# Investigation Of Effect of Variables on The Wear Loss of Ceramic Composites Using Response Surface Methodology

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**Abstract: -** Fused silica ceramic composite with combinations of Boron nitride and Silicon nitride were fabricated using gel casting, a near net shape fabrication technique. Methyl acryl amide (MAM) and N, N1-methylene bis acryl amide (MBAM) were used as monomers. After successfully preparation of ceramics samples, wear behavior of samples is investigated on Pin-On-Disk Tribometer and wear loss is found at different parameters. A Mathematical model was developed to determine the effects of load, sliding distance and sliding speed on wear loss. The influence of the surface methodology using central composite face centered design with six center points. The optimal values form minimum wear loss and parameter shave been presented. Moreover, the Mathematical model has been modified using Artificial Immune System: Negative Network Selection algorithm in Matlab and the optimum input parameters along with the corresponding values of minimum wear loss have been studied. A validation test on Pin-On-Disc Tribometer has been carried out and the comparison between the theoretical responses and experimented responses, based on optimum input parameters of both RSM and Matlab, has been made as well as the errors between the have been presented.

**Key Words:** ***Ceramic composite, Tribometer, RSM, Wear Loss.***

## I. INTRODUCTION

The capability to find wear of any component is a general problem to successful development of unique materials into many technologies, from small scale to large scale. Nowadays as more and more new materials are introducing, all specification design requirement of these unique materials in required method to predict performance and increased life of material. However, wear prediction is involved and most literature models are created specifically for an application under many operating terms and conditions and for a limited type of materials, hence limited applicability toothier specific materials.

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The decrease in utilization of the model material for design purposes recommend a need to re check wear prediction methodology from a basic and very basic way. This paper explains a scientific evaluation of wear prediction on superior ceramics as an instance to summarize a possible put on prediction methodology. Superior ceramics possess a completely new combination of weight, unique hardness, and chemically inertness. As a result, they are usually used in wear resistant applications. Their brittle nature of shape makes a problem for capacity untimely catastrophic disasters. Current discipline fulfillment of ceramics in engines (water pump seals turbine, blade, disc brake cam roller lifters, and put on pads), industrial pumps, and seals have lightened a lot of those issues. Strength and inertness fatigue resistance for the substances have also increased drastically over the last decade. Wear existence prediction, therefore will become more important in presenting much wanted design hints for similarly utility of ceramics.

Wear is a complicated system feature. As such, wear of a fabric is depending on contact geometry, floor roughness, micro structural capabilities, grain sizes, fracture longevity, speed, load, temperature, length, surroundings, and lubrication. Most of the wear fashions generally tend to fall into classes: put on mechanism fashions for a particular system beneath a specific operating condition; and correlation fashions that use wear records over a variety of situations to set up the exponents of a strength law system. Attempts have been made to version put one of several materials over an extensive range of running conditions. This paper first explains the existing fashions after which prepared numerous models that may be applied correctly for a single fabric over precise running tiers as illustrated by using a put-on map. Gel casting is a ceramic forming method which offers many benefits as an opportunity to the greater traditional ceramic forming methods which includes dry pressing, slip casting, and injection molding. The procedure was advanced as an easy and cost-efficient method for generating complex-fashioned advanced ceramic components. Gel casting involves the dispersion of ceramic powders in a polymerizable aqueous solution [1].

Monomer solution to make fluid, cast able slurry which is used then gelled for meld. Result obtained is a very homogeneous cast body which shows a uniform chemical and density cross-section. Apparently, shrinkage during drying and uniform (minimizing distortion) and material properties are constant throughout the body. A large variety of ceramic materials have been prepared using the gel casting process. During the growth of the gel casting process for making new ceramic materials, one of the main observations in the characteristics of gel cast ceramic materials was for dried greeny bodies was exceptional strong, though they contained at least 3.5–5.5 wt.% of organic binder. This is believed to be due to the even distribution of the binder throughout the casting on the equal scale as the powder particles. Green body having high strength is of great benefit for using of the parts before firing and to produce in a large no of castings material. Experiments also explain that the green parts can be machined. Although gel casting was developed as a near-net-shape forming process [2].

## II. Related Work

The analysis introduces that the study the effect of wear parameters applied load investigation of effect on the wear loss of ceramic composites using response surface methodology. Ceramics are used for mechanical homes and electricity, sturdiness and hardness. Silicon nitride ceramics our industry has mostly requirement for that sort of material having light, solid in execution, erosion safe and ready to acting high temperature situation.

