variation proposed. Finite element model is constructed and solved using Altair-Hyperworks. Post-processor Hyperview is used to visualize the results for inferring the probable solution. Solution is recommended upon culmination of the testing while applying the requisite loads.**

Keywords - Adhesive, araldite, Brake shoe, Hyperworks,liner, shear strength.

1. LITERATURE REVIEW

Neha B. Thakare, A.B. Dhumane [1]: Adhesive bonding as an alternative method of joining materials together has many advantages over the more conventional joining methods such as fusion and spot welding, bolting and riveting. Adhesive bonding is gaining more and more interest due to the increasing demand for joining similar or dissimilar structural components, mostly within the framework of designing light weight structures. The current trends are to use viscoelastic material in the joints for passive vibration control in the structures subjected to dynamic loading. These components are often subjected to dynamic loading, which may cause initiation and propagation of failure in the joint. In order to ensure the reliability of these structures, their dynamic response and its variation in the bonded area must be understood. Adhesive bonding is a process of joining materials in which an adhesive (liquid or a semi solid state material) is placed between the faying surfaces of the workpiece / parts (adherents) to be joined. Either heat or pressure or both are applied to get bonding.

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To get an adhesive joint three essential steps are required to follow to make an adhesive joint including (a) preparation of the surfaces, (b) application of the adhesive on to the mating surfaces, and (c) assembly of work pieces /parts and curing the joint.

K.Deepika, C.Bhaskar Reddy, D.Ramana Reddy [2]: Brake lining materials generally are asbestos, metals and ceramics. Asbestos during application releases the hazardous gases, which causes damage to the health. By the application of natural resources the material is made harm less. The main element is used for brake lining from palm kernel shell. The powder metallurgy technique is used in the production of components. It consists of stages as powder making, powder blending, compacting, sintering followed by heat treatment process. The average disk temperature and average stopping time for pass is increased and it has poor dimensional stability. Hence it has lost favor and several alternative materials are being replaced these days. In this work a non-asbestos bio-friction material is enlighten which is developed using an Agro-waste material palm kernel shell (PKS) along with other Ingredients. Among the agro-waste shells investigated the PKS exhibited more favorable properties. Taguchi optimization technique is used to achieve optimal formulation of the friction material. The developed friction material is used to produce automobile disk brake pads. The developed brake pads were tested for functional performance on a specially designed experimental test rig. Physical properties of this new material along with wear properties have been determined and reported in this paper. When compared with premium asbestos based commercial brake pad PKS pads were found to have performed satisfactorily in terms of amount of wear and stopping time. This composite is used in the automobile industry for brake linings.

2. INTRODUCTION

Brake shoes are the friction component within the drum brake system. Commonly applied to both main rear foot brake and also to the hand brake. They are used within drum braking systems, brake shoes sit inside the brake drums on each wheel. When the brake pedal is applied by the driver, hydraulic cylinders apply pressure on the brake shoes and cause them to expand within the drum, creating friction and stopping power. Generally need replacing every 50k miles or so, when friction material is excessively worn or when contaminated by oils or brake fluids. Also excessive hard braking will cause them to deteriorate far sooner. Replacing them as needed is essential for safe motoring.Due to the increasing demands for lightweight structures, the possibility to use the optimal material for each part of a structure needs to be utilized. This leads to a growing interest in adhesive joining since this method gives greater possibilities to join dissimilar materials as compared to more traditional methods such as riveting, bolting and welding.In many application areas, it is advantageous to use adhesives together with for example spot welding. This provides structural integrity during the assembly process before the adhesive is cured.

Adhesive joining has additional advantages, e.g. it provides some vibration isolation, it gives galvanic isolation and it gives smaller shape distortions than welding. To exploit all the advantages of adhesive joints, they have to be designed properly. If the same design as used for riveting and welding is used, the optimal properties of adhesive joints are not utilized. It is well known that adhesive joints can carry much larger loads in shear than in peel. It is therefore important to design the adhesive joint so that it is primarily exposed to shear stress. However, an adhesive joint is always hyper static and the stress distribution depends on the constitutive properties of the adhesive.Almosteverythingthatismadebyindustryhascomponentpiecesandthesehavetobefixedtogether.Oftenmechanicalconnections arechosen,suchasscrews,rivetsorspot welds.However,engineersnow oftenchoosetouseadhesivebonding.This joining technique is well proven and capable of replacing or supplementing mechanical fixing methods.

