# Weight Loss Investigation on the Surface Area of Ultra-High Molecular Weight Polyethylene (UHMWPE)

Kundan Sahu*, Prem Shankar Sahu[1], Anil Kumar[2]

[1]Department of mechanical engineering, BIT Durg

[2]Department of Metallurgical engineering, NIT Raipur

*Abstract:* **The main aim of this present work is to develop polymer composite matrix UHMWPE filled aramid fabric hybrid polymer composite and to investigate their structure property correlation. To achieve the above work plan has been made accordingly. The experimental work has been classified in to three type of specimen development of 1.UHMWPE filled 0% in composite material.2 UHMWPE filled 2% in composite material, 3. UHMWPE filled 4 % in composite material composite. The main purpose of adding the UHMWPE filled aramid filler materials increases the hardness of the material and improve the coating Quality of the composite material. And study the dry sliding wear test aspects of the UHMWPE filled aramid fabric composites material, weight losses survey on the surface area of the composite.**

*Keywords:* **Tribology, UHMWPE, Dry Sliding Wear Test, Aramid Fabric Composites Material, VARTM Process.**

## 1. INTRODUCTION

Tribology as the defined the science and technology of interacting surfaces in relative motion and of related to subject and practice. The word tribology was 1st reported in 1966.The word is derived from the Greek word " tribos" that means rubbing, is defined as the science and technology of interacting surfaces in relative motion and practices related to as an interdisciplinary science and technology, it includes friction, wear and lubrication. So the literal translation would be "the science of rubbing" equivalent is Friction & wear or lubrication science alternatively used. Tribology is the study of friction, wear and lubrication. Friction and wear are generated at the interface of contacting bodies in relative motion.

Leonardo da Vinci (1452-1539) the introduced 1st time the concept of coefficient of friction as the ratio of the friction force to normal force. Friction force does not depends on the apparent area of contact. French physics chares Augustan coulomb the added 3rd law of that friction force is independently of velocity one motion start and also made distinction between statics and dynamics frictions. And therefore occur in components as bearings, gears, screws and slip-rings.

The energy losses in the tribological components can be reduced drastically by better tribological designs. Therefore research in this area will lead to better performance of machines.

Composite materials are emerging as an advanced class of structural material for marine, aerospace, automotive, electronics and allied industries. These materials provide a substitute for conventional engineering materials when a specific mechanical property in terms of resistance to high ambient temperature conditions is required. The most commonly used composite materials in modern engineering, the polymer–matrix composites, have been finding increased applications owing to their much lower weight and better corrosion resistance and biocompatibility than the metal-matrix and ceramic-matrix ones. For example, ultrahigh- molecular- weight polyethylene (UHMWPE) has been widely used in bearing applications due to its good chemical stability, biocompatibility, and friction reducing and antiwear ability.

In comparison with High Density Polyethylene (HDPE), UHMWPE is significantly more abrasion-resistant and wear-resistant. Epoxy resins are most important class of thermosetting resins, having several outstanding characteristics but being brittle, low impact resistance and low toughness, limits the usage of epoxy resins. Epoxies, due to their low impact resistance may not provide excellent sliding wear resistance. Toughness of epoxies can be enhanced by the incorporation of second phase filler like ultra-high molecular weight polyethylene (UHMWPE). A property of ultra-high molecular weight polyethylene that distinguishes it from other polymers is its highly entangled molecular chains, which makes it wear resistant. It is well known that the wear resistance of UHMWPE can be significantly increased by the addition of various fillers to form UHMWPE composites. Therefore, many attempts have been made to improve the wear resistance and mechanical properties of UHMWPE. A widely practiced approach in this respect is the combination of UHMWPE with other polymers to form blends which may lead to the creation of attractive new composite materials.

