REINFORCING STRUCTURAL STRENGTH THROUGH ALTERNATIVE MATERIAL PROPERTIES OF ADHESIVE WHILE SUSTAINING SHEAR LOADS FOR BRAKE SHOE LINER

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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 shall underscore the aspects of design for such permanent joint. Variants of adhesive material shall be analyzed for determining the level of stress induced for each variation proposed. Mathematical model for initiation of the work could be handy to determine the loads acting on the liner and consequently the joint. Finite element model shall be constructed and solved using Altair-Hyperworks. Post-processor Hyperview shall help to visualize the results for inferring the probable solution. A fixture is proposed to be built for testing the benchmark variant for early stage validation. Solution shall be recommended upon culmination of the testing while applying the requisite loads.

KEYWORDS - *Brake shoe, Adhesive, shear strength, araldite, liner, Hyperworks*

I. INTRODUCTION

Brake shoes are the friction component within the drum brake system. Commonly applied to both main rear foot brake and also to the handbrake. 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.

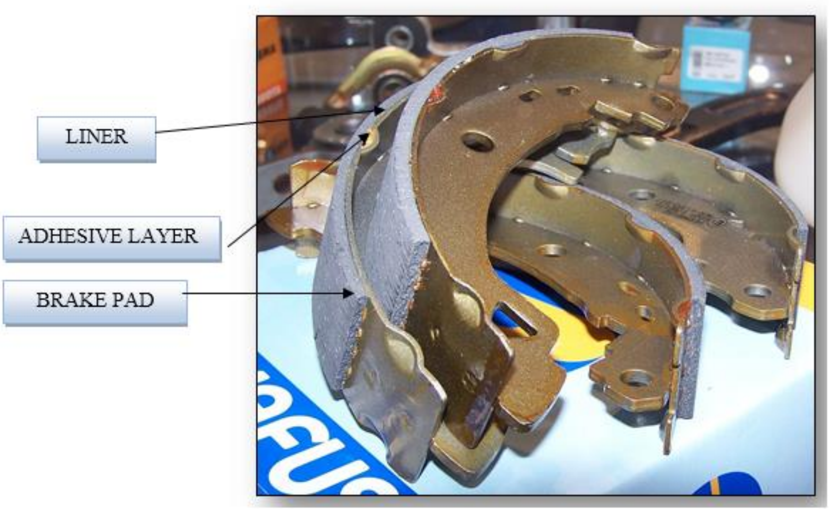


Fig.No.1 Brake Shoe Assembly with Adhesive Layer

Advantages of Adhesives:
1. The adhesives materials allow joint substrates with different geometries, sizes and composition.
2. The use of adhesives eliminates the corrosion associated with dissimilar metals joining with different galvanic potential, such as the joining of steel with aluminum
3. The use of adhesive as bonding material does not produce any deformation in the materials or substrates, eliminating metal grinding processes (grinding and putty), reducing the manufacturing cost and improving the aesthetics of the product
4. Do not produce any mechanical aggression to the substrate, avoiding any damage to the structure of the material.
5. Great flexibility in the product design as well as an improvement in its aesthetics.

Disadvantages are:
1. Specific joint design, lower stress levels, shear forces, larger surface areas
2. Surface treatment
3. Curing time adhesives
4. Adhesion difficult to control; Non Destructive Test (NDT) methods hardly available
5. Restricted structural behavior at high temperature.

II. LITERATURE REVIEW

K.H. Bhusal, Prof. S.R. Nimbalkar, Prof. S. B. Belkar, Swapnil Kulkarni [1] : Stated that an adhesive is any substance applied to the surfaces of materials that binds them together and resists separation. The term "adhesive" may be used interchangeably with glue, cement, mucilage,or paste. Adjectives may be used in conjunction with the word “adhesive” to describe properties based on the substance's physical or chemical form, the type of materials joined, or conditions under which it is applied. The use of adhesives offers many advantages over binding techniques such as sewing, mechanical fastening, thermal bonding, etc. These include the ability to bind different materials together, to distribute stress more efficiently across the joint, the cost effectiveness of an easily mechanized process, an improvement in aesthetic design, and increased design flexibility. Disadvantages of adhesive use The values below are random values obtained from general reference sources and suppliers catalogues. They are often rounded values from imperial. They are only of use to indicate the relative strengths of different adhesives.

