WEAR AND COEFFICIENT OF FRICTION CHARACTERISTICS OF ASBESTOS & CNT REINFORCED FRICTION MATERIAL

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Abstract- The present invention relates to a friction material surfaces and components thereof. The invention further relates to friction developed in clutches or brakes. A friction material has a resin amount distribution that is the largest at a portion near non-friction surface. Friction materials are applicable for braking and transmission in various machines and equipment. Their composition keeps changing to keep pace with technological development and environmental/legal requirements. As per available literature, asbestos has been used as a friction material because of its good physical and chemical properties. The friction material is made by molding and curing process with a composition of iron fibers, phenol formaldehyde, and other constituents of friction materials. They offer resistance to temperatures to the order of 250°C, and they char to high carbon content. They are usually readily mixed with other constituents of friction material composites and therefore, may be used in relatively high content. They offer resistance to temperatures to the order of 250°C, and they char to high carbon content. Virtually every manufacturer of automotive friction materials uses phenolics as the binder. However, phenolic resins are not without their limitations. Phenolics are also inherently brittle. For this reason, friction material composites are modified with tougheners such as epoxy resin. Rubber particles are added to increase flexibility. Cashew nut shell liquid (CNSL) at levels of up to 20 volume percent of the resin content has been added to minimize cracking of the composite. Cashew nut shell liquid (CNSL) is a naturally occurring chemical monomer consisting of four alkyl substituted phenols. Cashew nut shell liquid (CNSL), whose main component is cardanol, is a phenol derivative having a meta substituent of a C 15 unsaturated hydrocarbon chain with one to three double bonds. Its phenolic nature makes it suitable for polymerization into resins by formaldehyde. Both additives increase the high temperature limit and the high char yield of a phenolic binder composite and provide an improved resin with increased toughness as measured by compressive strain to failure. This also minimizes the need for toughening additives as required by phenolics and raises the decomposition/char yield of a resin-bonded composite. We have used phenolic resin in combination with epoxy resin, hardeners, rubbers, Asbestoses, cashew nut resins, reinforcing and friction imparting and modifying fillers to form a vastly improved clutch composition. While a guide to the percentages of some of the constituting components has been obtained from the references indicated, the appropriate amount of shellac, hardener and other constituents were selected based on the trial and error iterations. The composition was tested for wear, friction and temperature stability.

Keywords- Asbestos, Carbon Nanotube, Cashew Nut Shell Liquid, Iron Fibers, Phenolic Resin.

I. INTRODUCTION

The present work relates to brake lining materials for power propelled vehicles and methods for manufacturing the same. In automobile industry, brake lining materials for brakes mechanisms have conventionally been prepared from Asbestos and Carbon Nanotube. Asbestos was the most common fiber used in the manufacture of friction materials in general. It is a mineral occurring in veins traversing serpentine rock in the form of fine, silky, flexible fibrous crystals.

Asbestos and Carbon Nanotube’s are mixed with a binder solution such as phenolic resin and thereafter subjected to various processes to get the desired friction material. The use of the additives such as graphite and cashew resin are intended for improving the wear resistant property and adjusting the frictional coefficient. Friction imparting materials are typically carbides, oxides, and nitrides in fine particulate form are used. Graphite and molybdenum oxide are generally added to increase resistance to wear.

The binder is usually a phenol-formaldehyde resin of resol type, a novolac or even in a modified version. Phenolic resins are among the most commonly used binders in friction materials. They are usually readily mixed with other constituents of friction material composites and therefore, may be used in relatively high content. They offer resistance to temperatures to the order of 250°C, and they char to high carbon content. Virtually every manufacturer of automotive friction materials uses phenolics as the binder. However, phenolic resins are not without their limitations. Phenolics are also inherently brittle. For this reason, friction material composites are modified with tougheners such as epoxy resin. Rubber particles are added to increase flexibility. Cashew nut shell liquid (CNSL) at levels of up to 20 volume percent of the resin content has been added to minimize cracking of the composite. Cashew nut shell liquid (CNSL) is a naturally occurring chemical monomer consisting of four alkyl substituted phenols. Cashew nut shell liquid (CNSL), whose main component is cardanol, is a phenol derivative having a meta substituent of a C 15 unsaturated hydrocarbon chain with one to three double bonds. Its phenolic nature makes it suitable for polymerization into resins by formaldehyde. Both additives increase the high temperature limit and the high char yield of a phenolic binder composite and provide an improved resin with increased toughness as measured by compressive strain to failure. This also minimizes the need for toughening additives as required by phenolics and raises the decomposition/char yield of a resin-bonded composite. We have used phenolic resin in combination with epoxy resin, hardeners, rubbers, Asbestoses, cashew nut resins, reinforcing and friction imparting and modifying fillers to form a vastly improved clutch composition. While a guide to the percentages of some of the constituting components has been obtained from the references indicated, the appropriate amount of shellac, hardener and other constituents were selected based on the trial and error iterations. The composition was tested for wear, friction and temperature stability.