Advantages of adhesives

Reduced stress concentrations: The bonded structure is a safer structure because, owing to the fewer and less severe concentrations of stresses, fatigue cracks are less likely to occur. A fatigue crack in a bonded structure will propagate more slowly than in a riveted structure–or even in a machined profile because the bond-lines act as a crack stopper.

Joining sensitive materials: Adhesive bonding does not need high temperatures. It is suitable means for joining together heat- sensitive materials prone to distortion or to a change in properties from the heat of brazing or welding.

Vibrationdamping: Adhesivebondshavegooddampingproperties. Thecapacitymaybeuseful forreducingsoundorvibration.

Simplicity: Adhesivebondingcansimplifyassemblyproceduresbyreplacingseveralmechanicalfastenerswithasinglebond,or by allowingseveralcomponentstobejoinedinoneoperation.Adhesive bondingmaybeused in combination with spot welding or riveting techniques in order to improve the performance of the complete structure. All these advantages may be translated into economic advantages :improved design, easier assembly, lighter weight (inertia overcome at low energy expenditure), longer life in service.

Disadvantages of adhesives

1. Non Destructive Test (NDT) methods hardly available.

2. Restricted structural behavior at high temperature.

1.1 Problem Definition

Case - Motorcycle -HERO Splendor plus

The structural strength of adhesive joint is highly vulnerable in the application under study – Brake shoe for automobile. The shear strength displayed by the adhesive upon curing has to take up the applied loads entirely by itself. The liner is pasted to the shoe merely by a thin layer of the adhesive. For a new variant soon to be launched inputs are secured from the existing variant while building alternative concepts for the sub-assembly. For this work, the focus shall be the ‘material’ used as an adhesive for effecting a high performance joint. Alternative adhesive materials could be proposed for evaluation while finding the most suitable adhesive for the new variant. The shear loads for this variant need to be estimated as the same is aimed for fitment in a high powered bike. The total cost of creating the joint for production could be considered as an output parameters for evaluating this work.

1.2 Objectives of the study

1. To study the shear stresses developed in benchmark geometry of adhesive layer geometry in brake shoe assembly using CAE software.
2. To find the best configuration of the thickness for the adhesive to affect minimum permissible Shear Strength of the joint.
3. Recommend the best alternative design for optimal thickness or pattern of adhesive layer without affecting the shear strength of adhesive layer.

For this work, the focus is the material and its thickness used as an adhesive for effecting a high performance joint. Case study of Hero Honda Splendor has been taken. Alternative adhesive materials are proposed for evaluation while finding the most suitable adhesive for the new variant. The shear loads for this variant need to be estimated as the same is aimed for fitment in a high powered bike. The total cost of creating the joint for production is considered as an output parameters for evaluating this work. Recommendation of the best alternative design for optimal thickness or pattern of adhesive layer without affecting the shear strength of adhesive layer is given after testing the model using Hypermesh and experimental approach.

1.3 Methodology for the project

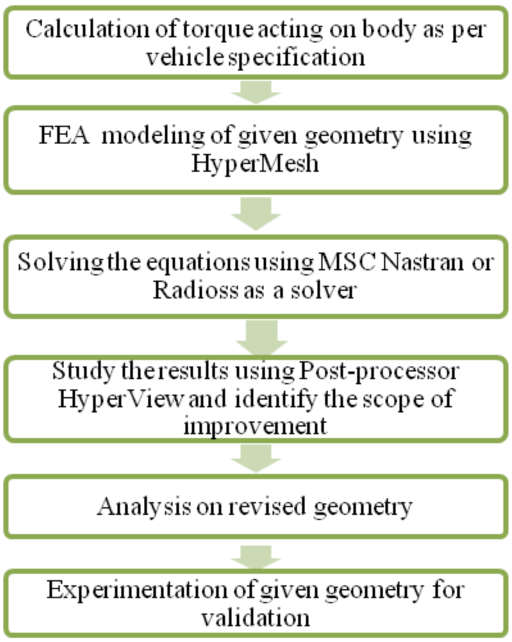

Fig.1. Flowchart for method study

3. ANALYSIS OF BRAKE SHOE LINER

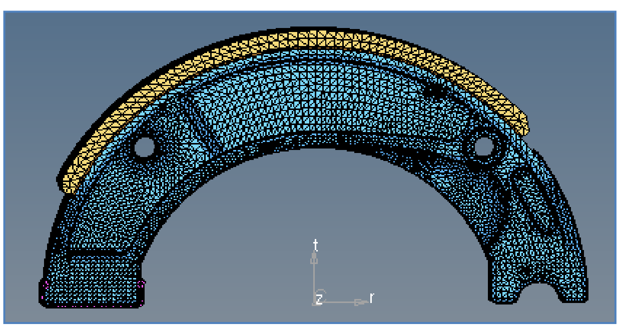

Fig.2.Meshed model of the brake shoe

No of elements = 22739
No of Nodes = 98455
Pre Processing = Hypermesh 12
Solver = Optistruct
Post Processing = Hyper view

