Tribology and Mechanical Properties of Vinyl Ester and Epoxy Polymer Matrix Composites - A review

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ABSTRACT

From the past few years the low cost, high performance and good quality materials have global need to cause a shift in manufacturing. Thus the polymer-matrix composite material achieves a system with more useful structural and functional properties in manufacturing field, which is non-attainable by any of the constituent material alone. This wonder material are necessary part of today's materials due to its august properties such as low weight ratio, corrosion resistance, high fatigue strength etc. Thus this material has been alive with countless applications like aircraft structure, space vehicle to home building or many others. This review inaugurates here with a discussion on its wondrous role in manufacturing industries for various applications and also focuses where they may be competitive in various research fields and also some mechanical or wears behaviour of some of categories.

Keyword- Vinyl ester matrix composite, Epoxy matrix composite, Silicon carbide (SiC), Graphite (Gr)

I. INTRODUCTION

Tribology is the science and a materials-related discipline that performs in term of measured quantities such as coefficient of friction, wear rate and durability.[1,3,4]. Technically, it is the technology of two mating solid surfaces which produced different effects such as friction, wear, adhesion, surface fatigue and largely dependent on environmental conditions like presence of impurities thermal heat and lubricants etc. [2 5]. For such tribological properties, the Composites, one of the fastest growing material class, are used larger. It has been attempted in recent years that this multipurpose material (two parts matrix and reinforcement) with its august properties like stronger light weight, wear resister, generally used in building, bridge, aircraft and car bodies [8]. In many engineering applications as tribological materials under different conditions are used to promote these properties and improve knowledge in the mundane areas of friction, lubrication and wear of the polymer matrix of the past few decades. [9,10,11,12,13,14,16].

1.1 Vinyl ester matrix composite:

he vinyl ester resins were first commercially introduced in the early 1960s, which is unsaturated easily handled mono-carboxylic epoxy-based resin that explores similar properties such as epoxy and polyester polymer composite, which was found to be an essential part of the thermo set engineering family because of its excellent mechanical, chemical and corrosion resistance. The vinyl ester has been widely recognized as highly resistant materials to a wide range of chemical environments.[27]

TABLE I. MATERIAL PROPERTIES OF VINYLESTER

Properties	Values
Boiling poit	64, 147(ºC,F)
Flash poit	34, 93(ºC,F)
Relative density	1.04(g/cm3)
Modulus	2.3-4(Mpa)

1.2 Epoxy-matrix polymer:

Epoxy-matrix also called poly epoxide is a class of reactive prepolymer sand which contains epoxide group and may reacted by catalytic homopolymerisation or with a wide range of co-reactant like poly functional amines, acids, phenol and alcohol etc. The epoxy is a most investigated matrix material because of its august properties in various tribological applications including architecture, automotive and railway transport system.

TABLE II. MATERIAL PROPERTIES OF EPOXY RESIN

Properties	Values
Boiling poit	50(ºC)
Flash poit	34, 93(ºC,F)
Relative density	1.36(g/cm3)
Modulus	112(N/mm^3)

2. TRIBOLOGICAL PROPERTIES:

2.1 Vinyl ester - matrix composite:

Due to its self-lubrication properties, vinyl ester thermosets material is used in many applications, but without reinforcement they can not meet the requirements [17].The effects of particle size ((2 µm, 900 nm and 400 nm), particle loading (10 N, 70 N and) and sliding distance (5000–25,000 m) on the friction and wear behaviour of vinyl ester composites sliding against hardened ground steel on a pin-on- disc wear testing machine is studied in previous study.[17].

Vinyl-ester polymer in different lubricated conditions and directions under normal load(10,30,50N) & sliding speed(1.6,2.8,4m/s) [17 21]. They also observed that coefficient of friction for pure vinyl ester under water lubrication. Therefore in normal condition and larger load range more than 50N, the friction coefficient and wear rate of carbon reinforced vinyl ester composite increased in flip and wrap directions

[17, 21]. As reinforcement increase the strength of composite so researcher has been used different reinforced material to investigate mechanical, thermo mechanical and erosion performance of vinyl ester with different fibres like carbon fibre, woven fibre, and cellulose fibre with different impact velocities(43-76m/s), stand-off distance(55-85mm)and erodent size(250-600μm) composite in flip and wrap direction [18. In the case of cellulose fibres, they found that due to the toughness mechanism of cellulose fibres, the presence of cellulose fibers and nanoclays in 5wt percent increased the toughness and flexural modules in vinyl ester composite by 60 percent compared to the pure matrix in the baseline. [19,20,22]. The tribological properties would be derigueur thing in manufacturing industries for different applications,

TABLE II. PARAMETERS OF VINYL ESTER RESIN

Author	**Years**	**Parameters**			**Material**	**Apparatus**
		Load	**Sliding Velocity**	**Impact Velocity**		
S.R. Chauhan et al	2010	10,30,50N	1.6, 2.8, 4m/s		Vinyl ester, 50 wt.% Glass fibre, 10&20 wt.% SiC	pin on a rotating disc
B. Suresha et al.	2008	22 and 32N	2.15m/s		Vinyl ester, E-glass woven fabric (8%,62%, 30%)	abrasive wear test rig
S. Kumar et al	2011	-	-	43-76m/s	Vinyl ester Short carbon fibre (20–50 wt .%)	Erosion Test rig
A. Alhuthali et al.	2012	-	-	-	Vinyl ester, Recycled cellulose fibre (1%,3%,5%), Nanoclay	ANOVA analyzes
Michael Dale et al	2012	13.3 kN	-	6.9, 19, 47 J	Vinyl ester, woven carbon	impact test setup
B. Suresha et al.	2010	42,92,142N.	0.5 m/s 1.0 m/s 1.5 m/s 2.0 m/s		Vinyl ester, glass Fibre, carbon fibre	Block-on-ring multipurpose wear tester
S.R. Chauhan et al.	2013	10 N, 70 N	1.9 m/s and 5.7 m/s		Vinyl ester cenosphere	pin-on disc wear testing machine