Lucas F.M. da Silva et.al.[2]: Has reported the effect of grooves on the strength of adhesively bonded joints. The objective of this work was to study the influence of the macroscopic state of the substrate surface on the strength of adhesive joints. For that, several patterns were made on the surface of aluminum substrates. The patterns were tested in two different ways, cleaned with acetone or chemically etched. Single lap joints were manufactured using a brittle adhesive and a ductile adhesive to assess the influence of the type of adhesive. The joints were tested statically and under fatigue loading conditions. The patterns applied to the specimens consisted of a series of grooves, which were applied with 00, 450and 900 orientations (relative to the sides of the specimen).The different patterns were always compared to specimens without pattern. The main conclusion is that the patterns can increase the joint strength of non-treated substrates in the case of the brittle adhesive. The conclusions that can be taken from the study are the depth of the patterns that lead to the highest joint strength is 0.1 mm for both adhesives, as shown by the static tensile tests. Tensile tests of joints with the brittle adhesive show that the surface patterns influence the joint strength. This influence is most notable for specimens with no chemical surface treatment, with the patterned specimens having a higher strength than the specimens with no pattern, because the failure mode changes from adhesive to mixed adhesive/ cohesive.

Nunziante Valoroso and Silvio de Barros [3]: Sated that the cohesive zone approach has gained increasing success in recent years for simulating debonding and fracture via finite element methods and is also suited for simulating adhesive joints, the potential crack paths are known to us in advance. In the paper the determination of the size of the so-called cohesive process zone is discussed, i.e. the region wherein the stress and damage state have to be correctly resolved in order to properly quantify the dissipated energy and the load bearing capacity of the structure. An a priori estimate for the size of the active process zone is provided based on the beam on elastic foundation model in which the material parameters of the cohesive law are incorporated. A major advantage of structural adhesive joints is that they provide more uniform stress transfer compared to other types of fastening systems; however, most adhesive bonds contain defects such as voids, regions with no or poor bonding and micro cracks, and such defects might grow under loading and give rise to local decohesion and formation of macro fractures. Adhesive joints may be loaded to failure in the design configurations or in the form of test specimens and it is important to fully understand the response obtained by such testing especially for the apparently simple configurations used in international standards since fracture behavior is in general governed by material properties, loading conditions and geometrical parameters as well.

Neha B. Thakare, A.B. Dhumane [4]: 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. 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 [5]: 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.

III. PROBLEM DEFINITION

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

Objective and Scope:

1. Study of literature review of adhesive layer and its material properties.
2. To study the geometry of brake shoe assembly for FE modeling
3. To study the shear stresses developed in benchmark geometry of adhesive layer geometry in brake shoe assembly using CAE software.
4. To find the best configuration of the thickness and area of contact for the adhesive to affect minimum permissible Shear Strength of the joint.
5. Experimental validation of benchmark model
6. Recommend the best alternative design for optimal thickness or pattern of adhesive layer without affecting the shear strength of adhesive layer.

IV. METHODOLOGY

In this project work, computational, analytical and experimental methodology used for validating the results.

1. Computational Method-

- CAD model of the brake shoe assembly with adhesive layer.
- Importing the CAD model in Pre-processor for meshing.
- Applying Material properties, loads, Boundary conditions.
- Exporting to solver to find out the stress developed in brake shoe layer.
- View results in post-processor
- Revision in geometry and Analysis for improvement
- Recommend the best suitable alternatives.

2. Numerical Method-

- **-** Find out the shear strength of adhesive layer by mathematical calculation for selected geometrical variant.

