INVESTIGATION OF THE EFFECT OF TITANIUM NANO PARTICLES ADDITIVES IN PHOSPHOR BRONZE COMPOSITE FOR WEAR APPLICATIONS

Mr Gubbala P Satish [a] Dr V.V.S Prasad [b] Pilla Chaitanya Sai Kumar[c]

Gubbala P Satish, Pilla Chaitanya Sai Kumar in Marine Engineering Department, Andhra University, Visakhapatnam, INDIA

Dr V.V.S Prasad

Professor in Marine Engineering Department Andhra University, Visakhapatnam INDIA

ABSTRACT

An investigation was carried out to assess the mechanical properties of phosphor bronze composite with addition of titanium nano particles. Phosphorous bronze composite main application is used to manufactured sleeve bearings and cam followers. The main objective of this paper is to study the effect of Titanium nano particles which improved strength and wear resistance. In this study, a series of mechanical experiments is done on casted phosphor bronze with blended titanium nano particles with varying percentage of compositions in nano titanium. The strength, hardness, Impact and wear properties are compared among them by varying titanium nano Particles.

KEY WORDS: Nano Titanium, phosphor Bronze, Wear Resistance, Radio frequency (RF) induction coupled plasma technique

1. INTRODUCTION

Phosphor bronze materials are generally used in bearings, bolts, springs and other components of machinery. Phosphor bronze possess good castability and machinability. It is mainly used to improve the wear resistance and cleanliness of casting. So that the strength and ductility of the materials are improved [1].

In phosphor bronze, generally copper is taken as a virgin material. Because of its high thermal and electrical conductivity. Copper composite s attain their corrosion resistance by the formation protective surface films [4]. Tin is one of the materials in phosphor bronze which is used for increasing the corrosion resistance and strength of the material and also marine application. Phosphorous is used to reducing the viscosity of the molten metal and cleaner to cast. The properties of the composite depend on melting and casting conditions that influences the composite recrystallization [1].

In this study, the effect of mechanical properties by increasing the weight of the titanium nano particles in the phosphor bronze composite .

1.1 TITANIUM NANOMATERIALS

Nano materials or nano particles are manufactured by using RF based induction coupled plasma technique. Radio frequency (RF) induction coupled plasma technique is used for manufacture of titanium nano particles.

This technique is adopted because of its feasibility among various RF Plasma techniques. [7] From this Technique the purity of 98% titanium nano powder is obtained and the average size is between 50-80 nm. Nano titanium was procured from matrix nano and its SEM, XRD, EDS Results are shown below.

