DRY LUBRICATION OF POLYMER GEARS USING EPOXY AND POLY URETHANE PAINTS

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Abstract: ***In most applications wear accounts for failure of polymer gears. By reducing the wear one can increase the gear life. This can be done by applying a dry lubricant film on the gear. Gear materials were chosen as Nylon 6 and Acetal. Epoxy and Poly Urethane resins were used to give coatings. Tests were carried out on coated versus coated, uncoated versus uncoated gears. Wear rates in weight loss form was estimated and running temperatures were recorded SEM test was conducted to estimate the wear.***

Keywords: ***Dry lubrication of polymer gear, thin film coating , friction, and wear.***

I. INTRODUCTION

Due to light weight and relatively lower noise compared to iron and steel gears, polymer gears are widely used in several low and medium load applications. These gears are primarily used in devices like printers, mixers. Low strength limits the application of use of polymer gears . Wear is an important factor for the failure of gear system [16]. The transmission efficiency of pristine polyamide 6 (PA6) and clay incorporated polyamide nanocomposite (PNC) spur gears was assessed and numerical studies were conducted to predict the frictional and hysteresis power loss [13]. Performance of different polymers used for the production of gears were observed [8]. In acetal gears the wear appreciated drastically on reaching a critical load beyond which the gear wear is maximum [18]. Wear behaviour in acetal were studied [5,18,19]. Polyamide 4,6 (PA46) and its aramid fibre composites (6 wt.%, 12 wt.% and 15 wt.%) were tested for tribological applications using a twin-disc wear test rig [17]. Water was used as a lubricant for PEEK to reduce wear in sliding contacts [7]. The wear behavior of glass reinforced polyamide in humid conditions were stuydied [15]. Polymer coatings have received increased attention as protection against corrosion and wear for several environmental conditions mainly in the automotive, petrochemical, oil and gas industries [20]. Attempts were successfully made to increase the durability of poly amide gears by tooth width modification [14]. In case of rolling and sliding contacts of PEEK its wear was estimated [1]. In addition the rolling fatigue of PEEK and its composites were analysed [2]. The general approaches to PEEK coating using painting and thermal spraying was studied [13]. The tribological noise generated as a result of the interacting gear tooth flanks were estimated [10]. Wear reduction was even achieved even by engaging dissimilar gears [21]. The effect of various fillers in sliding wear of polymers composites were studied [3]. Low thermal properties of polymers like low thermal conductivity of plastics contribute to gear failure. In a set up the running temperature of polymer gears tends to appreciate drastically due to the very low rate of escape of heat. The relation between thermal conductivity and wear was studied. As new analysis method Infrared cameras were used to study the thermal behavior of polyamide gears and to estimate the type of heat distribution [11]. The thermal wear in acetal gears was studied [4] . Cooling holes were placed to reduce the working temperature of the gears in order to reduce the thermal wear [6, 9].

II. POLYMER GEAR MATERIALS AND MANUFACTURING DETAILS

Polymer spur gears were milled from nylon 6,6 and acetal rods. Gears are cut at a pressure angle of 20 degree. A rack and pinion gear arrangement was set.

III. SPRAY COATING OPERATION AND HEAT TREATMENT

1. Two coating materials were selected as EPOXY and POLYURETHANE paints.
2. Primers were sprayed on the gears using conventional air spray gun at 27°C - 33°C.
3. Coating was given using air spray gun at 27°C - 33°C.
4. A 5 min flash off time was given followed by spraying.
5. After this, the intermediate paint was coated on the gears using the conventional air spray gun.
6. After a 10 minute flash off time the finish paint was coated on the gears using conventional air spray gun.
7. Spraying was followed by heat treatment.

IV. HEAT-TREATMENT

Since nylon 6 has a higher melting point compared to acetal they are heat treated separately.

A. Heat Treatment for Nylon 6

After spray coating nylon gears were heat treated at 180°C for 1 hour in a free air circulating oven. The gears are then cooled and de-masked prior to visual inspection for contaminants.