3. 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. The machine and strain gauge specification are as below:

Universal testing machine specification:

The specs for the **UTM** (Universal Testing Machine) used for the Test are as below:
Make: Star Testing System (India) - Software based
Model No: SPS 248
Type: DC Servo Control
Speed for loading: 5mm/min to 500mm/min
Plunger dia - 50mm

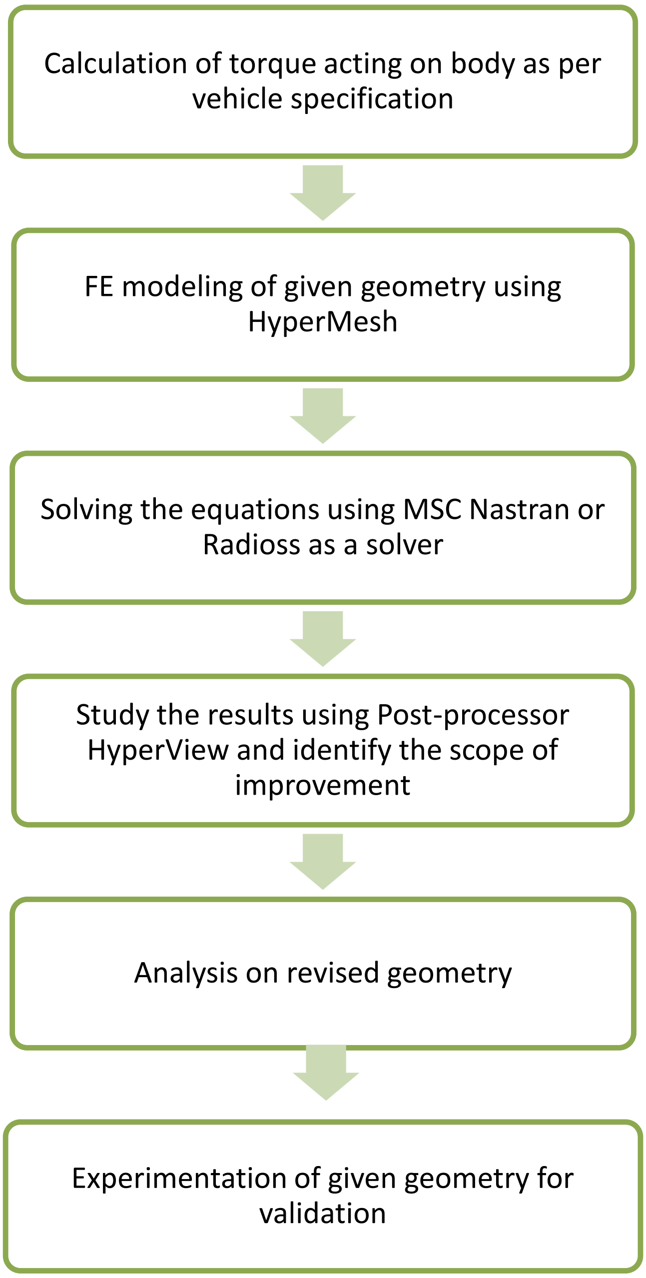
Strain Gauge
Type - Fixed Gauge
Gauge length - 25 to 50mm
Strain gauge positioned with the terminal

Fig.No.2 Experimental Setup- Universal Testing Machine

V. VALIDATION

Validation of the best suitable alternative design of adhesive layer by comparing the results obtained from Numerical method.
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.

Process Flow of Methodology:



VI. CONCLUSION

1) Review of literature shows that many authors have reported the design improvement for shear strength analysis of adhesive joint
2) Analysis is to done to check the effect of variation in the design parameter like thickness and geometry of adhesive layer
3) Computational method(CAE software) is identified as the prospective methodology to analyze shear strength of adhesive layer in brake shoe assembly.
4) Mathematical calculation used to find the shear strength of adhesive layer geometry and results to be compared with computational method used.

VII. FUTURE SCOPE

1. Experimentation of benchmark geometry.

2 .Analysis of adhesive layer for changes in material with high grades or different mechanical and chemical properties.
3. 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.

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