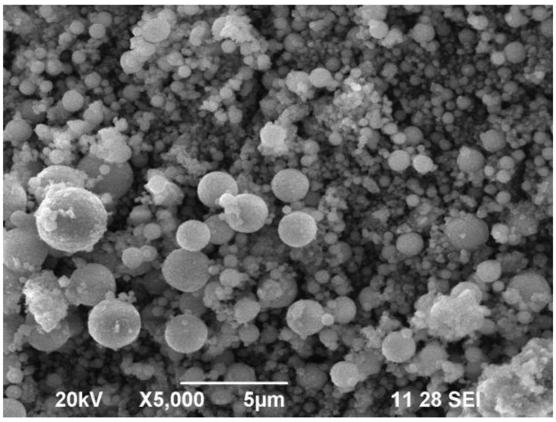
NANO TITANIUM

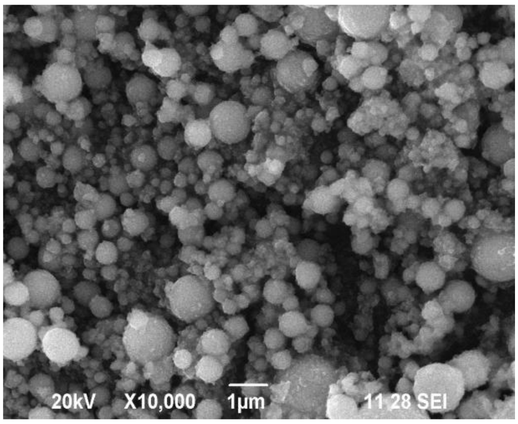
Nano Titanium has a high strength material and low specific weight with a density of 4.503g/cm^3. It has a high boiling point of 3287^{0}C. Titanium has highly resistant to corrosion. Aerospace materials, Micro sensors, Nanofibers, Optical filters are the main applications of the nano titanium particles. The results show for the nano TiO_2 has increase in the tensile strength, thermal resistance and mechanical properties [8]. Hence we adopted the Nano Titanium particles for our work.

NANO TITANIUM PARTICLES OF VARIOUS COMPOSITIONS OF 1.0, 1.5, 2.0, 2.5 GRAMS (1.1.1)

1.2 NANO TITANIUM

Scanning Electron Microscopy Imaging (SEM)



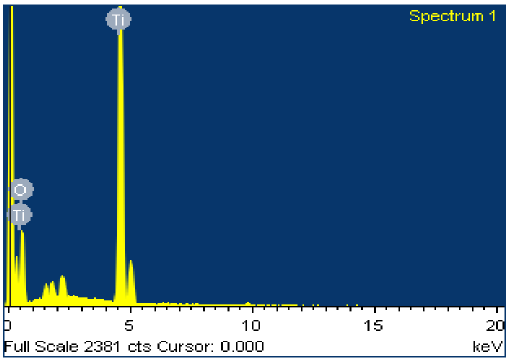


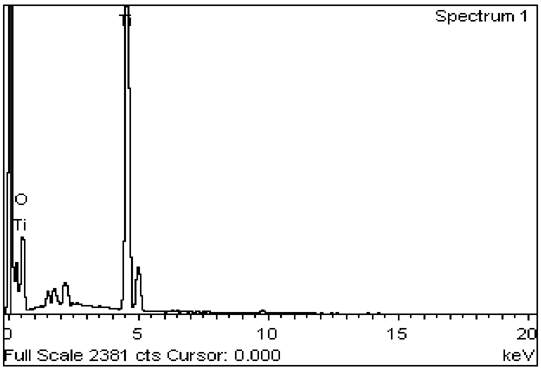
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

1.3 X – Ray Diffraction (XRD)

Spectrum processing: Peaks possibly omitted: 1.496, 1.757, 2.168, 9.750 keV
Processing option: All elements analysed (Normalised)
Number of iterations = 4

Element	App.Conc	Intensity Conc	Weight percentage	Weight Sigma percentage	Atomic Percentage
OK	**10.45**	**0.3596**	**53.03**	**1.28**	**77.17**
Ti	**87.42**	**0.8937**	**46.97**	**1.28**	**22.83**





2. SCOPE OF THE WORK

In the above literature we found out that the phosphor bronze is good corrosion resistance and strength composite . The significance of the phosphorus enhance the stiffness and wear resistance of the composite . These composite s are also found to be high in toughness, strength and low coefficient of friction with fine grain structure. In this work, we want to reinforce the original phosphor bronze with titanium nano particles to enhance its mechanical properties and study the wear, impact, strength (Tensile) and hardness of the values of it. Testing it with appropriate machinery to find out its effect.

TESTING MACHINERY	**MODEL NUMBER**
Universal Testing machine	UTE-20
Wear Testing Machine	En 31 Hardened to 61 HRC
Pendulum Impact Charpy Testing Machine	IT 30
Rockwell Hardness Machine	RAB 250

Its main applications are good wear resistant bearing, ship propellers, some dental bridges, abrasive prone areas.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

3. MATERIALS AND PREPARATION

3..1 CASTING TECHNIQUE

Open Hearth Liquefied Casting Technique is used in this paper and it is continuously stirred in order to avoid agglomeration of Nano particles in Phosphorus Bronze and materials are sand casted as per ASTM Standards employed for producing the final product. The temperature of $1660^{0}C$ is needed to produce liquified composite (copper, tin, phosphorous and titanium). During heating, molten metal was stirred by a stirrer for proper dispersion of titanium to the phosphor bronze materials. This process was done in four times for four different samples of materials and separate crucibles were maintained for each of them.