II. EXPERIMENTAL PROCEDURE

Methodology for the preparation of Asbestos & Carbon Nanotube frictional material:
Asbestos & Carbon Nanotube based friction materials were synthesized comprising of the following methodology. A die of 10 mm diameter and 40 mm length is used to prepare the specimens of friction material for wear test. 18% of phenol formaldehyde was blended with 25% of epoxy resin. To the uniformly blended mixture was added 9% of CNSL, along with 5% of graphite and the resultant composition mixed well. 5% of Asbestos & Carbon Nanotube (Equal Volumes) and 13% of iron fibre were blended into the mixture. Slowly, 6% of shellac, 9% of silica flour and 6% of silicone resin were added. On obtaining a uniform blend, 8% of rubber solution and 5% of tris phenol hardener were added. The mixture was blended and transferred to a die for compaction. After allowing the mixture to harden partially, it was compacted in a press at a pressure of about 200 psi to give the shape of the die.

The compacted sample was then subjected to a curing process which starts from 60°C and ends at 180°C. The curing process started at 60°C is continued by the increment of temperature by 10°C up to 180°C. The duration of curing process is one hour for every increment. After one increment the sample is allowed to cool and curing process is continued until the desired sample is obtained. The wear tests were done using a pin on disc wear test setup. The setup was connected to a computer to compute the results. Wear testing was done using samples of 8 mm diameter. Each sample was tested by sliding it against a steel disc and the friction and wear characteristics of the sample was then obtained from the test.

III. RESULTS AND DISCUSSIONS

The friction materials is made up of fibrous materials, abrasive particles, anti-wear materials, fillers and binders, curing agents and heat and wear resistance additives. The binder phenolic resin is a critical one in the whole component. The limits of heat resistance and strength of the frictional material are governed largely by the heat resistance and strength of the resin binder. Phenolic resins are highly brittle by nature, thus to reduce the brittle nature of the composite, specific ratios of epoxy resin and rubber particles are used. This improves the toughness of the resin-bonded mixture. The composite thus consists of phenolic resin and epoxy resin that function as the base matrix. The matrix is strengthened by reinforcing materials of Fe fibers. Graphite and silica flour are added to act as anti-wear additives and the addition of silicone resins acts as a fire retardant. The cashew nut resin is added to improve the temperature resistance of the composite. Shellac is a natural, organic resin that comes from an insect, used to improve the hardness of the composition. The rubber solution helps reducing the brittle nature of the phenolic base. A curing agent in the form of tris phenol is used to improve the curing time. The percentage of each component has been selected by trying various permutations and combinations in the percentages for the phenolic and epoxy levels. The same has been done to select the percentages of other filler materials, hardener and the like. For example, a higher percentage of phenolic content created a composite which was extremely brittle. Higher percentages of shellac resulted in a composite which was very hard but with reduced friction characteristics. Similarly, higher percentages of tris phenol resulted in composites which hardened extremely rapidly and lost its workability and hence, made it increasingly brittle. Increasing the percentage of graphite content increased the wear resistance but at the cost of friction coefficient. The filler contents were chosen at percentages which were optimum for blending and at the same time provided the desired characteristics. Thus, the appropriate composition as indicated have been obtained after a number of iterations and trials and errors associated with them, thus optimizing the process requirements. The friction material synthesized was subjected to a wear test by making use of a pin on disc wear tribometer which is shown in below figure 2.

The tribometer is coupled to a computer to generate the results for the plot as shown in figure 3.

![Fig 2: Pin on disc tribometer](image)

![Fig 3: Compared results of asbestos based brake liner materials and Asbestos+Carbonnanotube based material](image)
The sample used for the test was of 8 mm diameter and is slid against a rotating steel disc. Initially a load of 1.0 kg is applied on the sample against a speed of 500 rpm of the rotating disc for a period of 300 seconds. The next load is applied after every 300 seconds with the increment of 1.0 kg upto 5.0 kg against the same speed. From the graph it is observed that the wear increases as load increases and varies from 55 to 176 microns.

The graph clearly shows that the friction material has exemplary resistance to wear under different loading conditions. The same setup was used to determine the coefficient of friction of the composite friction lining. The prepared sample was found to exhibit excellent coefficient of friction as illustrated by the plot of coefficient of friction vs load in Fig 4.

![Fig 4: Variation of Coefficient of friction of the prepared sample under varying loading conditions](image)

CONCLUSION

In conclusion the friction material composite for brake lining is synthesized which contains fibrous reinforcing constituents, friction imparting and controlling additives, elastomeric additives, fire retarding components and a thermosetting resin. The samples were subjected to tests like wear test and friction tests. It was also found to exhibit exemplary friction and anti-wear characteristics. The constituents used in the composite are extremely economical and are hence appropriate for industrial applications. The composite becomes even more economical when manufactured in bulk for industrial applications.

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