## 2. LITERATURE REVIEW

**S. Basavarajappa, K.V. Arun, J. Paulo Davim:-**The tribological behavior of epoxy polymer composites with SiC and Graphite particles as secondary fillers was studied using a pin-on-disc wear rig under dry sliding conditions. Besides, a wider choice of materials and ease of manufacturing make them idea for many engineering applications [1–3]. On account of their good combination of properties, fiber reinforced polymer composites are used particularly in the automotive and aircraft industries, the manufacturing of spaceships and sea vehicles [3–5]. low density and ability to be tailored to have stacking sequences that provide high strength and stiffness in directions of high loading [6]. Composite materials consist of resin and are in for cement chosen according to the desired mechanical properties and the application. of application of polymer and its composites in mechanical components such as gears, cams, wheels, impellers are cited in literature [10].

The friction and wear characteristics of -filled Kevlar fabric composites with different filler proportions when sliding against stainless steel pins under dry friction conditions were studied, with unfilled Kevlar fabric composites used as references[13]. The worn surface and transfer film of Kevlar fabric composites were then examined with a scanning electron microscope. It was found that UHMWPE filled aramid fabric composite could improve the tribological behavior of the fabric composites with various applied loads, and the best antiwear property was obtained with the composites containing of different wt. % of filled UHMWPE in the composite material.

**Thomas Ø. Larsen a, Tom L. Andersen b, Bent Thorning c:-**Polymer matrix composites (PMC) are a class of materials which is used increasingly in applications where friction and wear are important parameters. Examples range from gears, seals and rollers to bearings, brakes and artificial joints. PMCs are often preferred over other materials because of their easy process ability, high strength-to-density ratio and chemical resistance. Furthermore, PMCs generally have a low coefficient of friction (μ) even under dry-sliding conditions.

This property can be utilized in applications where the addition of lubricants such as oil or grease cannot be tolerated [1–8].

**S.P. Lin, J.L. Han, J.T. Yeh, F.C. Chang, K.H. Hsieh:-**ultrahigh- molecular-weight polyethylene (UHMWPE) fibers. In the analyses, performed using electron spectroscopy for chemical analysis, changes in weight, and scanning electron microscope observations, demonstrated that the two fiber surface- modified composites formed between UHMWPE fiber and epoxy matrix exhibited improved interfacial adhesion and slight improvements in tensile strengths, but notable decreases in elongation, relative to those properties of the composites reinforced with the untreated UHMWPE fibers.

**Jean - Pierre Pascault and Roberto J.J. Williams***:-*Epoxy monomers containing vinyl groups, like glycidyl (meth) acrylate or glycidyloxystyrene can be used for the synthesis of functional oligomers. Linear or cross linked epoxy polymers are obtained by reaction of the epoxy monomers with co - monomers (hardeners) and/or initiators. Epoxy polymers can be produced by step or chain polymerizations or, eventually, by a combination of both mechanisms.

Erosive wear is caused by the impact of particles of solid or liquid against the surface of an object.[7] The impacting particles gradually remove material from the surface through repeated deformations and cutting actions.[11] It is a widely encountered mechanism in industry. A common example is the erosive wear associated with the movement of slurries through piping and pumping equipment.

The rate of erosive wear is dependent upon a number of factors. The material characteristics of the particles, such as their shape, hardness, impact velocity and impingement angle are primary factors along with the properties of the surface being eroded. The impingement angle is one of the most important factors and is widely recognized in literature.[12] For ductile materials the maximum wear rate is found when the impingement angle is approximately 30°, whilst for no ductile materials the maximum wear rate occurs when the impingement angle is normal to the surface.[12]

## 3. EXPERIMENTAL PROCEDURE

The experimental flow chart explains the work detail.

