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COMPUTATIONAL STUDY FOR ALTERNATIVE ADHESIVE MATERIALS OF BRAKE SHOE LINER FOR STRENGTH IMPROVEMENT

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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 underscore the aspects of design for such permanent joint. Variants of adhesive materials, their properties and thickness variations are analyzed for determining the level of stress induced for each variation proposed. Mathematical model for initiation of the work is kept handy to determine the loads acting on the liner and consequently the joint. Finite element model is constructed and solved using Altair-Hyper works. Post-processor Hyper view helped to visualize the results for inferring the probable solution. Appropriate variant of adhesive with better material properties is been proposed by optimising the thickness of adhesive material which ultimately gives economical benefit.

KEYWORDS: - Brake shoe, Adhesive, shear strength, araldite, liner, and hyper works

INTRODUCTION:

BACKGROUND OF STUDY:

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.

ADVANTAGES OF ADHESIVES:

1. The adhesives materials allow joint substrates with different geometries, sizes and composition. Any complex geometry that is not feasible with joints can be bonded effectively with adhesives.
2. The use of adhesives eliminates the corrosion associated with dissimilar metals joining with different galvanic potential, such as the joining of steel with aluminium. The adhesive bond is leak proof and is less prone to corrosion.
3. Adhesive bonding gives smooth and safe appearance as there are no fasteners , screws or rivets to protrude .
4. Do not produce any mechanical aggression to the substrate, avoiding any damage to the structure of the material.
5. It has good damping properties and high dynamic strength , it can be useful for reducing vibrations and sound.

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DISADVANTAGES OF ADHESIVES:

1. Non Destructive Test (NDT) methods are hardly available for testing the adhesive joints.
2. Adhesive joints shows restricted structural behaviour at high temperature as adhesives are prepared from polymers and they solidify. As temperature increases its strength decreases and its strain properties moves from elastic to plastic in the range 70 -220^0 C.

OBJECTIVE OF WORK STUDY:

The main objective of this work is to find out the most suitable and economical alternative adhesive material that can sustain the requisite load with no shear failure. Recommendation will be done of the best alternative design for optimal thickness and properties of adhesive layer without affecting the shear strength of adhesive layer.

ANALYSIS OF BRAKE SHOE LINER:

MESHING DETAILS:

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

Analysis = Linear static
Material = Liner =AL LM6
Pad =Kevlar
Adhesive = Araldite

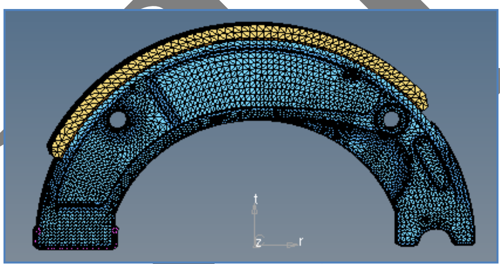

Fig.1.Meshed model of the brake shoe

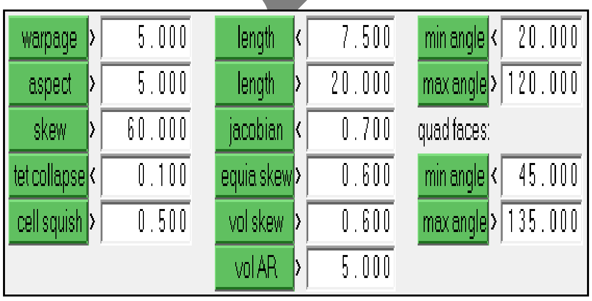

Fig 2. Quality check for meshing

Analytical calculations for the benchmark CAD model of the brake show was done and following stress contour are observed.

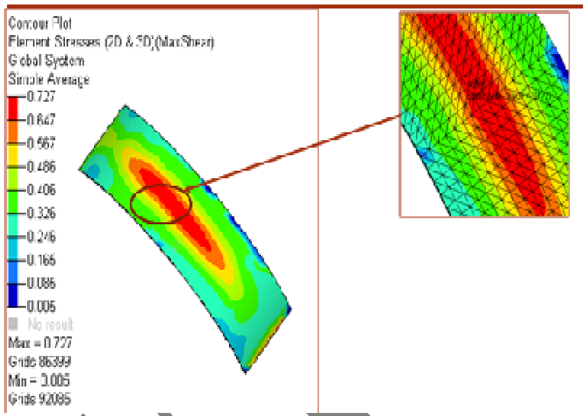

Fig.5 Maximum shear stress in adhesive joint of benchmark model

The shear stress observed for the benchmark adhesive is of 0.727 MPa. This stress is negligible while compared to the limit of 28MPa offered by the manufacturer of the adhesive. This favourable gap can be exploited for economic advantage. There is scope for exploring alternative materials in the light of economy offered by such materials. Further work is done in engaging alternative materials and variation in its thickness that would offer to leverage this advantage.