For other traditional processes, injection molding can produce complex shaped ceramic products but long binder removal time, size limitation and defects appearance are big problems which are hopefully solved. Slip casting can provide large size products but long forming the practical applications for high performance noteworthy functions which include high solid loading of the suspension, controllable casting and solidification through the usage of organic monomers, minimum drying and sintering shrinkage for ceramic our bodies from a dense suspension, and robust, machinable green bodies for greater complex shapes. Typically, this procedure is used to shape, near internet-form advanced ceramic materials inside the electronics, car, and protection industries. For $Si_3N_4$ however, it's far difficult to form dense structure due to gasoline-discharging reactions throughout the gel casting procedure, the low mass transmission and pyrolysis in the course of the sintering stage. However, from any other point of view gel casting is a good manner off a lubricating porous $Si_3N_4$ ceramics.

### 2.1 Applications of Gel Casting:

- Transparent sub micro meter grains alumina framed by gel casting utilizing a gar as gelling added substance.
- Profoundly porous gel-cast ceramics in medical applications.
- Permeable gel cast Ceramics for bone repair implants.
- Gel cast forming of non-oxide ceramics with reactive surfaces.
- Coordinate gel-casting of zirconia for dental application: gelation kinetic sand pyrolysis of organic additives.

Highly porous Gel-casting ceramics are used in medical applications.

- Transparent sub micro meter grains alumina is formed by gel casting using a gar as gelling.
- Porous Gel cast ceramics for Bone Repair Implants.
- Direct Gel-Casting of Zirconia for Dental Application.
- Gel-casting has also been successfully used in making highly porous ceramics by direct foaming techniques.
- Powder Injection Moulding (PIM) is a well-established forming technique for ceramics, particularly suited to the production of complex shapes.

Adhesive wear can be located between surfaces amid frictional contact and for the maximum element alludes to unwanted uprooting and connection of wear and tear misfortune and cloth mixes beginning with one surface then onto the next. Two separate additives work among the surfaces. Cement put on is often known as disturbing or scraping, in which interfacial cement intersections bolt together as two surfaces slide over every different underweight. Its miles put on misfortune because of constrained maintaining between attaining sturdy surfaces prompting cloth exchange between the two surfaces or misfortune from either surface.

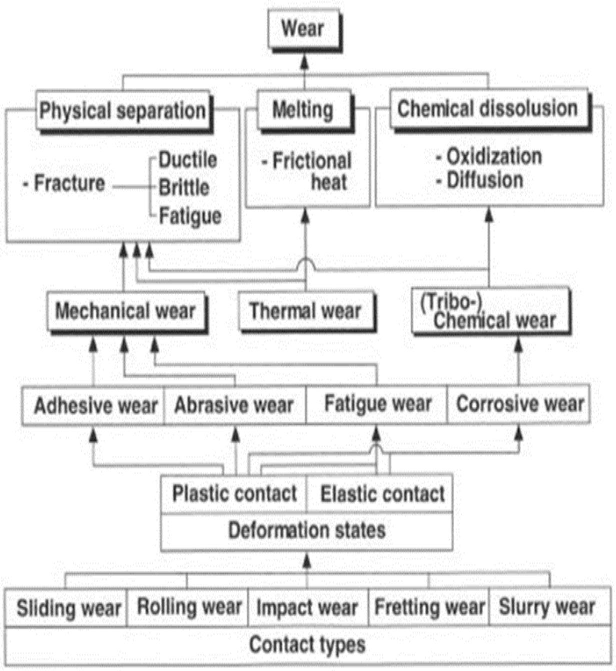


Fig.1. Classification of Wear

## III. Problem Statement

The flow chart of gel casting is shown in Fig. 1. Firstly, premix solution was prepared by mixing Darvan 821A dispersant (1 wt % of monomer content), PEG (surfactant), monomers MAM and MBAM (10-20 wt% of fused silica) in distilled water by magnetic stirring. After that required quantity of solid loading in vol % fused silica and stirred for about 6 hrs. The slurry was desired for 15-20 min and then the initiator Ammonium per sulfate APS (1 wt % of monomer content) is added for initiating polymerization. Finally, the slurry was cast into a glass mold and heated at7580$^{O}$C for1hfor polymerization to take place.1250$^{O}$C under nitrogen atmosphere.