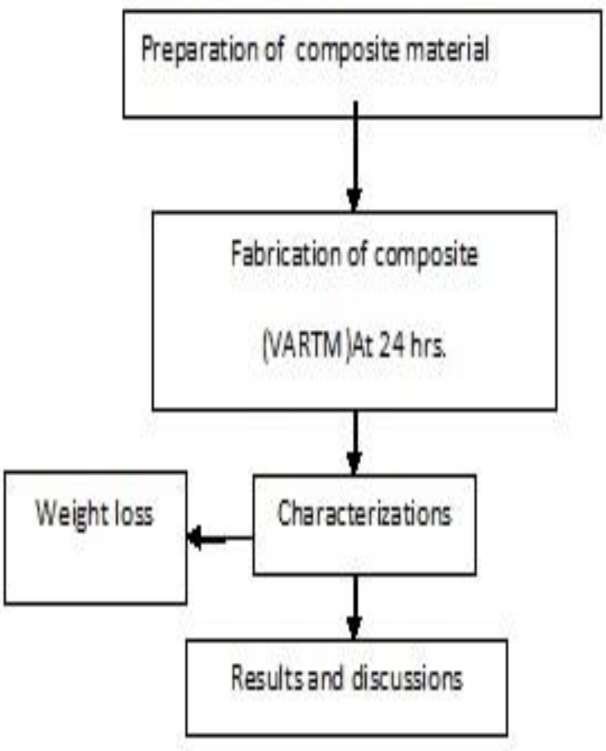



**Fig 1 Flow chart of the Experimental Procedure**

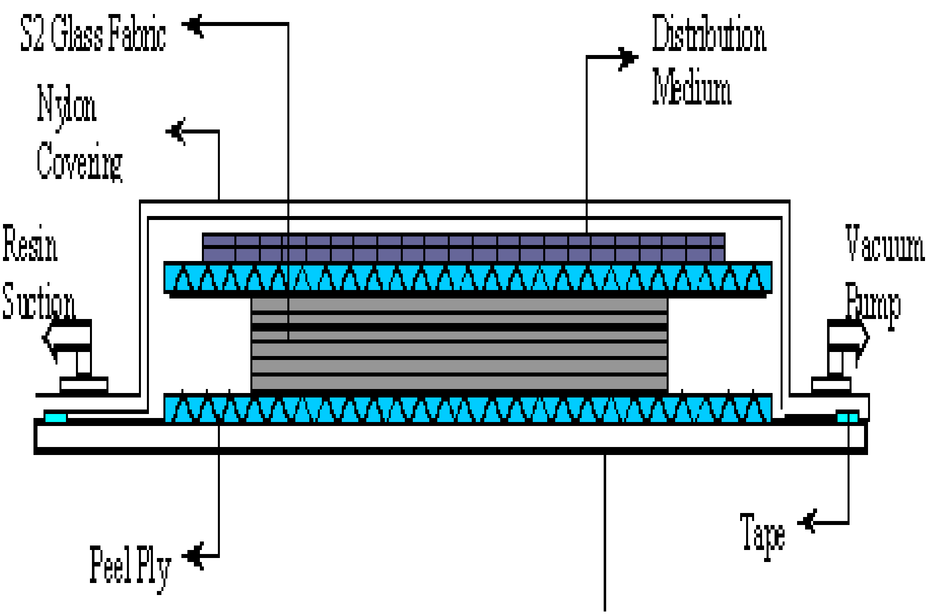



**Fig 2 Schematic of setup of VARTM process**

The composition and the volume fractions of the matrix, reinforcement and the secondary fillers has been shown in Table 1.

**Table 1 Composition and volume fraction of the UHMWPE and Aramid as fill in the Epoxy composites.**

| Specimen | Epoxy wt % | Fiber wt % | Filler wt % |
|---|---|---|---|
| A-E | 40 | 60 | 0 |
| UHMWE A-E | 38 | 60 | 2 |
| UHMWE A-E | 36 | 60 | 4 |

**Table 2 Process Parameters with their values at three levels**

| Level | Velocity (m/s) | Rotation of disc in (rpm) | Load in (N) | SD in (m) |
|---|---|---|---|---|
| 1 | 1 | 500 | 10 | 1000 |
| 2 | 2 | 1000 | 20 | 2000 |
| 3 | 3 | 1500 | 30 | 3000 |

## 4. TECHNIQUE

The solid particle dry sliding experiments were carried out as per ASTM-G99 standard on the sliding wear test shown digital photo graph in Fig.1 The test rig consists of pin on disc machine, weighing machine, for applying the load some different weights before and after experiment cleaning the specimen surfaces used to acetones, computer is connected to the pin on disc machine to records the usual values. Drying unit, coefficient of friction, displacement applied load and friction forces all graph are plotted by software loaded on computer. Dry sliding wear was measured by the Weight losses.

$$W_c = [W_{before} - W_{after}] \quad (1)$$

Where, $W_c$ is the loss in weight of the composite material and $WE_r$ is the total weight used for sliding wear of each specimen. Wc is determined by weighing the sample before and after the wear test using a digital electronic balance 0.1 mg accuracy. Each sliding wear tests was performed twice and average wear values were calculated. Square samples of size 7mm × 7mm× 2.5 and 3mm are cut from the diamond tipped cutter for wear tests. The experimental detail is presented in table 1.

