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Influence of Modifications of Straight Phenolic Resin on Life of Railway Brake Block

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Abstract

Life of a Railway brake block is directly related to wear rate of friction composite. Wear is influenced by binding of friction material ingredients. Phenolic resin and their modifications are used as a binder in friction material composite. However, modification of phenolic resins play important role in the wear rate of composite. Railway brake block is a friction material composite; hence it's very much influenced by the modification of phenolic resin. In present paper three modified resin were selected to make railway brake block viz. CNSL modified resin, Linseed oil modified resin and alkyl benzene modified resin with 12% amount by weight in selected formulation. Wear test for these three formulations is done as per R-90 standard method. It is observed that wear and mechanical properties is significantly influenced by the type of modification of phenolic resin. Wear was lowest in the friction composite having alkyl benzene modified resin. Thermal analysis by TGA was helpful to investigate the wear pattern of the railway brake block composite.

Keywords: *Railway brake block, Wear, Modified resin, Performance properties*

1. Introduction

A railway brake block is nothing but friction material composite, made by 8-12 chemical ingredients, in which every material plays an important role in performance properties of composite. Wear is an important property of friction material as it's directly related to the life of brake block. Normally the life of a railway block is 40000 km but it can be very much influenced by amount and nature of binder. Phenolic resins and their modifications are inversely used as binder in friction material composite.

A little is reported on state of art of exploration of new resins for replacement of currently used binders in the recently published review articles with an emphasis on the serious need of research in this direction [1]. Few papers available on the alternate binder system [2-6] report more on moulding of friction compositions rather than bringing out the comparatives aspects of using such resins. Wear of friction composite can also be correlated with fade and recovery behavior. Higher fade value leads to high wear rate. The restoration of coefficient of friction to an original level after showing the fade at elevated temperature at lower temperature is called recovery. The extant of this definitely depends on type of binders and ingredients. A lot is reported on the cause of fade [7-10]. To minimize the wear it necessary to make composition so that fade should be low.

Thermal degradation behavior of the composite also reveals the performance properties and wear rate of the composite. It shows loss in weight in different temperatures that can correlate the life of the composite. It's noticed that during braking temperature rises due to rubbing of brake block on wheel and at high temperature wear is high. Hence in the present work studies were performed on the compositions to bring out the influence of different modifications of phenolic resins.

2. Experimental

Three modified resins, CNSL modified, Linseed oil modified and Alkyl benzene modified resin were selected to prepare a railway brake block friction material composites. These were procured from Arora chemicals Ghaziabad and were characterized for IPF (Inclined plate flow), Gel-time, melting point, ash content and hexamine content with standard methods as shown in table 1 and also characterized for Thermal degradation by TG-DTA assembled by Shimadzu Corporation, Japan as shown in fig 1. TGA analysis is done with temperature rising @10°C/Min up to 800°C with air atmosphere. The fabrication of composites were carried out on the basis of keeping all other ingredients same. Varying the types of modified resins with 12% amount by weight in composites. M1, M2, and N3 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 four cavity mould supported by the adhesive coated back plates. Each cavity was filled approximately 100g of mix and was heat cured

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at a temperature of 150°C under a pressure of 250 kg/cm^2 for 5 minutes in a compression moulding machine as shown in fig 2.

Table 1 Details of the properties of the selected resin characterized in the laboratory

	Results of different modification		
Properties	***CNSL***	***Linseed oil***	***Alkyl benzene***
Hexamine (wt. %)	10.82	11.03	10.79
IPF (in cm)	4.1	4.7	3.3
Gel time (in sec)	90	96	87
Melting point (°C)	78	95	96
Ash cont. (wt. %)	0.41	0.53	0.27

Thermal stability of a resin also plays an important role in Noise during braking, if resin unable to withstand temperature rises during breaking than fade µ of composite increase and the time of fade noise level becomes always high, so to determine the thermal stability of resin TGA is carried out as shown below. Thermal analysis is carried out with TGA instrument procured from Shimadzu, Japan. Thermal degradation of weight shows a high loss after 300°C as shown in fig.1

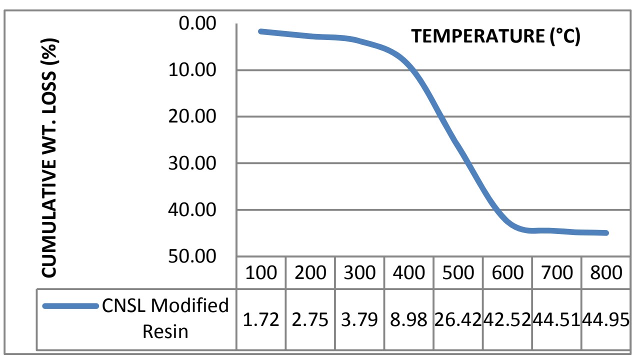


Fig.1 Thermal analysis of **CNSL Modified resin** in air atmosphere, Heat rises@10°C/min