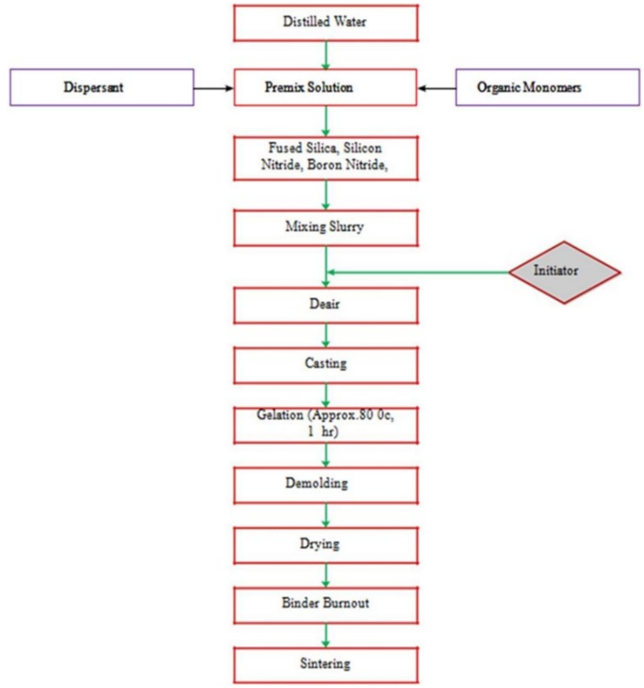


Fig.2. Flow chart for Gel Casting Process

The sample has to put in the electronic balance with utmost care and see that windows of the electronic balance are tightly closed so that air will not enter into it and readings will come accurately without any fluctuations. Every time while measuring weight the balance should be tarred, that is the digital display has to show zero reading so that there is no error in the final reading.

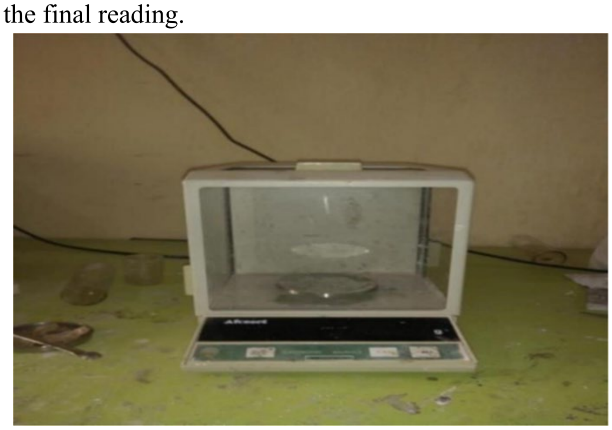

Fig.3. Weighing Machine

*Specifications:* Readability: 0.1 mg
Capacity: 200-220 g
Repeatability: 0.1mg
Pan Size: 80-100mm Diameter
Response Time: 4–5 Sec
Tare Range: Full

Operating Temperature: Room Temperature

### 3.1 Wear Test Experiment

*Tribometer:* A Tribometer is a device which is used to measures friction and wear on a product surface. A tribo-tester is the common name given for a machine or product used to do more than one check sand simulations of wear and tear of any cloth, friction and lubrication that is the issue of the look at of tribology. Even as tribo-testers are extraordinarily unique in his characteristic and are made by using producers who preference to check and examine the lengthy-time period overall performance of their merchandise Types of Tribometers:

- Four ball Pin-on-disc
- Block on ring
- Bouncing ball
- Twin disc

### 3.2 Pin-on-disc Tribometer

Normally there are two types of pins on disc machines. One type of system made of a driven chucks to hold for revolving disc, a lever-arm device for holding the pin, and attachment for allowing the pin against rotating disk specimen with a controlled load. Friction characteristics of pin contact on a rotating disc. The wear and friction tester are usually operated in dry conditions but could also be operated under lubricated conditions. Machine model-DD). IEICOS wear and friction tester made of a stationary stylus pin and a hardened rotating disc below it. The pin which is hold by a chuck is loaded against the rotating disc using a lever arrangement and the end of the lever is used with a loading arrangement using weight sand loading pan. Hence, the load of the pin on the disc can be varied by adding weights to the loading pan. The same is measured using the load cell provided in series with the loading pan and displayed on the axial force display. The instrument is also provided with an AC motor driven by an electric disc. The digital display is provided for indication of both speed and digital counter with are set button is provided for indication of Revolution counts. A frictional force sensor is also provided for measurement of frictional force of the pin on the rotating disc and the frictional force is indicated on the digital display for frictional force. A LVDT displacement sensor is provided to measure the wear in real-time and the wear of the pin is displayed on the digital display. Also, wear track diameter can be varied by moving the pin forward and backward using the bolts provided.