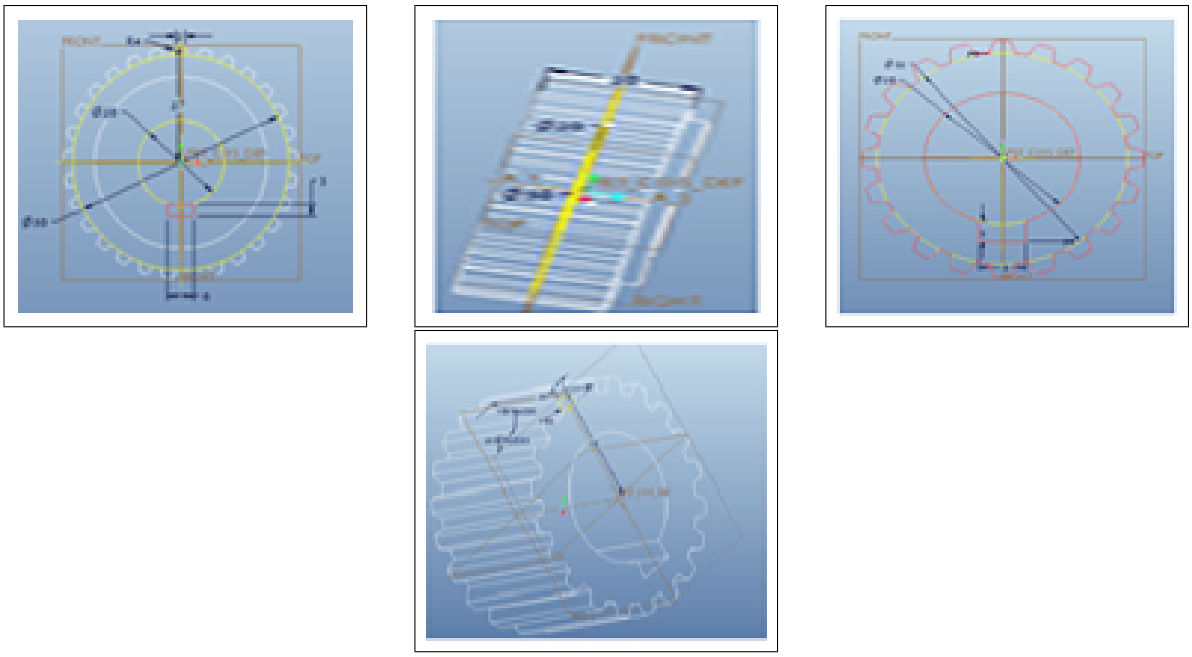

Figure 1: Polymer spur gears

Type of the Paint	Name of Paint	Compostion
Primer	Poonam Epoxy ROZC Primer	Two Component, polyamide cured, air drying epoxy composition with red oxide and zinc chrome pigments
Intermediate	Poonam Epoxy MIO Paint	Two Component, high build epoxy polyamide composition with micaceous iron oxide pigment
Finishes	Poonam Epoxy Finish Paint	Two Component, air drying polyamine adduct cured epoxy coating

Table 1: EPOXY Paint Details.

B. Heat Treatment for ACETAL GEARS

After spray coating acetal gears were heat treated at 130°C for 1 hr in a free air circulating oven. The gears are then cooled and de-masked prior to visual inspection for contaminants.

C. Morphologies of Different Coatings

The morphologies of POLYURETHANE and EPOXY on NYLON6 :

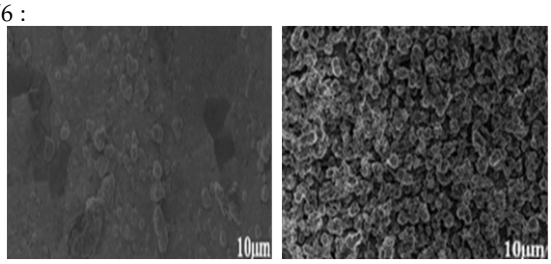

Figure 2: Morphologies of POLYURETHANE and EPOXY on NYLON6

The morphologies of POLYURETHANE and EPOXY coated ACETAL Gears :