3.1. Determination of Shear stress of Adhesive Materials with Different Material Properties and Thickness

The focus for this project work is the 'material' used as an adhesive for effecting a high performance joint. Alternative adhesive materials are proposed for evaluation while finding the most suitable adhesive for the new variant with optimum thickness and sustain the shear load . The variants have been checked for the `abuse condition' at 120kmph. Load on each node for this case is (3.52N) . The thickness of adhesive applied to the brake shoe has been varied from 0.5mm to 0.2mm . The range of shear strength from 5Mpa to 28 Mpa has been selected from the following chart from the adhesive guide.

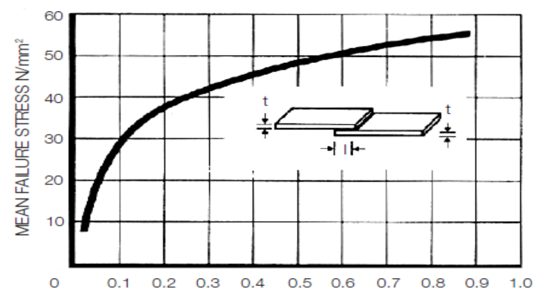

Fig.3. Correlation diagram between shear strength and thickness of material between the joint

Torque for abuse condition at 120kmph

KE=1/2 MV^2...1
Work Done=Kinetic Energy= 127196.78 J..................2
Static friction between good tires and a good road surface Mu=0.8
Stopping distance –
d=V^2/(2*Mu*g)...3
d=17.7044m
Fb=7186.26 N
Fb = 7186.26 N (for 2nos brake shoes i.e. two brake shoes for each rear wheel)
Fb = 3593.13N
Torque=Braking Force * Radius of Wheel rim....................5
T=189.50 *103 Nmm

Table I.Adhesive material sand its properties

V. no.	Adhesive Material	Young's Modulus (E) N/mm^2	Poisson 's Ratio	Thicknes s mm
1	Araldite 71	2583	0.40	0.50
2	Araldite CT200/HT901	2700	0.36	0.50
3	Araldite CT200/HT907	3100	0.34	0.50
4	Araldite 71	2583	0.40	0.35
5	Araldite 71	2583	0.40	0.25

6	Araldite 71	2583	0.40	0.20

The meshed model of the brake shoe is analyzed using Hyper mesh software. The results obtained after post-possessing are as follows :