Pin on disc tribometer is shown below–

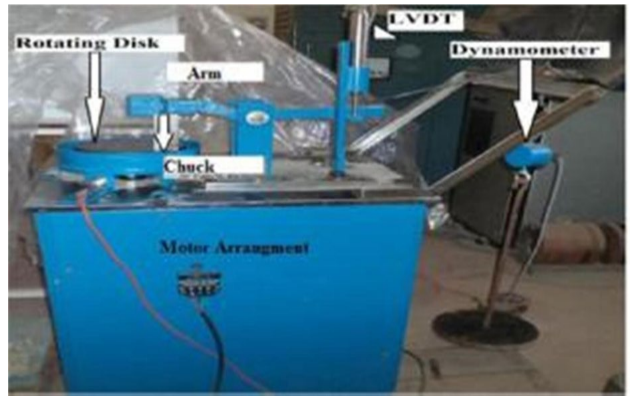


Fig.4. Pin-on-Disc Tribometer

Fig.5. Pin-on-disc Tribometer digital display unit

*Formulas for Calculating Wear Loss:*

Sliding speed (m/s) = (πDN)/60

Sliding Distance (m) =πD*number of rotations

where D =wear track diameter in m,

N=speed of disc in rpm

Wear weight loss (mg) = initial weight-final weight

### 3.3 Input and Output Value of the Proposed Work

Table.1. Inputs and Outputs of the Proposed Work

| **Inputs** | **Outputs** |
|---|---|
| Wear samples by gel casting | Actual wear loss by experiment |
| Sliding speed | Optimization of wear loss by RSM |
| Sliding distance | % Contribution of each input on wear loss by ANOVA |
| Applied load | Confirmation test for optimum value of parameters |

| LOAD (N) | SLIDING DISTANCE (m) | SLIDING SPEED (m/s) | WEAR LOSS-1 (g) | WEAR LOSS-2 (g) | WEAR LOSS-3 (g) | WEAR LOSS-4 (g) | StdOrder | RunOrder | Blocks | PtType |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 600 | 3 | 0.0023 | 0.00235 | 0.00226 | 0.00229 | 1 | 1 | 1 | 1 |
| 5 | 600 | 1 | 0.0018 | 0.00182 | 0.00176 | 0.00179 | 2 | 2 | 1 | 1 |
| 15 | 900 | 2 | 0.014 | 0.0138 | 0.0141 | 0.0147 | 3 | 3 | 1 | 1 |
| 15 | 600 | 1 | 0.009 | 0.0086 | 0.0089 | 0.0093 | 4 | 4 | 1 | 1 |
| 10 | 900 | 3 | 0.0067 | 0.0062 | 0.0068 | 0.0064 | 5 | 5 | 1 | 1 |
| 15 | 600 | 3 | 0.016 | 0.0157 | 0.0154 | 0.0161 | 6 | 6 | 1 | 1 |
| 5 | 900 | 2 | 0.0024 | 0.00237 | 0.00242 | 0.00239 | 7 | 7 | 1 | 1 |
| 5 | 1200 | 1 | 0.00256 | 0.0026 | 0.00257 | 0.00261 | 8 | 8 | 1 | 1 |
| 15 | 1200 | 3 | 0.029 | 0.0281 | 0.0283 | 0.0292 | 9 | 9 | 1 | 1 |
| 15 | 1200 | 1 | 0.0121 | 0.0129 | 0.0127 | 0.0123 | 10 | 10 | 1 | 1 |
| 10 | 900 | 2 | 0.0051 | 0.0055 | 0.0049 | 0.0054 | 11 | 11 | 1 | 1 |
| 10 | 900 | 2 | 0.0049 | 0.0052 | 0.005 | 0.0055 | 12 | 12 | 1 | 1 |
| 10 | 900 | 2 | 0.00485 | 0.0048 | 0.00489 | 0.00481 | 13 | 13 | 1 | 1 |
| 5 | 1200 | 3 | 0.0028 | 0.00278 | 0.00281 | 0.00285 | 14 | 14 | 1 | 1 |
| 10 | 600 | 2 | 0.00415 | 0.0042 | 0.00396 | 0.00416 | 15 | 15 | 1 | 1 |
| 10 | 900 | 2 | 0.005 | 0.00497 | 0.00515 | 0.00506 | 16 | 16 | 1 | 1 |
| 10 | 900 | 2 | 0.00522 | 0.00527 | 0.00497 | 0.00516 | 17 | 17 | 1 | 1 |
| 10 | 1200 | 2 | 0.0061 | 0.00616 | 0.00619 | 0.00598 | 18 | 18 | 1 | 1 |
| 10 | 900 | 1 | 0.0042 | 0.00418 | 0.00412 | 0.00425 | 19 | 19 | 1 | 1 |
| 10 | 900 | 2 | 0.00515 | 0.00519 | 0.0052 | 0.00524 | 20 | 20 | 1 | 1 |

