Comparison and Optimization of Wear Rates of Dentsply (Esthet-X) and Kulzer (Charisma) Dental Composite Materials

Dr. Chaitali U. Hambire[1] Dr. U. V. Hambire[2] Sandip P. Barange[3]
[2]Student [3]Professor
[1]Department of Pediatric Dentistry [2,3]Department of Mechanical Engineering
[1]Maharashtra University of Health Sciences, Nashik [2,3]Government Engineering College Aurangabad-431001, Maharashtra India

Abstract— In this study, two types of dental composites materials are tested on the basis of wear rate. The specimens were prepared in plastic and cured using LED light torch. They were weighed on Precision Digital Balance machine (LWL Germany Make Model: LB 210S, Least count of 0.0001gm). Then they were mounted on Two Body Wear Tester (Pin on Disc machine) for testing of wear rate. The variables considered for the research work were load, speed and sliding distance. Various combinations of these variables were made. Pre-experimentation was also carried to find out the most influencing values of these variables. The variables were so chosen that they would represent actual conditions under which the dental composites were supposed to work. The results were put into Minitab 17 software for further analysis. It was found that Dentsply (Esthet-X) shows more resistance to wear rate than Kulzer (Charisma).

Key words: Dental Composites Materials, Wear Rate, Optimization, Taguchi Method

I. INTRODUCTION

In conservative dentistry ceramic-polymer composites are most commonly used. It applies not only to the front teeth, but also to the side teeth – molars and premolars. The ceramic-polymer composites have suitable physical – mechanical properties to oral cavity conditions [1]. They maintain aesthetic appearance similar to the appearance of the natural tooth tissues for a long operating time. Due to clinical reasons they should also ensure long life of the fillings

Dental composites consist of a matrix (organic phase-resin) and filler (inorganic phase). The mechanical and tribological properties of dental composites are determined by many parameters such as: size, shape, content and distribution of filler particles in resin matrix [2]. Commonly used fillers are silica fillers, glass and quartz. However, constantly new materials are being developed, which among other things would increase abrasive wear resistance of the fillings [3]. It is believed that the use of filler particles in nano-sized enhance physical and mechanical properties of ceramic-polymer composites. The quantity of filler in the matrix depends on the type of the composite. Hybrid composites have the highest ratio of inorganic to organic phase, for which the content of the filler ranges from 60 up to 70 percent of the composite volume (% volume) or from 70 up to 85 percent of the composite mass (% weight).

Wear resistance of denture teeth has been considered as one of the most important requirements for oral rehabilitation of edentulous patients with removable dentures, in order to maintain a stable occlusal support over time [4]. Wear of the occlusal surfaces may result in insufficient posterior tooth support, loss of chewing efficiency and nonfunctional activities. Although wear of acrylic resin teeth has also been related to the loss of vertical dimension of occlusion with complete dentures, the major factor affecting it is the reduction of residual ridges by absorption

Wear of the composite filling in the clinical conditions is a result of the opposing teeth contact, food consumption, teeth brushing and illnesses e.g. bruxism. The wear is a sum of phenomenon occurring in the operating conditions, thus abrasive wear and adhesive effect between two mating surfaces, as well as fatigue of the surface layer of the material and corrosive effects [5]. Especially important types of teeth wear are abrasion and attrition. The abrasive wear [6-8] occurs by means of the following three bodies, wearing friction surfaces of opposing teeth and foreign particles between them. In case of composite fillings the abrasive wear appears as abrasion of the soft polymer matrix exposing filler particles. The attrition is the effect of wear caused by the direct contact of the opposing teeth surfaces, thus the result of interaction of two bodies. During mating of two rough surfaces the micro-roughness contact occurs. If both body surfaces are hard and brittle at the same time, thus as a result of micro roughness contact they deform and fracture after exceeding a critical stress value. In case when the surface of one body has a higher hardness than the opposing surface, it can cause a fast wear by micro cutting

II. MATERIALS AND TEST METHOD

The materials chosen for the present study was ESPE 3M Z350 (micro filled) and Filtek Z250 (micro hybrid).

A. Sample preparation

The samples were prepared in plastic mould. The size of samples was 4 mm in diameter and 27 mm length. The flow able composites were inserted in the cavity. The quantity taken actually for the sample preparation was somewhat more than the cavity in order to ensure that the cavity was filled completely every time. The surfaces were covered with the glass slides to ensure the flatness of the specimen. Care any was taken to ensure that there will not be any air bubble in the specimens.

