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The Effect of amount of CNSL Modified Resin as a Binder on Performance Properties of Brake Friction Materials

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ABSTRACT

Phenolic resins or their modified versions are invariably used as binder materials for friction composites. However, poor shelf life, evolution of harmful volatile during processing, need of inclusion of curing agent before dispatching to market, shrinkage in final products along with voids, etc. are the major problem associated with phenolic. In order to overcome this alternative resin is used in present work. The formulation of friction material requires the optimization of multiple performance criteria. Current work investigates the characterisation composite made with CNSL modified resin. Five friction material composite containing nine ingredients along with CNSL resin in five different concentrations viz. 9,10,11,12, and 13% (by weight) were formulated and evaluated for physical and performance properties. Friction, wear and physical properties were significantly influenced by the amount of resin. With increase in percentage of resin friction (□) decreased while compressibility is within 2% in allcomposites except composite having 9 % resin content. Wear was lowest in composite with 12% resin content.

1. INTRODUCTION

Fade is the term used to indicate a loss in braking at elevated temperatures (typically in the range 300-400°C) because of a reduction in the kinetic friction coefficient (μ). The return to acceptable levels of friction at lower temperature is referred to as recovery[1]. The fade phenomenon in friction materials represents a deviation from Amonton's law of friction[2], and its occurrence reduces braking efficiency and reliability. Three primary attributes governing brake fade have been identified by Rhee[2]: load fade, speed fade, and temperature fade.

According to Blau and McLaughlin [3], high interfacial temperatures can load to a decrease in shear strength of the pad and consequently a decrease in frictional force which induced fade. Herring [4] proposed that fade is caused by gas evaluation at the braking interface as a consequence of pyrolysis. Fade has also been attributed to the formation of a load- carring friction film that leads to an effective increase in the true contact area and thereby reduces the applied pressure on the pad [5-6].

Fade is reported to be highly- dependent on the tribo-logical history of the material [7-9]. In non-asbestos organic (NAO) friction composites, the phenolic resins degrade thermo- oxidative leading to formation of organic components in the interface at high temperatures. Therefore, resin in the friction material should have minimum tendency for thermo-oxidative degradation under the expected brake operating range of pressure, sliding speeds, and temperatures.

The objective of the work reported here was to investigate the properties and performance of friction materials made with different percentage of CNSL modified resin. Standardised testing procedures were used. In particular, the fade and recovery behaviour of non-asbestos organic fibre based composites.

1. EXPERIMENTAL

A CNSL modified resin was selected as the basis for preparing friction material. It was procured from Aditya chemicals Faridabad and it was characterised for IPF (Inclined plate flow), Gel-time, melting point, ash content and hexamine content with standard methods as shown in table 1. The fabrication of composites was carried out on the basis of keeping all other ingredients (except resin and space fillers). Varying the CNSL modified resin in 9, 10, 11, 12 and 13% by weight and compensating it with barium sulphate as space filler in composite M1, M2, M3, M4 and M5 respectively as shown in Table 2. The most important step for success of any formulation was carried in plough shear mixer and detail is given in table 3. The mixture was then put into two cavity mould supported by the adhesive coated back plates. Each cavity was filled approximately 95g of mix and was heat cured at a temperature of 150°C under a pressure of 20 kg/cm^2 for 8 minutes in a compression moulding machine.

Table 1

DETAILS OF THE PROPERTIES OF THE SELECTED RESIN CHARACTRISED IN THE LABORATORY

Properties	Results
Hexamine content (wt.%)	10.11
IPF (in cm)	4.5
Gel time (in sec)	82
Melting point (°C)	78
Ash content (in wt. %)	0.51

Table 2

DETAILS ABOUT THE FORMULATIONS OF DIFFERENT COMPOSITES

S.No	Material Name	% QUANTITY				
		M1	M2	M3	M4	M5
1	Aramid fibre	3	3	3	3	3
2	Barium sulphate	35	34	33	32	31
3	Cashew friction dust	6	6	6	6	6
4	Synthetic graphite	5	5	5	5	5
5	Steel wool	30	30	30	30	30
6	Brass chips	2	2	2	2	2
7	Calcium oxide	5	5	5	5	5
8	NBR	5	5	5	5	5
9	CNSL Resin	9	10	11	12	13
		100	100	100	100	100

Five intermitted breathing were also allowed the initiation of curing to expel out volatiles and moisture. Subsequently the pads were taken out and were then kept in oven at 150°C for 7 hours for the post curing to cure the uncured resin in the pad. The surface of the pad was then polished with a grinding wheel to attain the desired thickness and to remove resinous surface.

Table 3

MIXING SEQUENCE OF THE SELECTED COMPOSITES

Process	Material Name	Part	Time
MIXING	Aramid fibre	A	**30 Minutes**
	Barium sulphate		
	A	B	**5 Minutes**
	Other ingredients		

2. RESULTS AND DISCUSSION

The data on characterisation of composites for various physical,chemicaland mechanical properties are shown in table 4. It is clear from the table that with increase in the amount ofCNSL modified resin, Ash content of the composite increase. This was expected since each increment of resin in the step of 1% was done at cost of removal of equal amount of $BaSO_4$ which is highly thermally stable as compared to CNSL Modified resin.