Fig.6. Creation of RSM Table in Minitab

## IV. RESULTS

### *4.1 Initial Results*

*4.1.1 Response Surface Regression: Wear Loss-1(g) v/s Load (N), Sliding Distance (m) and Sliding Speed (m/s)*

Table.2. Coded Coefficients

| Source | DF | AdjSS | AdjMS | F-Value | P-Value |
|---|---|---|---|---|---|
| Model | 9 | 0.000768 | 0.000085 | 36.28 | 0.0002 |
| Linear | 3 | 0.000577 | 0.000192 | 81.74 | 0.0003 |
| LOAD (N) | 1 | 0.000466 | 0.000466 | 198.04 | 0.0033 |
| SLIDING DISTANCE (m) | 1 | 0.000037 | 0.000037 | 15.86 | 0.003 |
| SLIDING SPEED (m/s) | 1 | 0.000074 | 0.000074 | 31.32 | 0.0001 |
| Square | 3 | 0.000085 | 0.000028 | 12.03 | 0.0021 |
| LOAD (N)*LOAD (N) | 1 | 0.000032 | 0.000032 | 13.79 | 0.004 |
| SLIDING DISTANCE (m)*SLIDING DISTANCE (m) | 1 | 0.000000 | 0.000000 | 0.15 | 0.706 |
| SLIDING SPEED (m/s) * SLIDING SPEED (m/s) | 1 | 0.000001 | 0.000001 | 0.55 | 0.477 |
| 2-Way Interaction | 3 | 0.000106 | 0.000035 | 15.05 | 0.0032 |
| LOAD (N)* SLIDING DISTANCE (m) | 1 | 0.000028 | 0.000028 | 11.71 | 0.007 |
| LOAD (N)* SLIDING SPEED (m/s) | 1 | 0.000067 | 0.000067 | 28.51 | 0.0001 |
| SLIDING DISTANCE (m) * SLIDING SPEED (m/s) | 1 | 0.000012 | 0.000012 | 4.94 | 0.050 |
| Error | 10 | 0.000024 | 0.000002 | | |
| Lack-of-Fit | 5 | 0.000023 | 0.000005 | 222.24 | 0.00001 |
| Pure Error | 5 | 0.000000 | 0.000000 | | |
| Total | 19 | 0.000791 | | | |

*Regression Equation in Uncoded Units*

WEAR LOSS-1(g) = 0.02970 -0.003653LOAD(N) - 0.000021 SLIDING DISTANCE (m)
-0.00943 SLIDING SPEED (m/s) +0.000137LOAD (N)* LOAD (N)
+0.000000 SLIDING DISTANCE (m)* SLIDING DISTANCE (m)
+0.000684 SLIDING SPEED (m/s) * SLIDING SPEED (m/s)
+0.000001 LOAD (N)* SLIDING DISTANCE (m)
+0.000579 LOAD (N)* SLIDING SPEED (m/s)
+0.000004 SLIDING DISTANCE (m)* SLIDING SPEED (m/s)

*4.1.2 Response Surface Regression: Wear Loss 2 (g) v/s Load (N), Sliding Distance (m) and Sliding Speed (m/s)*

Table.3. Analysis of Variance

| Source | DF | AdjSS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Model | 9 | 0.000729 | 0.000081 | 39.52 | 0.0002 |
| Linear | 3 | 0.000553 | 0.000184 | 90.06 | 0.0008 |
| LOAD(N) | 1 | 0.000451 | 0.000451 | 220.33 | 0.0006 |
| SLIDING DISTANCE (m) | 1 | 0.000039 | 0.000039 | 19.27 | 0.001 |
| SLIDING SPEED(m/s) | 1 | 0.000063 | 0.000063 | 30.58 | 0.0002 |
| Square | 3 | 0.000079 | 0.000026 | 12.92 | 0.001 |
| LOAD (N)*LOAD (N) | 1 | 0.000031 | 0.000031 | 15.25 | 0.003 |
| SLIDING DISTANCE (m)*SLIDING DISTANCE(m) | 1 | 0.000001 | 0.000001 | 0.29 | 0.601 |
| SLIDING SPEED (m/s)*SLIDING SPEED (m/s) | 1 | 0.000001 | 0.000001 | 0.30 | 0.594 |
| 2-Way Interaction | 3 | 0.000096 | 0.000032 | 15.58 | 0.0006 |
| LOAD (N)* SLIDING DISTANCE (m) | 1 | 0.000030 | 0.000030 | 14.64 | 0.003 |
| LOAD (N)* SLIDING SPEED (m/s) | 1 | 0.000058 | 0.000058 | 28.44 | 0.0003 |
| SLIDING DISTANCE (m)*SLIDING SPEED(m/s) | 1 | 0.000008 | 0.000008 | 3.67 | 0.085 |
| Error | 10 | 0.000020 | 0.000002 | | |
| Lack-of-Fit | 5 | 0.000020 | 0.000004 | 68.26 | 0.0001 |
| Pure Error | 5 | 0.000000 | 0.000000 | | |
| Total | 19 | 0.000749 | | | |

| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 0.0014312 | 97.27% | 94.80% | 68.73% |

Table.4. Model Summary

| Term | Coef | SECoef | T-Value | P-Value | VIF |
|---|---|---|---|---|---|
| Constant | 0.004979 | 0.000492 | 10.12 | 0.0002 | |
| | 0.006718 | 0.000453 | 14.84 | 0.0006 | 1.00 |
| SLIDING DISTANCE (m) | 0.001987 | 0.000453 | 4.39 | 0.001 | 1.00 |
| SLIDING SPEED (m/s) | 0.002503 | 0.000453 | 5.53 | 0.0002 | 1.00 |
| LOAD (N) * LOAD (N) | 0.003370 | 0.000863 | 3.91 | 0.003 | 1.82 |
| SLIDING DISTANCE (m)* SLIDING DISTANCE (m) | 0.000465 | 0.000863 | 0.54 | 0.601 | 1.82 |
| SLIDING SPEED (m/s) * SLIDING SPEED (m/s) | 0.000475 | 0.000863 | 0.55 | 0.594 | 1.82 |
| LOAD (N) * SLIDING DISTANCE(m) | 0.001936 | 0.000506 | 3.83 | 0.003 | 1.00 |
| LOAD (N) * SLIDING SPEED (m/s) | 0.002699 | 0.000506 | 5.33 | 0.0003 | 1.00 |
| SLIDING DISTANCE (m)* SLIDING SPEED (m/s) | 0.000969 | 0.000506 | 1.91 | 0.085 | 1.00 |

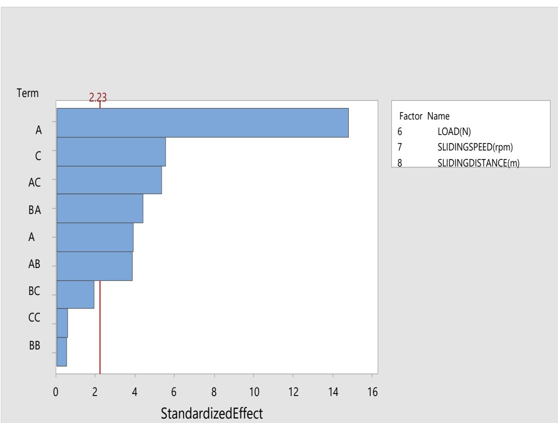


Fig.7. Effects Pareto for WEAR LOSS-2(g)

From Pareto Chart it is cleared that the interaction effects BB, CC and BC are insignificant factor interactions, hence they can be removed from the regression equation based on their P-values as found in ANNOVA table (the factors or factor interactions terms whose P-value is greater than or equal to 0.05 can be removed from regression equation to get a better fit).

*4.1.3 Optimum Value of Factor sand Analysis of Effect of Input Parameters on Wear Loss for all samples by RSM*

*Response Surface Regression:* Wear Loss 1(g) v/s Load (N), Sliding Distance (m) and Sliding Speed (m/s).

Table.5. Model Summary

| Source | DF | AdjSS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Model | 6 | 0.000754 | 0.000126 | 43.39 | 0.0007 |
| Linear | 3 | 0.000577 | 0.000192 | 66.41 | 0.0002 |
| LOAD (N) | 1 | 0.000466 | 0.000466 | 160.89 | 0.0004 |
| SLIDING DISTANCE (m) | 1 | 0.000037 | 0.000037 | 12.88 | 0.003 |
| SLIDING SPEED (m/s) | 1 | 0.000074 | 0.000074 | 25.45 | 0.0004 |
| Square | 1 | 0.000082 | 0.000082 | 28.46 | 0.0002 |
| LOAD (N)*LOAD (N) | 1 | 0.000082 | 0.000082 | 28.46 | 0.0003 |
| 2-Way Interaction | 2 | 0.000095 | 0.000047 | 16.34 | 0.0003 |
| LOAD (N)* SLIDING DISTANCE (m) | 1 | 0.000028 | 0.000028 | 9.51 | 0.009 |
| LOAD (N)* SLIDING SPEED (m/s) | 1 | 0.000067 | 0.000067 | 23.17 | 0.0001 |
| Error | 13 | 0.000038 | 0.000003 | | |
| Lack-of-Fit | 8 | 0.000038 | 0.000005 | 222.63 | 0.0001 |
| Pure Error | 5 | 0.000000 | 0.000000 | | |
| Total | 19 | 0.000791 | | | |

| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 0.0017013 | 95.24% | 93.05% | 89.99% |