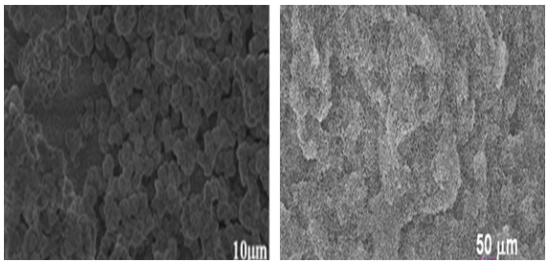

Figure 3: Morphologies of POLYURETHANE and EPOXY coated ACETAL Gears

V. TESTING METHODS

1. A constant load of 3kfg was applied to the pinion gear using a spring balance.
2. Tests were conducted at a constant speed of 1000 rpm in pinion gear and a corresponding speed reduction was achieved in rack gear as the gears meshed.
3. The gears were periodically removed and their weight loss was estimated using an analytical weighing balance .

Type of the Paint	Name of Paint	Compostion
Primer	RELY 882 Poly Urethane	Base contains acrylic resin and acid/alkali/light fast pigments
	Primer	And hardness contains alipathic / aromatic Poly Isocyanate resin
Intermediate	Aliphatic acrylic polyurethane	component face paint with containing hydroxyl acrylic resin as binder
Finishes	882 Poly Urethane Finishing Paint	Base contains acrylic resin and acid/ alkali / light fast pigments and hardness contains alipathic / aromatic Poly Isocyanate resin

Table 2: POLYURETHANE Paint Details.

4. Temperature was estimated using non-contacting type Infrared thermometer.
5. The gears were removed and the weight of pinion gear was measured using analytical weighing balance and characteristics of relative weight loss versus Time was obtained.
6. Tests were conducted on coated-coated, uncoated-uncoated gears.
7. A temperature and weight loss characteristics were estimated.
8. Coating thickness was estimated using paint coated on sample gears using thickness meter Digital Dt-156 Paint Coating Thickness Gauge Meter.
9. SEM tests were conducted to estimate the wear of the given gear.

VI. ACKWLODGEMENTS

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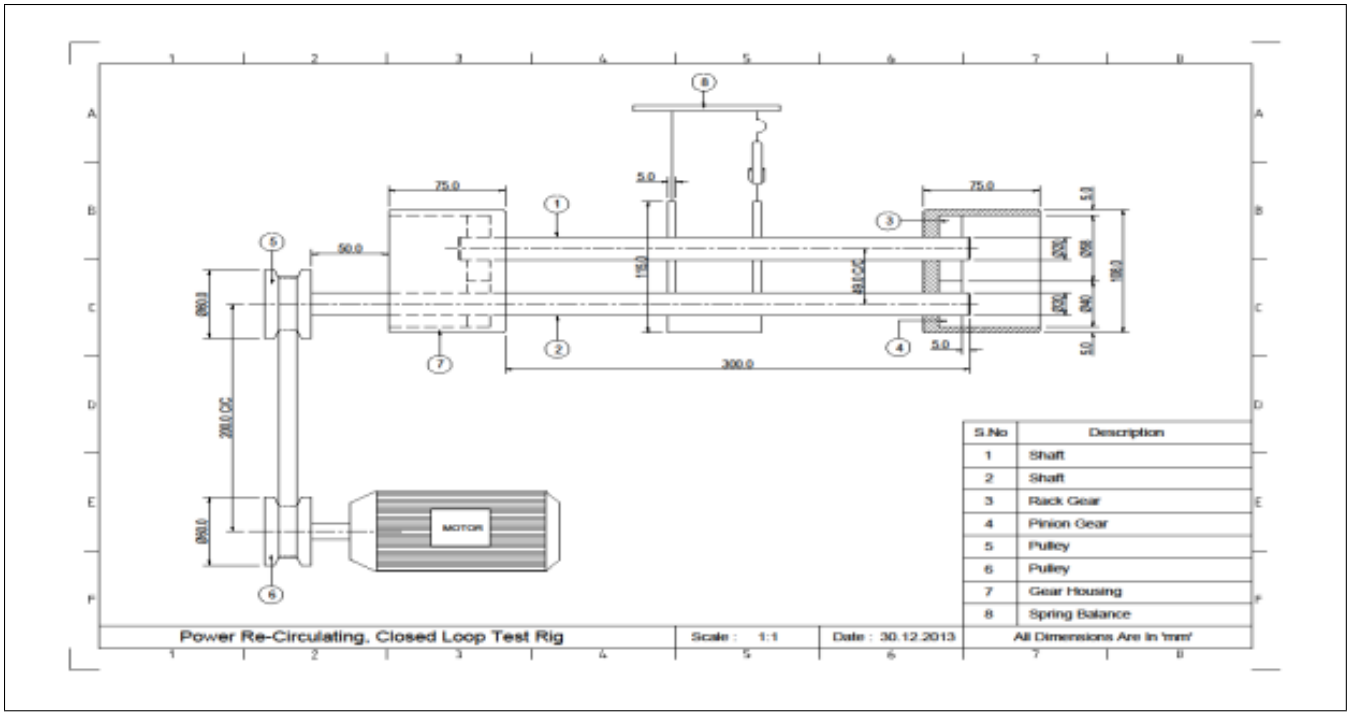