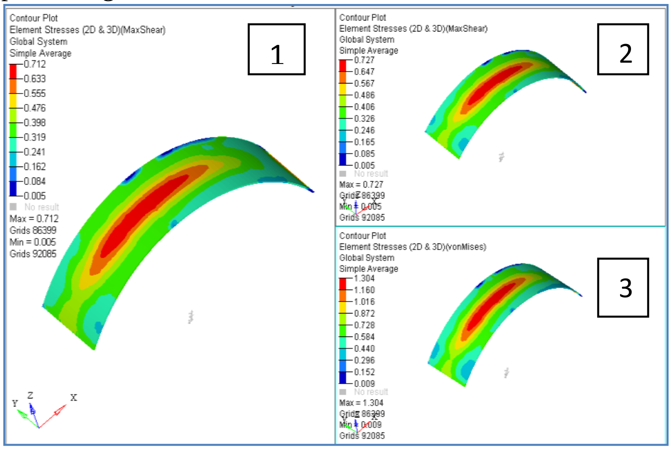

Fig.4.Maximum shear stress contour foe variants 1 to 3

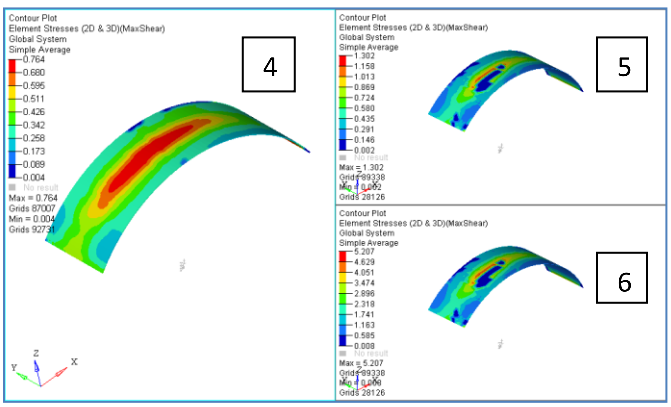

Fig.5.Maximum shear stress contour foe variants 4 to 6

3.1.OBSERVATION TABLE

Table II. Responses determined for Adhesive layer for different thickness

V.no	Adhesive Material	Young's Modulus (E) N/m^2	Poisson's Ratio	Thickness mm	Displacement mm	Maximum Shear stress MPa
1	Araldite 71	2583	0.40	0.50	0.007	0.712
2	Araldite CT200/ HT901	2700	0.36	0.50	0.007	0.727
3	Araldite CT200/ HT907	3100	0.34	0.50	0.007	0.753
4	Araldite 71	2583	0.40	0.35	0.007	0.764
5	Araldite 71	2583	0.40	0.25	0.007	1.302
6	Araldite 71	2583	0.40	0.20	0.029	5.207

Above table shows the alternative adhesive materials, their properties , thickness of adhesive applied and maximum shear load sustained by that material for the corresponding thickness.(V- Variant).

5. EXPERIMENTATION AND VALIDATION

5.1. Experimentation

With the help of fixture, the component is tested in UTM machine to find out the stresses developed in localized region of brake shoe. Strain gauge is used for stress determination purpose. Test Variant As per IS 15708 (2006): Road vehicles brake procedure for disc brake pad and drum brake shoe assemblies [TED 4: Automotive Braking Systems].

Fig.6.Test set up-brake shoe in fixture and plunger for application of load

In the analysis actual operating condition replicated and Test is performed as per (I S standard 15708 ROAD VEHICLES — BRAKE LINNGS — SHEAR 'TEST PROCEDURE FOR DISC BRAKE PAD AND DRUM BRAKE SHOE ASSEMBLIES). The test is conducted using the IS standard that has specified the Testing conditions.The fixture is designed as per ISO 15708 standards and the test is conducted on special purpose UTM equipped with load cells to apply load. Load cell of 1KN was used to apply the load. Maximum 1268.1 N load was applied till the adhesive layer fails to sustain the applied load. The displacement of 0.45mm was obtained..No undue damage and crack was observed for permissible load. No failure was detected at or near the bonded region.

5.2 Analytical method

According to the results obtained variant no.6 ,Araldite 71 with thickness 0.2mm is taken as the suitable alternative. FEA analysis is again carried out for the same test variant.

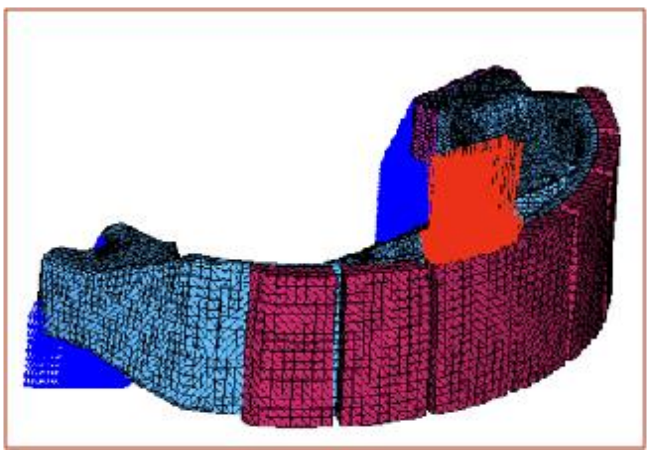

Fig.7. FEA model for the final test variant

A load of around 1268.1 N was applied to the meshed model and the displacement contour was observed which showed the displacement of 0.371mm.