Table.6. Coded Coefficients

| Term | Coef | SECoef | T-Value | P-Value | VIF |
|---|---|---|---|---|---|
| Constant | 0.005137 | 0.000538 | 9.55 | 0.0007 | |
| LOAD (N) | 0.006824 | 0.000538 | 12.68 | 0.0004 | 1.00 |
| SLIDING DISTANCE (m) | 0.001931 | 0.000538 | 3.59 | 0.003 | 1.00 |
| SLIDING SPEED(m/s) | 0.002714 | 0.000538 | 5.04 | 0.0004 | 1.00 |
| LOAD (N)* LOAD (N) | 0.004059 | 0.000761 | 5.33 | 0.0003 | 1.00 |
| LOAD (N) * SLIDING DISTANCE (m) | 0.001855 | 0.000601 | 3.08 | 0.009 | 1.00 |
| LOAD (N)* SLIDING SPEED (m/s) | 0.002895 | 0.000601 | 4.81 | 0.0001 | 1.00 |

*Regression Equation in Uncoded Units*

WEAR LOSS-1(g) = 0.01921-0.004153 LOAD (N) - 0.000006 SLIDING DISTANCE(m)
-0.00308 SLIDING SPEED (m/s) +0.000162 LOAD (N)*LOAD (N)
+0.000001 LOAD (N)* SLIDING DISTANCE (m)
+0.000579 LOAD(N)* SLIDING SPEED (m/s)

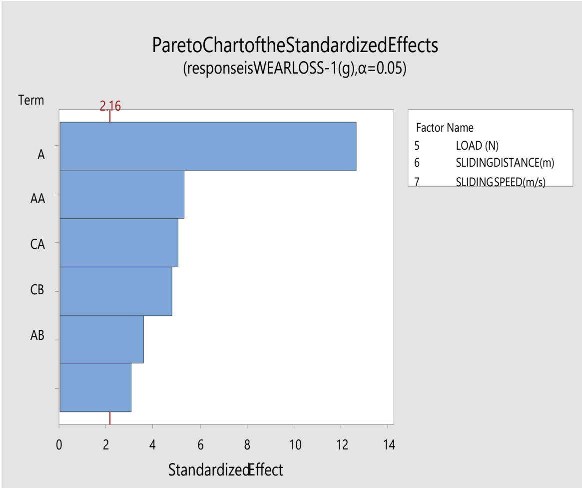


Fig.8. Effects Pareto for WEAR LOSS-1 (g)

Effects of factors and factor interaction terms can be inferred from the Pareto Chart given above. It is clear that factor A (load) is highly significant factor and factor (sliding distance) is least significant factor among all the factors, on the other hand, interaction A A(load*load) is highly significant interaction term and interaction AB (load sliding distance) is least significant interaction term among all the interaction terms.

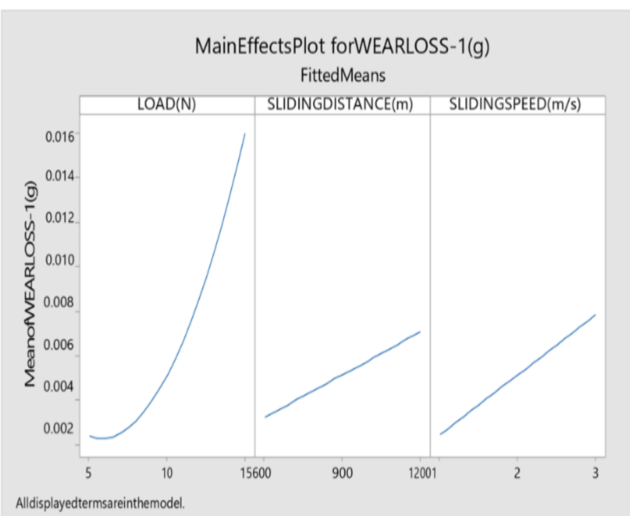


Fig.9. Main effects Plot for WEAR LOSS-1(g)

Levels of all the main effects are shown in the Main Effect Plot for Wear Loss-1 (g). Main effects in decreasing order of their significance are A (load), C (sliding speed) and B (sliding distance).