Figure 4: The setup for testing of gears

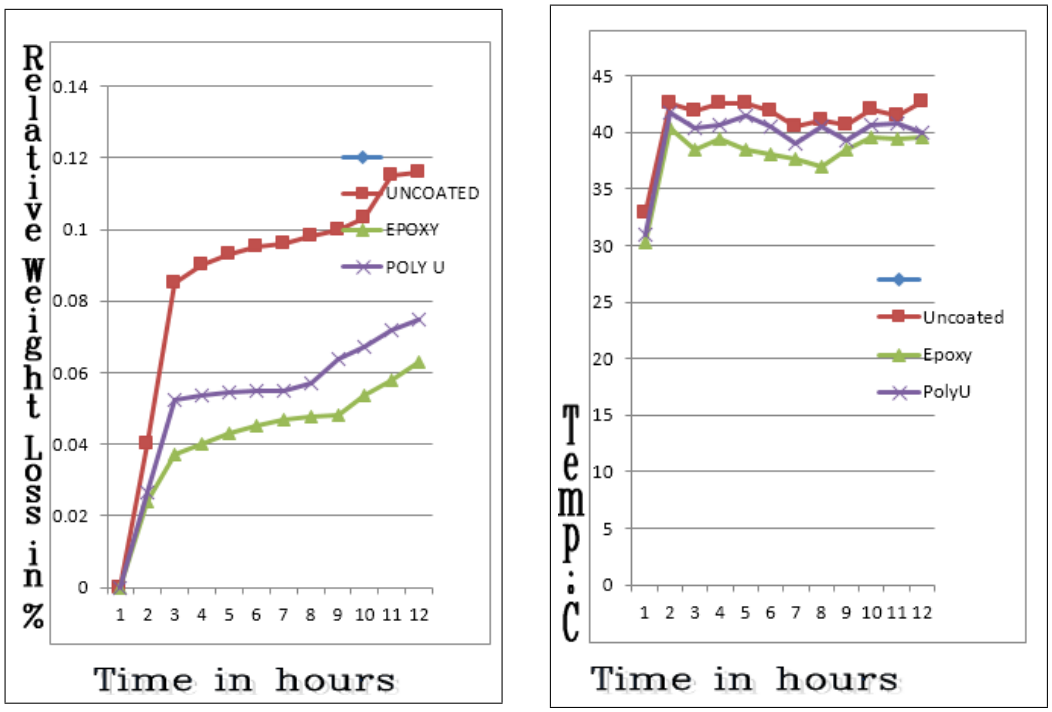

Figure 5: The characteristics of Acetal pinion gears versus time

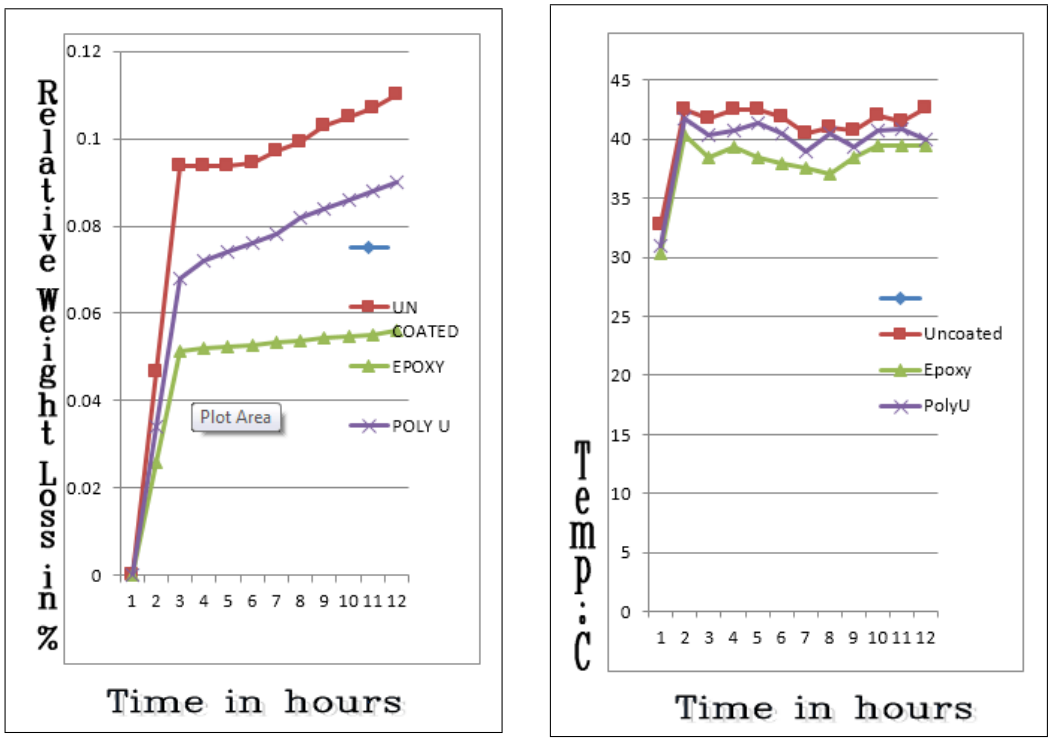