(a)moulds (b)open hearth furnace (c)molten metal (d) solidified metal (e)final product

CASTING PROCESS (FIG 3.1.1)

3.2 PREPARATION OF SPECIMEN

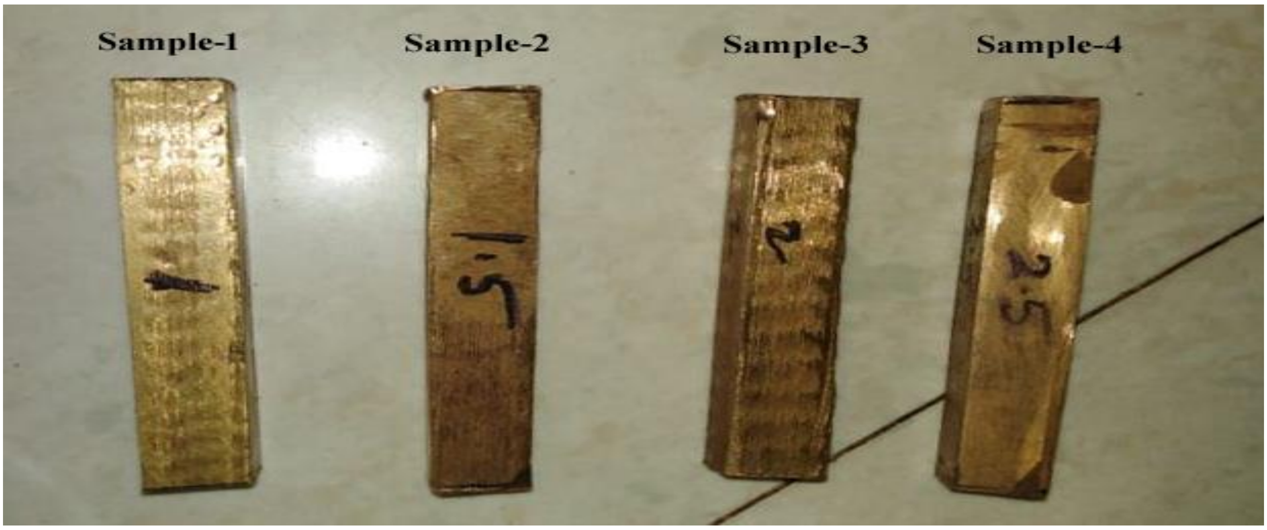
After casting, the tensile test specimen was machined by using lathe machine and impact specimen was made by using horizontal shaping machine. Finishing work was done by using sand paper, grinding and Buffing as per the tolerances of ASTM Standards.

3.3 COMPOSITION

We had prepared four samples: -

Materials	**Sample-1**	**Sample-2**	**Sample-3**	**Sample-4**
Copper	93.80%(575g)	93.72%(575g)	93.648%(575g)	93.57%(575g)
Tin	5.546% (34g)	5.542% (34g)	5.5374% (34g)	5.5329% (34g)
Phosphorous	0.4894% (3g)	0.4889% (3g)	0.4885% (3g)	0.4882% (3g)
Titanium	0.163% (1g)	0.244% (1.5g)	0.3257% (2g)	0.4068% (2.5g)

Table: 1 Percentage Of Cu, Sn, p, and Ti

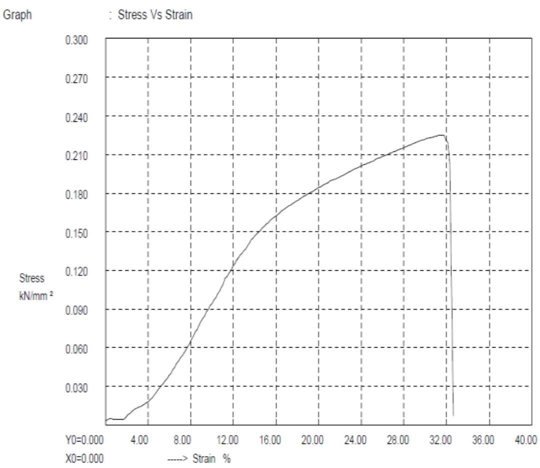


TYPES OF SAMPLES (3.3.1)