B. Curing

The specimens were cured using LED light torch for the time suggested by the manufacturer. The torch was held about 2 to 3 cm away from the specimen. The hardened specimens were then placed under water at room temperature for a week. After a week, they were taken out, dried with soft cotton cloth and placed in dry environment at room temperature.

C. Wear Tests

The wear test was carried on pin -on-disc machine shown in figure 1. The wear tester was Two Body Wear Tester .Before testing, the specimens were weighed on Precision Digital Balance machine (LWL Germany Make, Model: LB 210S, Least count of 0.0001gm). The values of load, speed and sliding distance were chosen as per the experimental procedure for the research work.

Fig. 1: Experimental set up of Pin on Disc machine

According to SHIQI HE, et at [4]. Wear is usually expressed as the amount of material removed from a surface such as weight loss or volume loss per unit sliding distance. Thus,

$$\text{Wear rate} = \frac{\textit{Weight loss}}{\textit{Sliding Distance}}$$

III. Result and Discussion

A. *Optimization of wear rate*

In order to optimize the wear rate, experiments were carried out on Pin on disc machine as per the L_9 orthogonal array and the methodology is presented below. Theoretically, the amount of wear rate is calculated and the results are reported.

ANOVA analysis is carried out to determine the influence of main factors and to determine the percentage contribution of each factor

S. No	Parameter	Unit	Level		
			Low	Medium	High
1	load	N	29.43	39.24	49.05
2	speed	Rpm	400	500	600
3	Sliding Distance	M	600	800	1000

Table 1: Details of parameters and their levels used in the experimentation

ANOVA analysis is extended to determine the influence of main factors on the wear rate of dental composites materials. The effects of main factors on temperature and surface hardness are given in Fig 2.and Fig 3.for 3M Z350 and Filtek Z250 respectively.

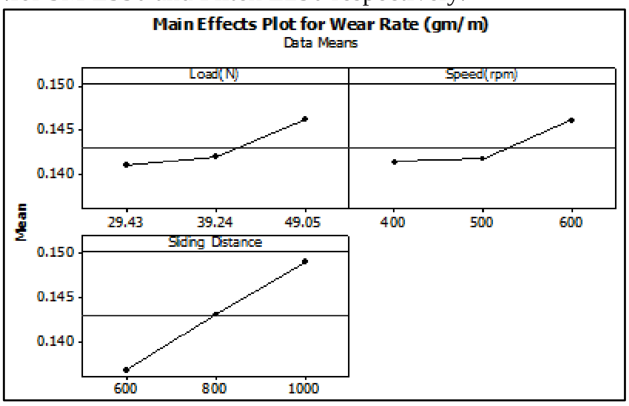

Fig. 2: Main effect plot for 3M Z350

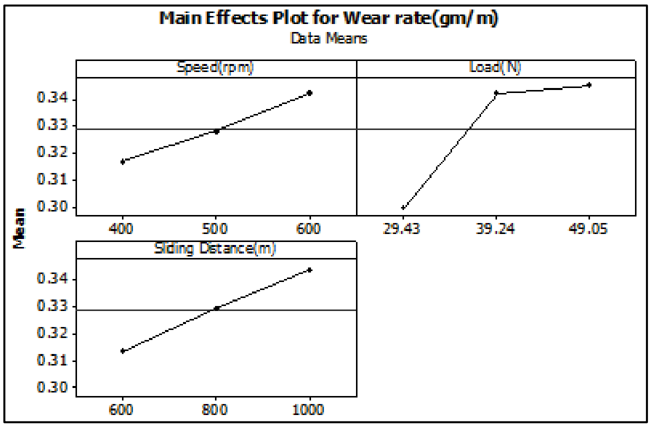

Fig. 3: Main effect plot for Filtek Z250

The optimum wear rate conditions obtained in the present work for various requirements are listed below;

1) *Low wear rate for 3M Z350*

Load 29.43N, Speed 400 rpm and sliding distance 600 m

2) *Low wear rate for Filtek Z250*

Load 29.43N, Speed 400 rpm and sliding distance 600 m

The confirmation test was carried out and it was validated. The minimum wear rate obtained for 3M Z250 is 0.1352 x 10^{-4} gm/m and for Filtek Z250 is 0.2612 x 10^{-4} gm/m.