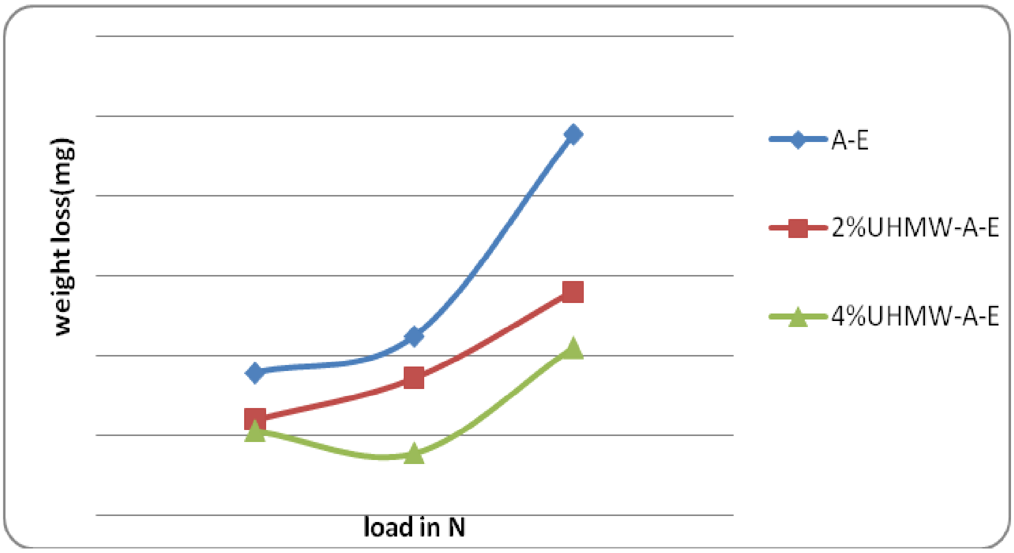
## 5. RESULTS AND DISCUSSION

**Dry Sliding Wear Tests:**

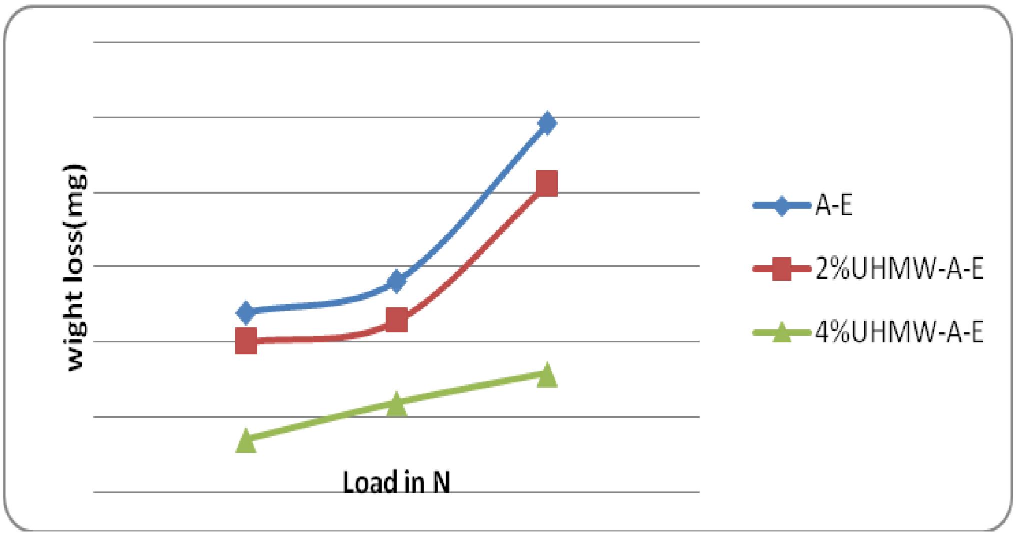
The wear tests were conducted with a constant load of 10N, 20N and 30N, at room temperature, sliding distance and speed. At room temperature the weight loss was quite large and becomes negligibly small. The coefficient of friction data obtained from the tangential force recorded during wear tests showed that, at room temperature, the average coefficient of friction different composite material is about 0.84, 0.66, and 0.38 at different load. On the other hand, during sliding wear test at room temperature, the coefficient of friction was significantly lower (ranging from 0.38-0.33) when for applying the minimum load. When test conducted on three different percentage UHMWPE filled aramid fabric composite at 0%, 2% and 4% the weight loss was slightly decreasing when test load and sliding distance is raised from room temperature. The coefficient of friction data obtained from the tangential force recorded during wear tests showed that ,coefficient of friction is about 0.36 at room temperature, and during sliding at minimum load and maximum load and distance coefficient of friction was higher (ranging from 0.71 -0.88). The wear resistance of the deposition is higher at higher load and more distance when compared to room temperature. On the other hand, for the low load less distanceUHMWPE aramid fabric composite the wear resistance decreases with decreasing time. This can be explained with wear mechanisms occurred during sliding wear of the metals.