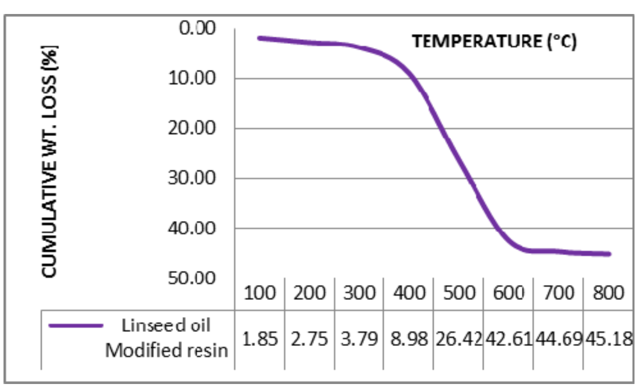


Fig.2 Thermal analysis of **Linseed oil Modified resin** in air atmosphere, Heat rises@10°C/min

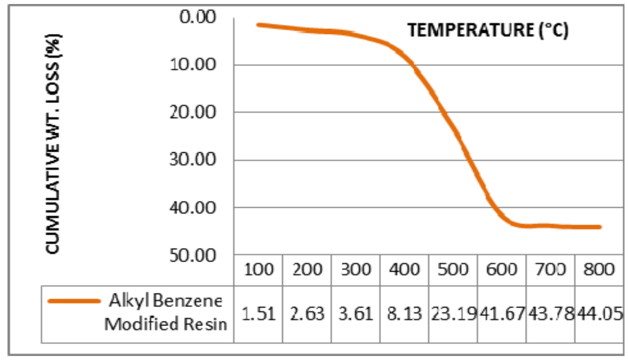


Fig.3 Thermal analysis of **Alkyl benzene modified** resin in air atmosphere, Heat rises@10°C/min

Six intermitted breathing were given with 10 sec pressing to initiation of curing to expel out volatiles and moisture and finally compressed for 240 sec to binding the composite. Subsequently the pads were taken out and were then kept in oven at 160°C for 8 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.

Eight ingredients are selected to prepare formulation for railway brake block. Keeping the Percentage same for all ingredients, by varying the type of resin in three formulations as shown in table 2. Composite is based on a standard formulation of a friction material which is having all necessary group of material like Kevlar and Rockwool is used as fiber, Alumina is used as abrasive, Synthetic graphite is used as lubricant, Barium sulphate is used as filler and finally different modifications of resin is used as binder. SBR powder is also used in the formulation to increase compressibility to minimize noise and brittleness in the friction composite of railway brake block. Brass chips is used to make composite semi-metallic nature.

Table 2**:** Details about the formulations of different composite

S .No	Material Name	% Quantity by weight		
		M1	M2	M3
1	Kevlar	5	5	5
2	Barium sulphate	20	20	20
3	Rockwool fiber	20	20	20
4	Synthetic graphite	15	15	15
5	Copper powder	15	15	15
6	Alumina	5	5	5
7	SBR powder	8	8	8
8	CNSL Modified resin	12	--	--
9	Linseed oil Mod. resin	--	12	--
10	Alkyl Benzene Mod. resin	--	--	12

Mixing is an important process in the preparation of a friction composite, because it's necessary to open fibrous material completely to gain actual results. Here barium sulphate is selected as filler to open fiber and mixing cycle is selected as shown in table 3.

Table 3: Mixing sequence of the selected composite

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

3. Result and discussion

3.1 Physical properties interpretation of designed composites

Analysis of designed railway brake block composite is carried out for Thermal, Physical, and Mechanical, chemical and wear properties as shown in table 4. Different friction composite tests were conducted to evaluate the performance nature of the composite. As shown in table 4 Rockwool hardness is highest in M1 whereas moderate in M3 which indicates better performance nature of M3. Ash content is lowest in M3 which shows that at high temperature it will degrade less as compared to other two composites. Shear load is also an important property of the railway brake block because at high load and speed friction material can be detaches from the plate and it's noticed that M3 with alkyl benzene modified resin composite can withstand high load. Porosity and compressibility is very much related to the noise and it's found that both the properties are moderate in M3. Heat swell refers to swelling or increment in the composite.