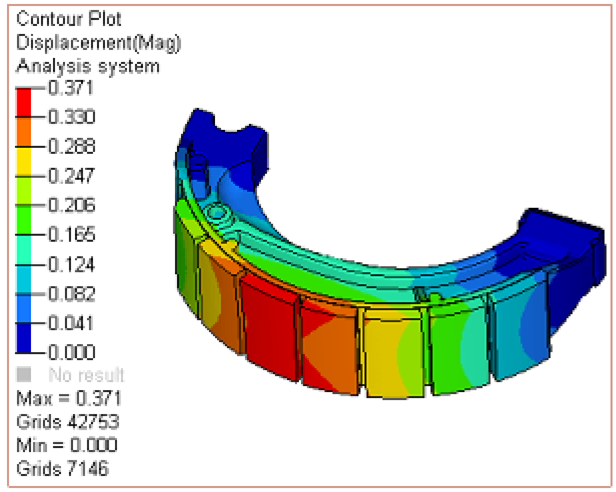

Fig.8. Displacement contour for the test piece

The mean shear stress is calculated using the formula and is applied to the adhesive layer and displacement is calculated using FEA.

τ = mean shear stress in the joint = P/I
P = load per unit width of joint
I = Optimum overlap
=1268.1/(13.92 * 24.94)
τ =3.65 N/mm^2 (Mean shear Stress)

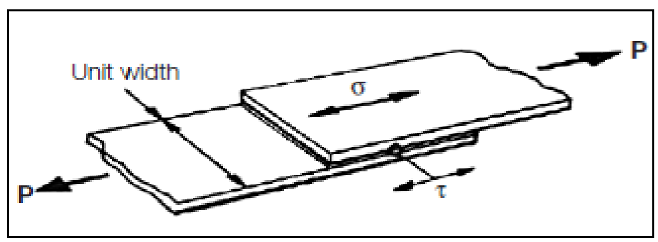

Fig.9. Conventional design for stresses in lap joint

From the below figure maximum shear stress obtained in the test variant is 12.539 N/mm^2 and the safe zone ranges between 3.047 to 8.470 N/mm^2 which is close to the value 3.65 N/mm^2 obtained by analytical method.

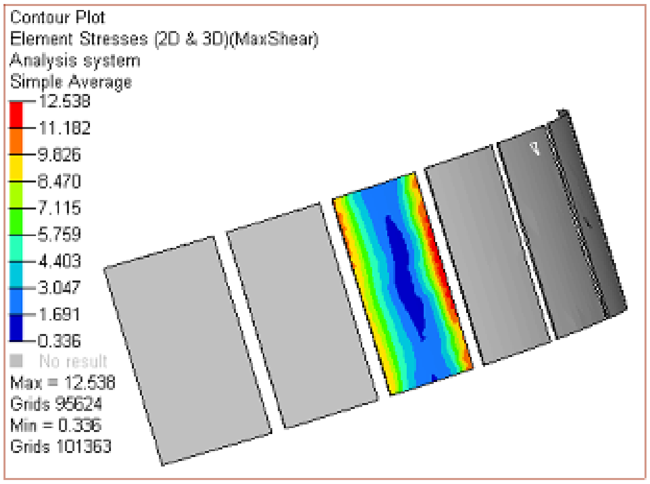

Fig.10. Shear stress area in adhesive test variant

Table III :Comparison table for various methods applied for study

Variant no.6, Araldite 71 with thickness 0.20mm		
	Shear load N/mm^2/ MPa	Displacement mm
FEA /Numerical approach	5.207	0.029
Analytical approach	3.65	0.371
Experimental approach	3.65	0.45

Comparison of results of best suitable design variant with reference to benchmark geometry of adhesive layer for the affected shear strength due to variation in geometry and the experimental results give the best alternative of the adhesive material for the brake shoe . All the three approach show more or less same results.

6.CONCLUSION

The variant with minimal amount of adhesive applied over the Liner Base is the obvious choice among the alternatives while also addressing the compliance over the Maximum stress permissible.Variant no.6, with material Araldite71 and thickness 0.2 mm for the Adhesive layer offers to be the best alternative for this application. The stress level observed for this variant (5.207 MPa) complies safely with the set limit for the Adhesive material used (28MPa). Although the range for the Shear Strength being 8MPa to 50MPa, the Design is recommended considering the safest value of the stress expected over the Brake Shoe (8MPa). As the thickness is minimized from 0.5mm to 0.2mm there is economical advantage as the material is saved by 60% .

7. FUTURE SCOPE

Analysis of adhesive layer for changes in material with high grades or different mechanical and chemical properties.Identifying scope for changing the method of application of adhesives or the structural changes that can be made of brake shoe for effective utilization of adhesive layer

8. REFERENCES

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