B. *Regression Analysis*

Regression analysis gives the functional relationship between input parameters and output response.

Regression equation for wear rate of 3M Z350 as a function of load, speed and sliding distance is

Wear rate (gm/m) = 0.0966 + 0.000263 Load (N) + 0.000023 Speed (rpm) + 0.000031 Sliding Distance

Regression equation for wear rate of 3M Z350 as a function of load, speed and sliding distance

Wear rate (gm/m) = 0.115 + 0.00231 Load (N) + 0.000126 Speed (rpm) + 0.000075 Sliding Distance (m)

Comparison of experimental and predicted wear rate for 3M Z350 and Filtek Z250 is shown in fig 4 and Fig 5 respectively.

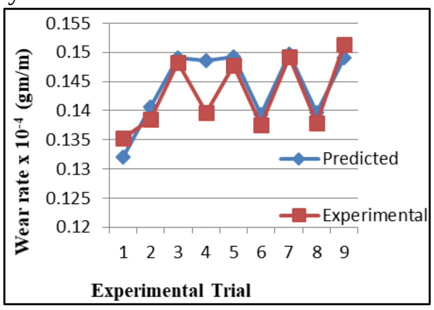

Fig. 4: Predicted VS. Experimental Wear rate 3M Z350

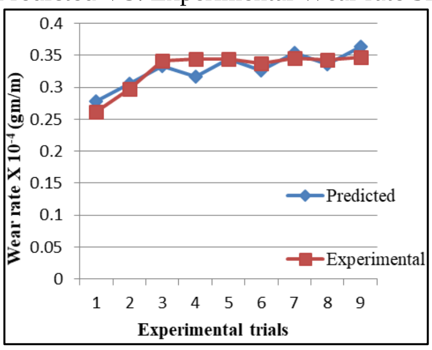

Fig. 5: Predicted VS. Experimental Wear rate Filtek Z250

IV. CONCLUSION

From the ANOVA results following conclusions can be made

- In this study the micro filled composites shows better wear resistance than the micro hybrid composites
- From the give study it is observed that load has maximum influence on wear rate while sliding distance has minimum influence on wear of dental composites materials
- From regression analysis it is observed that with increase in load, speed and sliding distance wear rate increases
- Optimum values for load, speed and sliding distance are 29.43 N, 400 rpm and 600 m respectively
- The optimum wear rate for 3M Z350 is less than Filtek Z350. Hence it is concluded that micro filled dental composites shows more wear resistance than micro hybrid composites.

REFERENCES

[1] Emmanuel Incau, Christine Couture, Bruno Maureille "Human tooth wear in the past and present: Tribological mechanisms, scoring systems, dental and skeletal compensations", Archives of oral Biology 57(2012) 214-229

[2] C. S. Ramesh, C. K. Srinivas, "Friction and wear behavior of laser-sintered iron carbide composites", Journal of materials Processing technology 209(2009) 5429-5436

[3] Ruili Wang, Maolin Zhang, Fengwei lui, "Investigation on the physical-Mechanical properties of dental resin composites reinforced with novel bimodal silica nano structures", Material Science and Engineering C50(2015) 266-273

[4] L. H. Mair "Wear in dentistry-current terminology", J. Dent. 1992;20:140-144

[5] Daniela S. Rodrigues, Mihaela Buciumeanu2, Antonio E. Martinelli,Rubens , M. Nascimento, Bruno Henrique "Mechanical Strength and Wear of Dental Glass-Ionomer and Resin Composites Affected by Porosity and Chemical Composition", J Bio Tribo Corros (2015) 1:24

[6] Muhammad Zakir, Abdul Aziz Abdullah Al Kheraif, Muhammad Asif, Ferranti See Leng Wong, Ihtesham Ur Rehman, "A comparison of the mechanical properties of a modified silorane based dental composite with those of commercially available composite material", Dental materials 29(2013) e53-e59

[7] A.Ramalho, P. Vale Antunes, "Reciprocating wear test of dental composites against human teeth and glass" Wear 263 (2007) 1095–1104

[8] Dr. Chaitali Umesh Hambire, Dr. Umesh Vishnu Hambire, Subodh Ashok Shirsath " Comparison and Optimization of Wear Rates of Two Types of Dental Composites On The Basis Of Micro Hardness" International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 3 Issue 10 ǁ October 2014 ǁ PP.01-05

