ISSN 2348 – 7968

Effect of Amount of Straight Phenolic Resin on NVH Properties of a Friction material composite

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Abstract

Resin is known as heart of a friction material composite; in present technology it is not possible to prepare a friction material composite without resin. It binds all ingredients present in the composite and without binding a single ingredient cannot play its role in performance of friction composite. Friction, wear and NVH (Noise, vibration and harassment) are major performance properties. Noise generation is normal phenomena during braking and it's acceptable up to 87 dB but higher shows poor NVH performance. Present paper is based on a study of effect of amount of straight phenolic resin on NVH of designed composite. Four formulations are designed containing eight ingredients with straight phenolic resin with different concentrations Viz. 8, 10, 12 and 14% (by weight) and evaluated for physical, Mechanical and NVH properties. Physical and NVH properties are significantly influenced by amount of resin. With increase in amount of resin noise increased for the designed composite. But other physical and mechanical properties shows better results for the composite having 12%, concentration of straight phenolic resin

Keywords: *Friction Composite, NVH, Phenolic resin, Performance properties*

1. Introduction

Friction material for automobiles is an important part because it associated with safety of human. During the development of a friction formulation it is necessary to keep safety factor in mind. Most of the performance properties of friction product related to safety. A friction composite consist different ingredients mainly Fibers, Abrasive, Lubricants, Fillers and Binders. In the form of binders phenolic resins are used to bind the other ingredients of composite. A commercial friction material normally contains more than 10 ingredients; every material plays a role in physical, tribological and NVH properties of the composite. The selection of ingredients and the composition in formulation has been largely relied on hand-on experience and systematic studies of friction material for optimum brake performance have been seldom found in literature because of the complexity of the material system.

According to available literature, different combination of fibers, fillers, friction modifiers had been explored in asbestos and NAO friction material [1-7]. Kim et al. [8] modified the straight phenolic resin by replacing the formaldehyde with alkyl ether to achieve higher thermal stability However, a little reported on systematic studies about the influence of resins and their modifications on fade and recovery behavior of a friction material composite [9]. But it is difficult to find in literature that the effect of straight phenolic resin on NVH properties of friction composite. Hence present paper deals to evaluate the effect of amount of straight phenolic resin on NVH properties. Friction material formulation with different amount of straight phenolic resin keeping other ingredients constant to avoid synergistic effect of other ingredients on noise of composite.

2. Experimental

A straight phenolic resin was selected to prepare friction material composites trials. It was procured from Arora chemicals Ghaziabad and it was 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 was carried out on the basis of keeping all other ingredients (except resin and space fillers). Varying the Straight phenolic resin in 8, 10, 12 and 14% by weight and compensating it with barium sulphate as space filler in composite N1, N2, N3, and N4 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 110g of mix and was heat cured at a temperature of 150°C under a pressure of 25 kg/cm^2 for 8 minutes in a

ISSN 2348 – 7968

compression moulding machine. Table 2: Details about the formulations of different composite

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

Properties	***Results***
Hexamine content (wt. %)	11.07
IPF (in cm)	3.4
Gel time (in sec)	87
Melting point (°C)	91
Ash content (in wt. %)	0.17

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

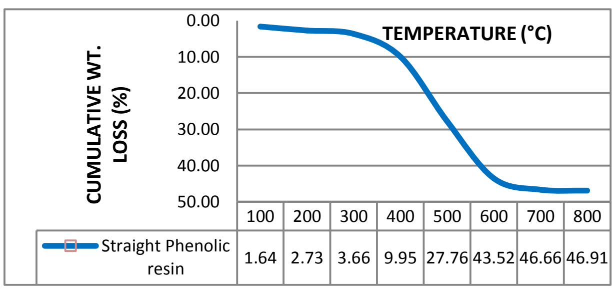

Fig.1 Thermal analysis of Straight phenolic resin in air atmosphere, Heat rises@10°C/min

Four 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 9 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 composite