**Graph plotted Weight losses vs. applying load:**

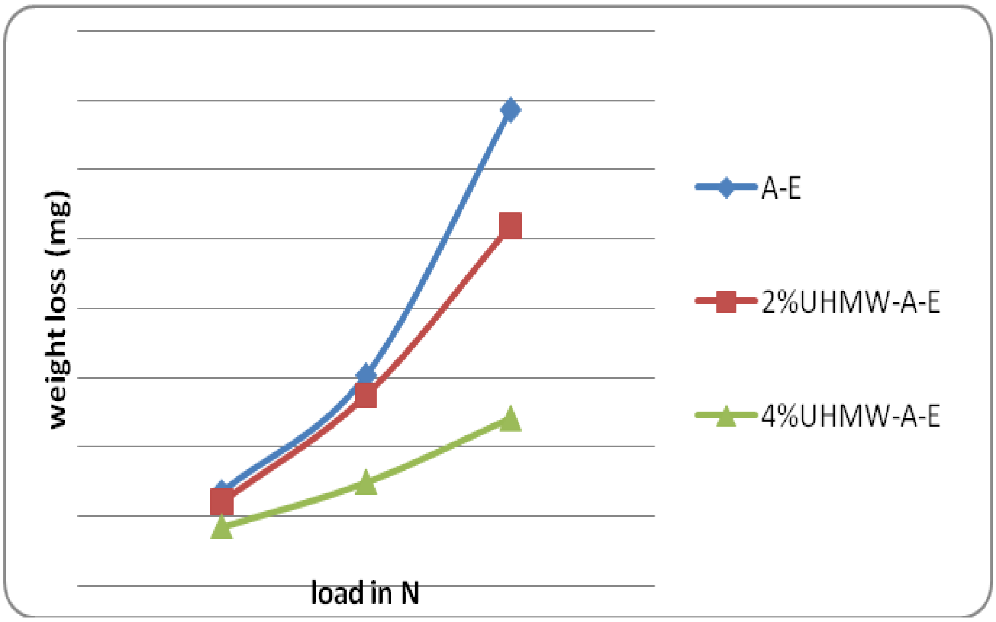
X-axis shown in applied load (10N, 20N and 30N) and Y-axis weight loss in mg ($10^{-3}$gms).