Table 4

PHYSICAL, CHEMICAL AND MECHANICAL PROPERTIES OF THE COMPOSITES

Properties	Unit/scale	M1	M2	M3	M4	M5
Rockwell Hardness	HR'L	78	81	83	88	95
Sp. Gravity	----	2.35	2.32	2.30	2.29	2.25
Acetone extraction	%Wt.	1.81	1.89	1.98	2.07	2.19
Ash content	%Wt.	35.52	36.12	37.01	37.88	38.52
Cold shear	Kgf/cm^2	37.5	38.25	43.52	39.25	37.56
Hot shear	Kgf/cm^2	29.56	32.56	35.19	33.58	32.61
Cold Adhesion area	%	80%	85%	95%	80%	75%
Hot Adhesion area	%	65	75	85	70	70
Porosity	%	15.28	15.12	13.45	13.01	12.92
Heat swell	mm	0.18	0.15	0.11	0.16	0.20
Water swell	mm	0.08	0.07	0.07	0.05	0.04
Compressibility	%	1.98	1.78	1.75	1.72	1.70

Hardness of the composites increases with increase in the amount of resin, Porosity decreases due to filling of resin in the pores of composite, Compressibility decreases with increase in the amount of resin due increase in hardness of composites.

2.1 Fade, Recovery, Performance μ and wear behaviour of the composite

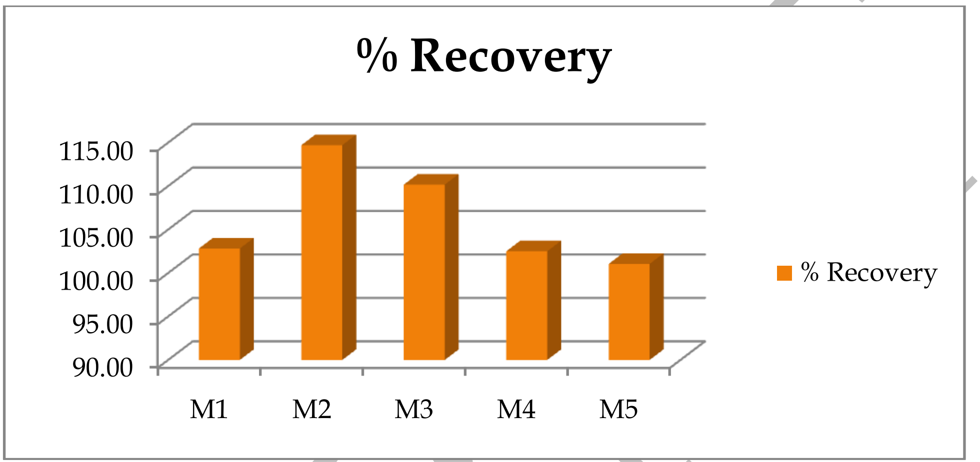
The R-90 frictional response for five composite at a constant speed (660 rpm), constant interval (5 sec) and constant pressure (1.82 MPa) as summarized in Table 5 in terms of performance μ, fade μ, Recovery μ and wear. As seen in Table 5 overall magnitude of μ decreased with amount of resin in the composites. In the Fade cycle fade is also increase with amount of resin, recovery is highest in M2 composite with 10% resin content (as shown in Histogram 1. Wear is very important performance criteria of friction composite and it observes that it is lowest in M5.μ is maximum in M2 whereas minimum in M5.

Table 5

PERFORMANCE ATTRIBUTES FROM FADE AND RECOVERY STUDIES ON THE COMPOSITES

Performance attributes	M1	M2	M3	M4	M5
Performance □	0.389	0.412	0.375	0.369	0.351
Fade □	0.318	0.378	0.316	0.289	0.256
% Fade	18.252	8.252	15.733	21.680	27.066
Recovery □	0.391	0.417	0.381	0.371	0.352
% Recovery	102.82	114.71	110.17	102.50	101.05
Maximum □	0.406	0.421	0.398	0.381	0.385
Minimum □	0.305	0.325	0.289	0.265	0.239
Wear (cc)	4.126	3.826	4.458	4.326	4.301

Fig. 1 showing recovery behaviour of composites



3. CONCLUSIONS

Since Friction (μ), Fade, Recovery and wear are the most important performance properties in friction material, the composites were evaluated for tribo-behaviour in all these conditions. Based on the studies on selected composites, it was concluded that increase in amount of CNSL modified resin from 9% to 13% in composite M1 to M5 respectively influenced the performance properties as follows.

Performance μ : M2>M1>M3>M4>M5

% Fade: M5>M4>M3>M1>M2

% Recovery: M2>M3>M1>M4>M5

Maximum μ : M2>M1>M3>M4>M5

Wear (cc) : M3>M4>M5>M1>M2

Resin percentage beyond 10, imparts unacceptable fade. Hence M3,M4 and M5 were declared to be unsuitable friction composites in spite of its acceptable wear. The best performance is observed in M2 with Maximum recovery and lowest wear rate. So it is concluded that M2 is the best with 10% resin content out of five composites.

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