Table 4: Physical, chemical and mechanical properties of composite

Properties	Unit/ scale	M1	M2	M3
Rockwell Hardness	HR'L	85	82	83
Ash content	%Wt.	38.20	38.08	37.82
Cold shear	Kgf/cm^2	32.26	33.89	37.48
Hot shear	Kgf/cm^2	26.12	25.49	31.89
Cold Adhesion area	%	90	85	95
Hot Adhesion area	%	70	70	82
Porosity	%	18.26	16.28	17.27
Heat swell	mm	0.21	0.20	0.08
Water swell	mm	0.06	0.07	0.03
Compressibility	%	2.50	2.35	1.99

If thickness of composite will be higher than specified thickness it will fill the gap between the railway brake block and wheel, due to which it's difficult to move the wheel. So heat swell property of composite should be within range. Water swell can also stop movement due swelling of composite and it's also lowest in M3.

3.2 Wear and other performance property of designed composites

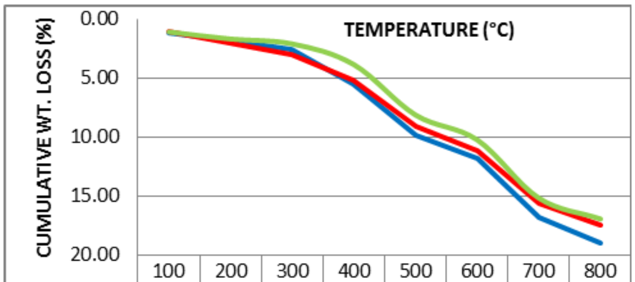
Performance of railway brake block is overall magnitude of all physical, mechanical and chemical properties. Finally friction level, fade, recovery and Wear are the properties which appear at the time of braking. In the present composites performance μ is highest in M3. Fade should be minimum in a composite because it reduce the friction level at the time of braking, which can leads to brake failure that is very serious phenomena related to human health and safety. As shown in table 5 friction level is highest in M3 composite.

Table 5: Performance attributes of designed composites

Performance attributes	M1	M2	M3
Performance μ	0.323	0.317	0.328
Fade μ	0.262	0.275	0.288
Recovery μ	0.324	0.312	0.326

Maximum μ	0.331	0.329	0.330
Wear (cc)	5.641	5.682	4.852

In present paper we focused on wear property of railway brake block which id directly related to life of the brake block and wear is lowest in M3 composite. TGA analysis also reveals the wear rate of any composite at high temperature during braking. When a railway train reaches to platform where it has to be stop, at that time a huge braking is applied to stop the train and due regular friction between wheel and block heat generates which leads to high wear also. TGA graph of composites shows that M3 has better thermal stability due to which it will wear less as compared to other two composites as shown in fig 4.



	100	200	300	400	500	600	700	800
M1	1.15	1.82	2.56	5.56	9.87	11.89	16.87	18.99
M2	1.12	2.10	3.02	5.23	9.12	11.21	15.68	17.52
M3	1.10	1.70	2.11	3.87	8.15	10.26	15.20	16.97

Fig.4 Thermal analysis of designed composites in air atmosphere, Heat rises@10°C/min

4. Conclusions

Wear Study of three designed composites as per R-90 regulations shows that M3 has lowest wear rate as compared to other two composites. Which reveals that composite M3 with Alkyl benzene modifies resin have highest life out three designed railway brake block composites as shown in fig 5.

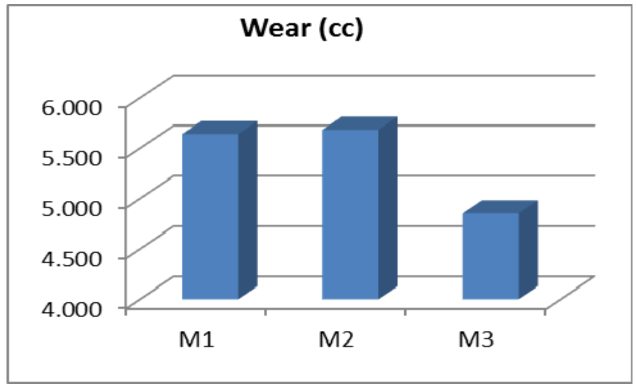


Fig. 5 shows wear pattern of designed composites

TGA graph in fig 4 also reveals that M3 has highest thermal stability and lowest wear rate at high temperature. Composites M1, M2 and M3 have weight loss at 800°C 18.99, 17.52 and 16.97 respectively. As per analysis Railway brake block composite M3 have lowest wear rate at normal and high temperatures. Due to low wear rate composite M3 has longer life of railway brake block out of three. Hence it is concluded that composite M3 is best composite with Alkyl benzene modified resin for longer life of railway brake block.

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