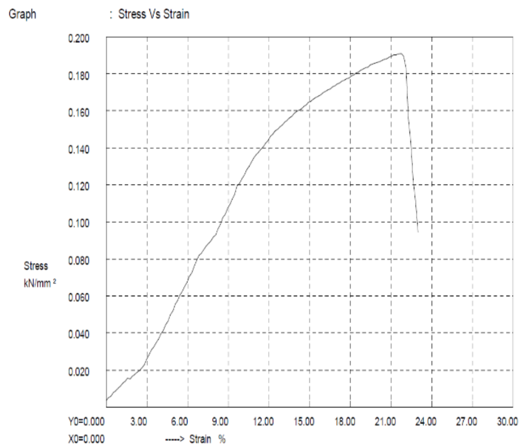
4. EXPERIMENTATION, RESULTS AND DISCUSSIONS:

4.1 UNIVERSAL TESTING MACHINE (UTM):

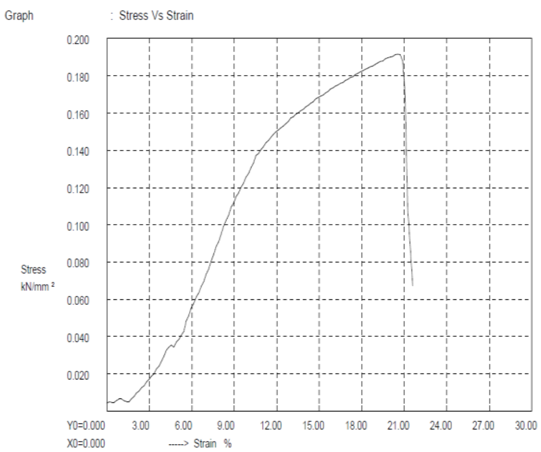
TENSILE SPECIMENS (FIG 4.1.1)



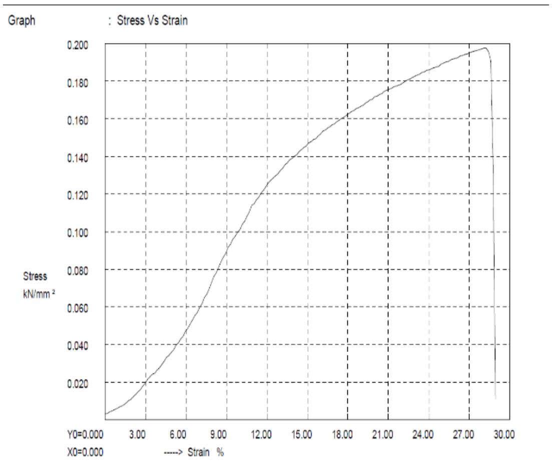
NANO TITANIUM 1.0 (FIG 4.1.2)



NANO TITANIUM 1.5 (FIG 4.1.3)



NANO TITANIUM 2.0 (FIG 4.1.4)



NANO TITANIUM 2.5 (FIG 4.1.5)