2.2 Epoxy - matrix composite:

In the study of various reinforced epoxy composite the sliding velocity and sliding distance emerges as most significant factor which effect wear rate, therefore to overcome this effect the dry sliding wear behaviour of epoxy reinforced with orgomodified montmorollonite (OMMT) at 0wt%,2wt% and 5wt% under sliding velocity of 0.5m/s, 1m/s and 1.5m/s and normal load of 10N,20N, and 30N and also reinforced with both silicon carbide(5-10wt%)as well as graphite(5wt%) with different load(20N-80N) and sliding velocity(5.44m/s). In case of SiC and Gr reinforced composite wear rate is seen to be high at applied load of 20N and decreases on increasing the applied load up to 60N. And 5wt%Gr and 35wt%SiC exhibited highest wear resistance for that composite [24, 25, 28]. The use of synthetic fibre in resin material is cost effective and has high density as compare to the natural fibre. Thus the natural fibres considered in many applications due to their excellent dimensional stability, low specific gravity, improvement in tribological behaviour and biodegrable nature and the study on these natural fibre shows that the friction coefficient of composite would be increased about 44% at low speed when reinforced with bamboo fibres in various orientations under normal applied load (30N), sliding velocity(1.7m/s-3.96m/s) and sliding distance(1000-4000m)respectively. The existing survey also shine that the friction coefficient is also an important factor in wear for some direct contact between the copper and steel disk during sliding process, and is increased if epoxy reinforced with fabricated foamed copper, containing graphite(15wt%) and load(30-100N), sliding velocity(0.26m/s) [26,29]. The wear resistance of ACNTs/EP was improved 219 times than of pure epoxy under 2.4Mpa and 0.69m/s and friction coefficient for same reinforced epoxy composite decreased with increasing sliding velocity [30]. It also has been reported that the PTW/graphite at 2.5wt% when include in glass fibre reinforced epoxy composite and tested under a normal load of 30,60,90N ; sliding velocity of 2.5,5,7.5m/s and for constant sliding distance of 4200 m [27]. The main goal of designing this type of composite is to show how different potential fillers and their combinations influence the tribological actions and other essential epoxy composite issues such as a motion process where additional oil-lubrication is not required and lubrication has been achieved with fuel itself, e.g. diesel and kerosene. For those conditions tribological properties of carbon fibres or glass fibres reinforced epoxy composite was tested under diesel lubricating condition

TABLE II. PARAMETERS OF EPOXY RESIN

Author	Years	Parameters		Materials (in wt%)	Apparatus
		Load	Sliding velocity		

Qing Bing Guo et al.	2010	3MPa	0.42 m/s	Epoxy, oil-loaded micro capsules, silicon oxide (1 to 10 phr), short carbon fibre (0.5-5phr)	block-on ring apparatus
Rashmi et al.	2011	10N, 20N, 30N	0.5M/s,1 m/s, 1.5m/s	Epoxy, organo - modified montmorillonite (OMMT) 0wt%,2wt%,5wt.%	A pin-on-disk setup
S.Basavarajapp et al.	2012	20N,40N, 60N,80N,120N	2.72-9.52m/s	Epoxy, Glass Silicon carbide (Sic) 5to10% Graphite5%	pin-on-disc test apparatus
Umar Nirmal et al.	2012	30 N,	1.7–3.96 m/s	Epoxy, Bamboo	Pin on Disc
G. Zhang et al.	2013	5 MPa	0.5 m/s	Epoxy, CF, GF(5,10,15,20wt%Nano SiO_2 (2,4wt%) Graphite (5,8wt%) PTFE (5wt%)	four-lever Block-On-Ring (BOR) apparatus
Xiao-Jun Shen et al.	2014	1 MPa	1 m/s	Epoxy, carbon nanotube, graphene oxide (0.1phr,0.5phr)	pin-on-disc machine
M. Sudheera et al.	2014	30N,60N, 90N	2.5m/s, 5m/s 7.5 m/s	Epoxy50wt%Glass50wt%PW7.5wt% Graphite 2.5%	pin-on-disc machine

K.Srinivas et al.	2014	10N, 20N, 30N	5.23m/s	Epoxy Graphite (10%,20%, 30%40%) SiC 5%	Pin on Disc wear tester

3. CONCLUSION:

The main objective of the study is to investigate the epoxy-based composite at different sliding speeds, load applied and sliding distance. The study concluded that the friction coefficient of composite are largely depend on sliding velocity. At normal condition and larger load range more than 50N, the friction coefficient and wear rate of carbon reinforced vinyl ester composite increased.

- Specific Wear rate is function of sliding velocity and increased on increasing the sliding velocity
- The fibre is reinforcement in different orientation also a major factor in study of wear behaviour and followed the order AP-O > P-O > R-O.
- The specific wear rate of epoxy based composite was noticed to increase at about 3000m of sliding distance
- The inclusion of natural fibres in composite also improve the mechanical properties about 46% on increasing time duration

4. References

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