DETERMINATION OF SHEAR STRESS FOR DIFFERENT VARIANTS OF ADHESIVE MATERIALS AND THICKNESS:

Variant no.	Adhesive Material	Young's Modulus (E) N/mm^2	Poisson's Ratio	Thickness 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:

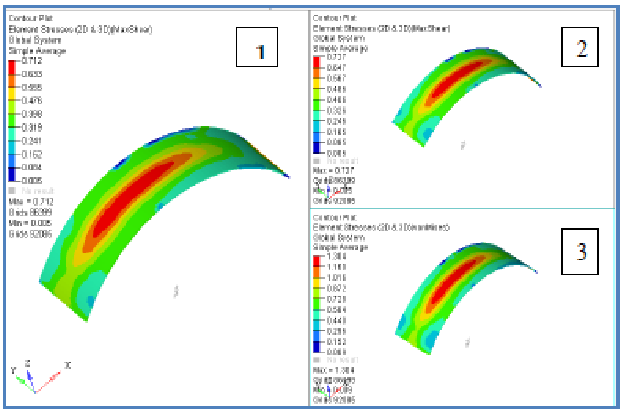

Fig.6. Maximum shear stress contour foe variants 1 to 3

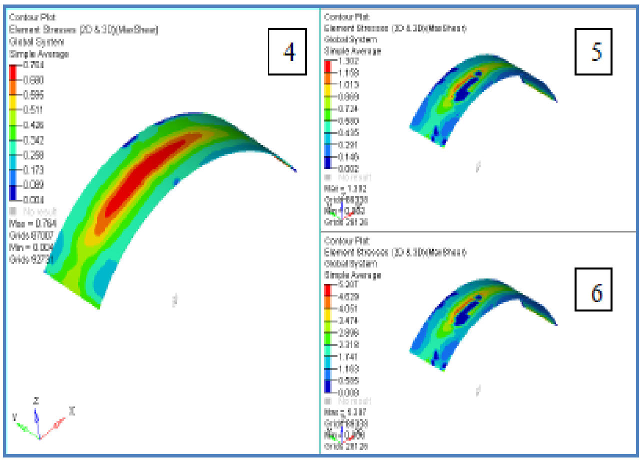

Fig.7. Maximum shear stress contour foe variants 4 to 6

RESULTS:

Following table shows the alternative adhesive materials, their properties , thickness of adhesive applied and maximum shear load sustained by that material for the corresponding thickness.

Table 1. Responses determined for Adhesive layer for different thickness

Variant no.	Adhesive Material	Young's Modulus (E) N/mm^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	0.007	5.207

MATERIAL AND COST OPTIMIZATION:

According to the analysis and the results obtained it is clear that the variant no. 6 , adhesive material Araldite 71 with thickness 0.2mm is the best alternative choice of the material . Thickness reduction has been achieved from 0.5mm to 0.2mm that is 60% saving in the adhesive material and ultimately the cost of purchasing the material.

Amount of Araldite71 required per month = 1100 kg
Actual Cost of 1 kg Araldite71 = Rs 558 /-
Total cost of material required initially = 1100*558
= Rs 6,13,800 /-
Cost after 60% reduction in material =Rs 223.2/-
Total cost of material required after optimization
=1100*223.2
= Rs 2,45,520 /-
Economical advantage obtained = Rs (613800 - 245520)
=Rs 3,68,280 /-

Hence due to study of the material properties and its optimization, an economical advantage of Rs 3,68,280 /- is obtained per month.

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 Araldite 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)

VALIDTION:

Validation of the obtained results can be done using experimental methods. Experimentation can be done using software based UTM machines and results can be compared with those obtained from computational methods. A standard fixture with ISO 15708 can be designed that can replicate the actual working conditions and performance test can be done.

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