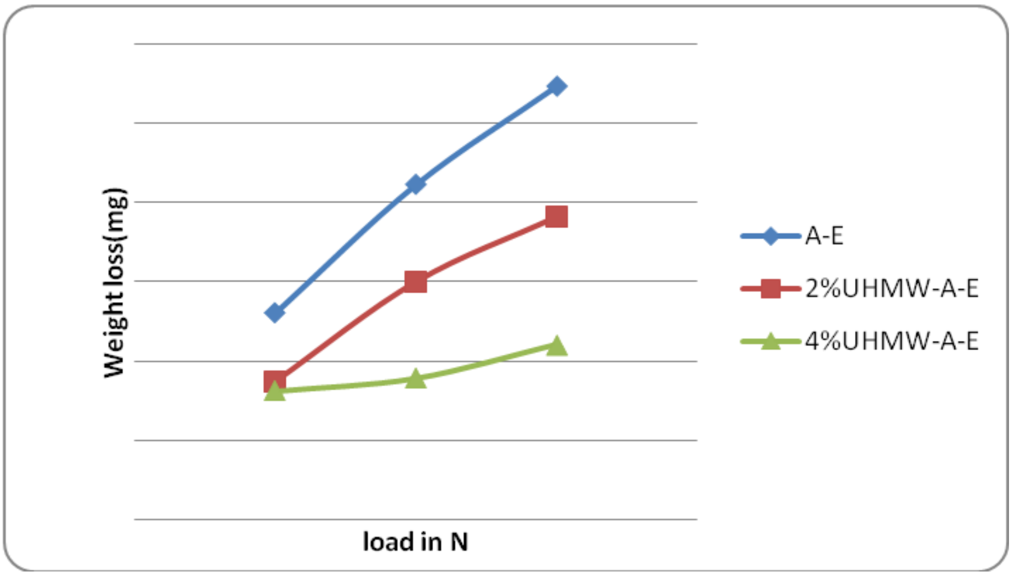

**Graph 1.When at Sliding Distance 1000,time 16 min and 500 rpm**



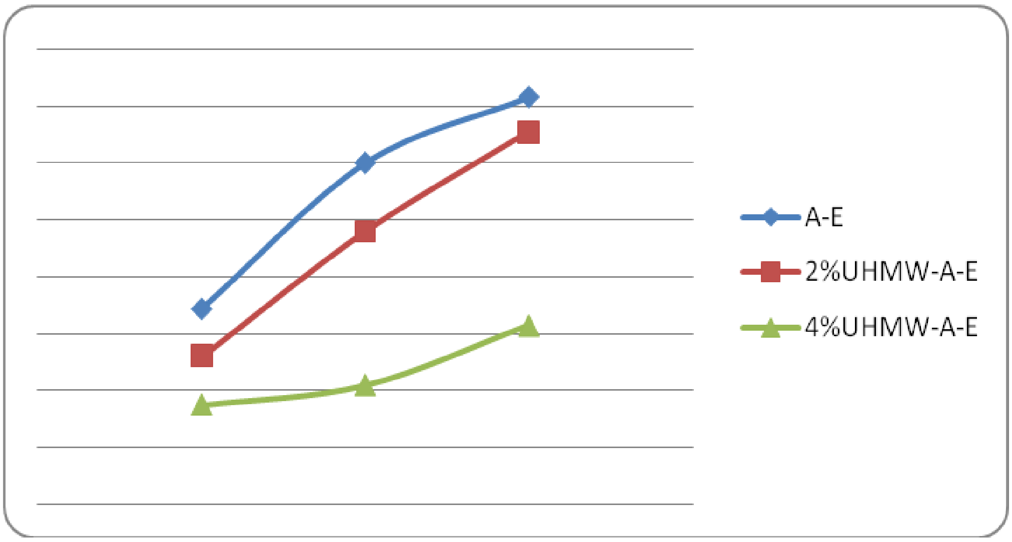

**Graph 2.When at Sliding Distance 2000,time 32 min and 500 rpm**



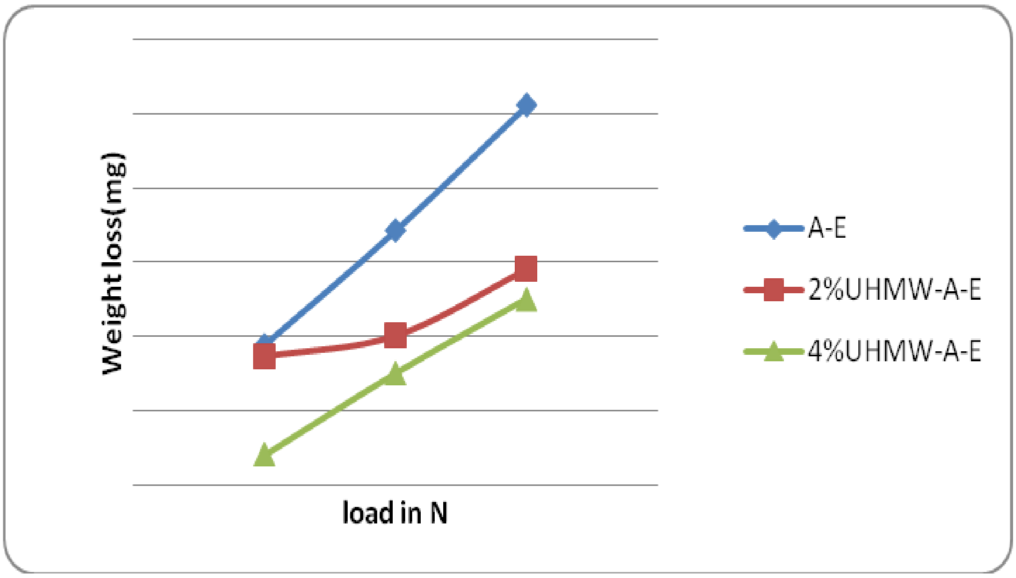

**Graph 3.When Sliding Distance 3000, time 48 min and 500 rpm**



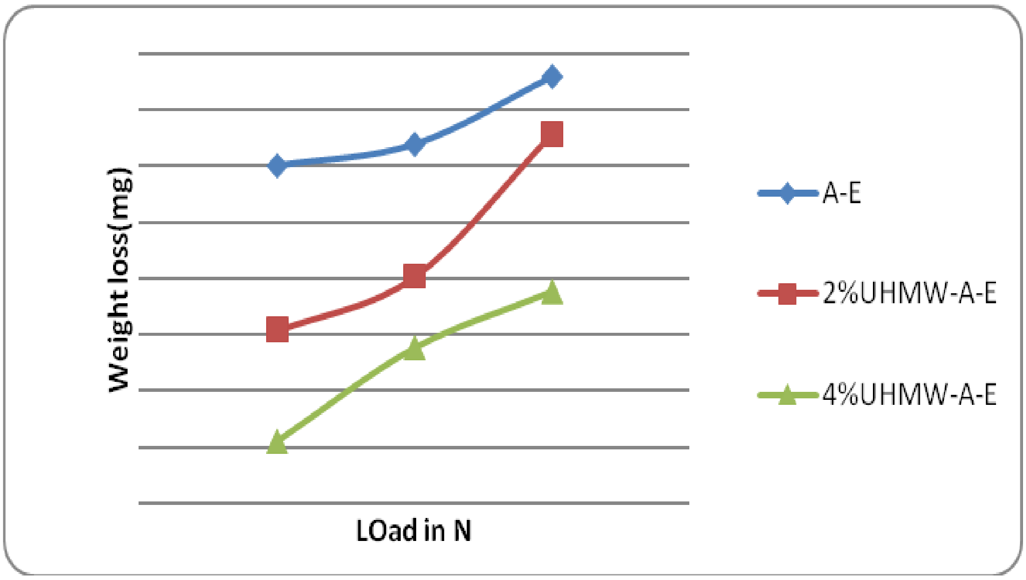

**Graph 4.When at Sliding Distance 1000,time 16 min and 1000 rpm**



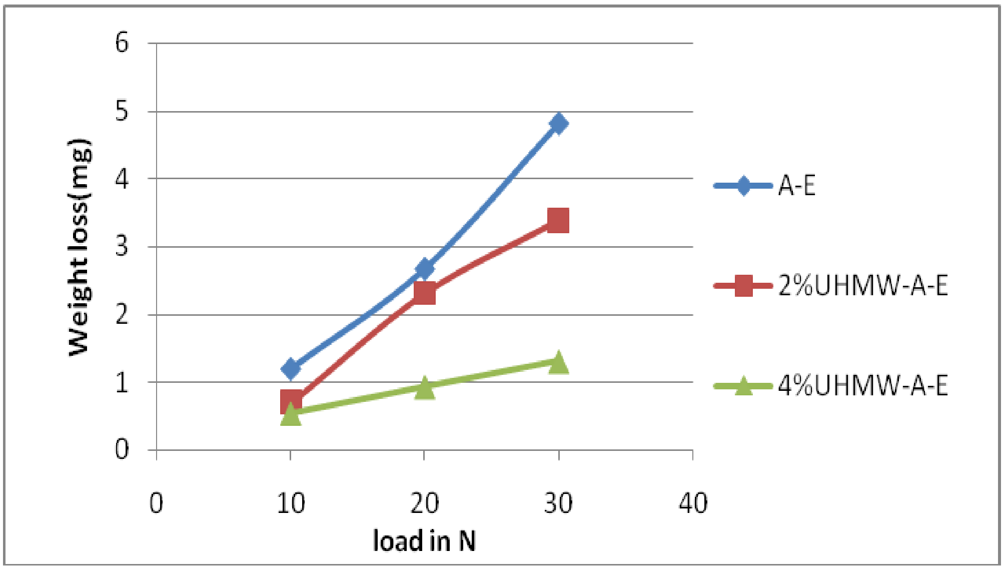

**Graph 5.When at Sliding Distance 2000,time 32 min and 1000 rpm**



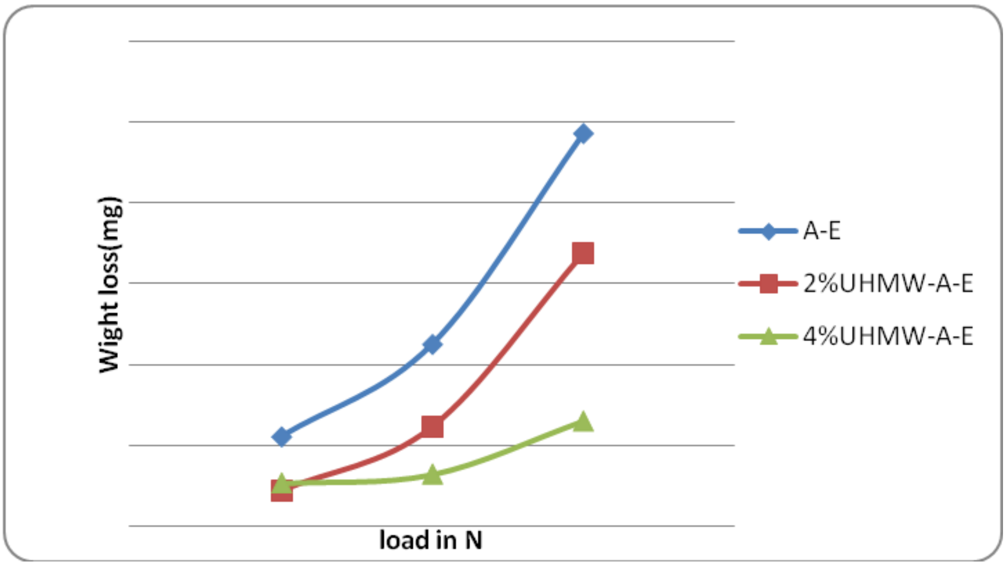

**Graph 6.When at Sliding Distance 3000, time 48 min and 1000 rpm**




**Graph 7.When at Sliding Distance 1000,time 16 min and 1500 rpm**




**Graph 8.When at Sliding Distance 2000, time 32 min and 1500 rpm**




**Graph 9.When at Sliding Distance 3000, time 48 min and 1500 rpm**

## 6. CONCLUSION

This paper is aimed to characterize the UHMWPE filled aramid hybrid composite produced through the fabrication method. The results obtained from various experimental studies. Taguchi's robust design method can be used to analyze the dry sliding wear problem of the polymer matrix composites as described in the paper. The following generalized conclusions can be drawn from the work.

• Effect of variables i.e., load and sliding distance is more pronounced on the wear of the composite rather than sliding speed.

• Factorial design of the experiment can be successfully employed to describe the wear behavior of the samples and to develop linear equations for predicting Weight losses within selected experimental conditions.

For Substrate, weight loss is slightly decreasing when test load and sliding distance with time increased from room temperature.

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