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

Table 2: Details about the formulations of different composite

S .No	***Material Name***	***% Quantity by weight***			
		N1	***N2***	***N3***	***N4***
1	Pan fiber	10	10	10	10
2	Barium sulphate	27	25	23	21
3	Rockwool fiber	25	25	25	25
4	Natural graphite	10	10	10	10
5	Copper powder	10	10	10	10
6	Fused Alumina	5	5	5	5
7	NBR powder	5	5	5	5
8	Phenolic resin	8	10	12	14

3. Result and discussion

Characterization of composite is carried out for Thermal, Physical, Mechanical and chemical properties as shown in table 4. Test results show a trend that higher resin amount leads to high hardness. Specific gravity decreases due to gradually decrease of barium sulphate amount. Acetone extraction increases due high amount of uncured resin.

Table 4: Physical, chemical and mechanical properties of composite

Properties	***Unit/ scale***	***N1***	***N2***	***N3***	***N4***
Rockwell Hardness	HR'L	80	83	87	91
Ash content	%Wt.	34.3	35.5	40.2	39.7
Cold shear	Kgf/cm^2	31.4	35.4	35.1	42.1
Hot shear	Kgf/cm^2	25.7	28.6	30.3	29.6
Cold Adhesion area	%	70	72	75	71
Hot Adhesion area	%	65	70	74	69
Porosity	%	15.7	14.8	14.7	14.2
Heat swell	mm	0.19	0.18	0.12	0.15
Water swell	mm	0.07	0.06	0.05	0.06
Compressibility	%	2.1	1.95	1.88	1.96

Change in amount of straight phenolic resin affects the physical and chemical properties of a friction material as shown in table. 4. Results shown a different pattern for the composite N3 with 12% straight phenolic resin amount and its noticed that the results of N3 are best suitable for a friction material composite.

3.1 NVH behavior of designed composites at different temperature

NVH test of a friction material generally refers to a noise level generated during braking. At different temperature a noise level may differ. Normally noise level becomes high at higher temperature. A full scale NVH dynamometer is used to test the composites procured from Micro-face UK. The results shown in table 5 are observed during test. Test is carried out as per SAE J2521 different dB levels observed as shown on Table 5.

Table 5: Maximum Noise levels at different temperature

composites	Temperature (°C)						
	50	100	150	200	250	300	400
N1	72	75	80	82	85	92	78
N2	75	78	81	83	86	93	82
N3	68	73	77	80	81	88	73
N4	76	80	80	85	88	90	79

4. Conclusions

At different temperatures noise plays different levels due to fade of friction composite. During test it's observed as shown in table 5 that Noise levels increases up to 200°C gradually but become lower after this specific temperature for the designed composite. For N1 Noise level decrease 2 dB from 200°C to 225°C. It's also noticed that after 175°C noise is at the lowest level for temperature200°C and 225°C.

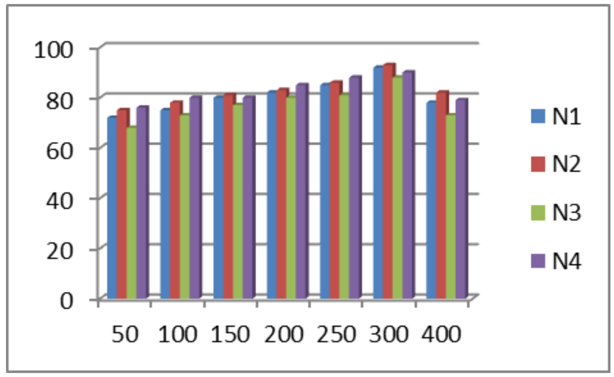

Fig. 2 Shows maximum noise levels at different temperatures

It's also noticed that noise level increases with increase in the amount of resin, but N3 shows lowest noise level out of three designed formulations, as also shown in fig 2. So it can be concluded that N3 is best formulation out of four designed formulations

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The research is "Friction material and composites"

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