Figure 6: The characteristics of pinion Nylon gears versus time

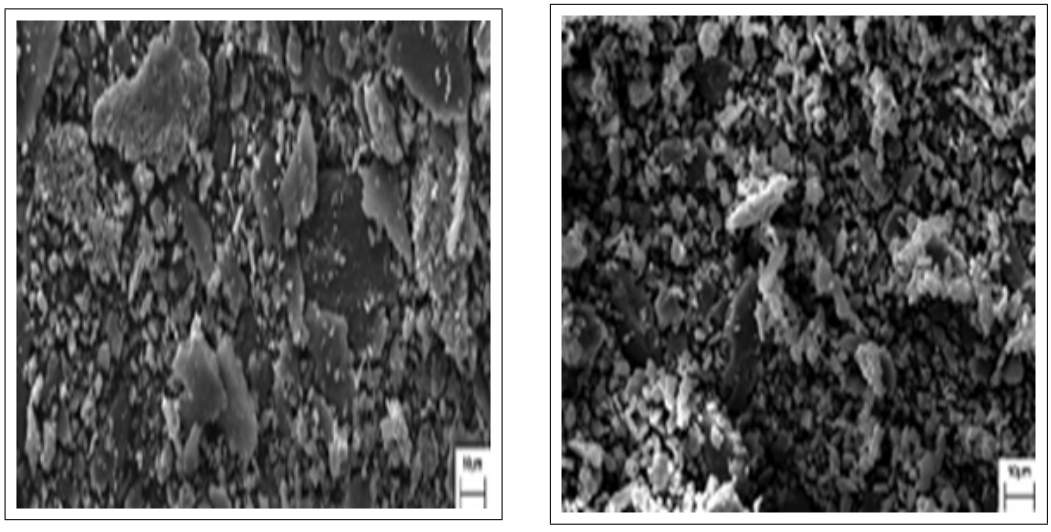

Figure 7: SEM Image of Epoxy coated Acetal pinion gears before and after WEAR

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