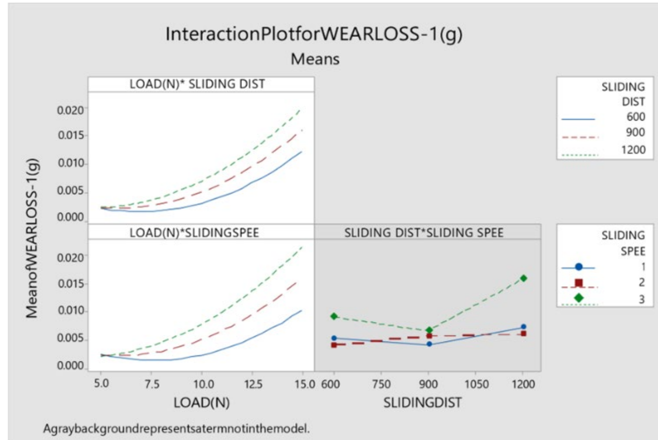


Fig.10. Interaction Plot for WEAR LOSS-1(g)

From the interaction plot for Wear Loss-1 (g), it can be concluded that the interaction effects BB (sliding distance * sliding distance), CC (sliding speed* sliding speed) and BC sliding distance * sliding speed) are the least significant interaction effects.

Response Surface Regression: Wear Loss-2(g) v/s Load (N), Sliding Distance (m) and Sliding Speed (m/s).

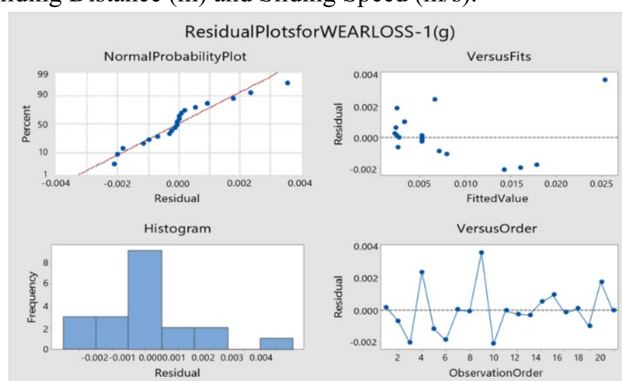


Fig.11. Residual plots for Wear Loss-1 (four-in-one)

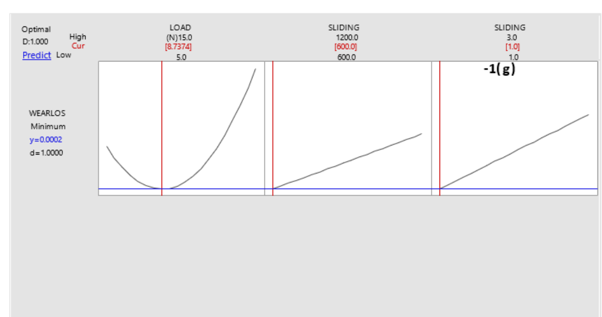


Fig.12. Response optimization using RSM for Wear Loss

Table.8. Comparison of MSE and MAPE for Experimental Data and RSM

| S.No. | Samples | Mean Square Error (MSE) | Mean Absolute Percentage Error (MAPE) |
|---|---|---|---|
| 1. | Sample-1 | 1.88E-06 | 13.23739% |
| 2. | Sample-2 | 1.5E-06 | 12.9984% |

## V. Conclusions

- Ceramics composite samples having different composition were successfully prepared by gel casting method.
- Wear behaviour of ceramics composite was investigated by pin on disc Tribo meter.
- Optimization and prediction of wear loss by using Response Surface Methodology and ANOVA along with Matlab Tool.
- Load is most significant and sliding distance is least significant factor among all the factors for Wear Loss-1.
- Load is most significant and sliding distance is least significant factor among all the factors for Wear Loss-1.
- For the optimized regression equation of the experimental data through RSM.
- Optimum Input parameters for Wear Loss-1, by Matlab are Load=8.4105N, Sliding Distance = 639.3328 m, Sliding Speed=1.2862m/s, and the Minimum wear loss is 0.0002109(g).
- Optimum Input parameters for Wear Loss-1, by Matlab are Load=9.1684N, Sliding Distance =672.6634m, Sliding Speed=1.3122m/s, and the minimum wear loss is 0.0004296(g).

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