TITANIUM (1.0)	TITANIUM (1.5)	TITANIUM (2.0)	TITANIUM (2.5)
Maximum Force (Fm) : 29.950 kN	Maximum Force (Fm) : 25.370 kN	Maximum Force (Fm) : 25.440 kN	Maximum Force (Fm) : 26.230 kN
Disp. at Fm : 18.000 mm	Disp. at Fm : 12.400 mm	Disp. at Fm : 11.700 mm	Disp. at Fm : 16.000 mm
Max. Disp. : 18.600 mm	Max. Disp. : 13.100 mm	Max. Disp. : 12.200 mm	Max. Disp. : 16.500 mm
Tensile Strength (Rm) : 0.226 kN/mm ²	Tensile Strength (Rm) : 0.191 kN/mm ²	Tensile Strength (Rm) : 0.192 kN/mm ²	Tensile Strength (Rm) : 0.198 kN/mm ²
Elongation : 36.842 %	Elongation : 22.982 %	Elongation : 21.228 %	Elongation : 28.772 %
Reduction in Area (Z) : 14.793 %	Reduction in Area (Z) : 16.207 %	Reduction in Area (Z) : 16.207 %	Reduction in Area (Z) : 3.053 %
Yield Load : 20.500 kN	Yield Load : 20.430 kN	Yield Load : 18.840 kN	Yield Load : 14.670 kN
Yield Stress : 0.154 kN/mm ²	Yield Stress : 0.154 kN/mm ²	Yield Stress : 0.142 kN/mm ²	Yield Stress : 0.110 kN/mm ²
YS/UTS Ratio : 0.684	YS/UTS Ratio : 0.805	YS/UTS Ratio : 0.741	YS/UTS Ratio : 0.559
Initial Diameter : 13 mm	Initial Diameter : 13 mm	Initial Diameter : 13 mm	Initial Diameter : 13 mm
Final Dia : 12 mm	Final Dia : 11.9 mm	Final Dia : 11.9 mm	Final Dia : 12.8 mm
Initial Gauge Length : 57 mm	Initial Gauge Length : 57 mm	Initial Gauge Length : 57 mm	Initial Gauge Length : 57 mm
Final Gauge Length: 78 mm	Final Gauge Length: 70.1 mm	Final Gauge Length: 69.1 mm	Final Gauge Length: 73.4 mm

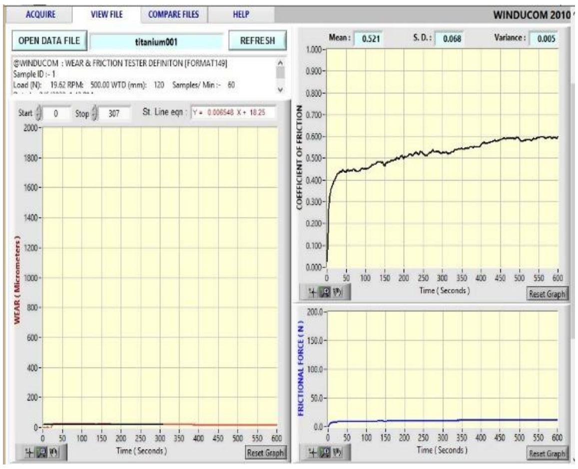
Table: 2 Comparison of four Nano Titanium Samples

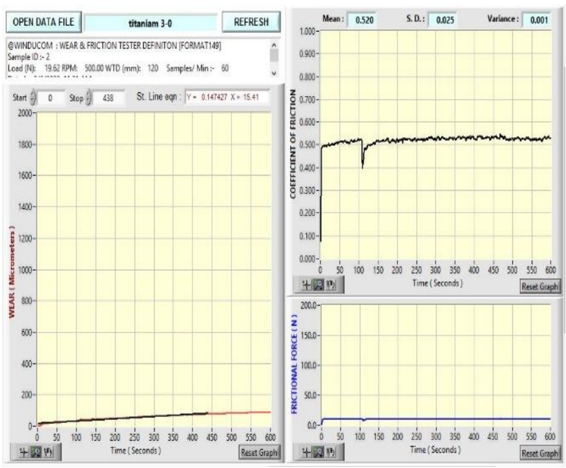
- From the comparisons among four compositions, the highest tensile strength of 226 Mpa for 1.0 gram of nano titanium.
- Lowest tensile strength is obtained for 1.5 grams of nano titanium is 191 Mpa.

- The specimen standard is ASTM D638-02a.

4.2 WEAR TEST:

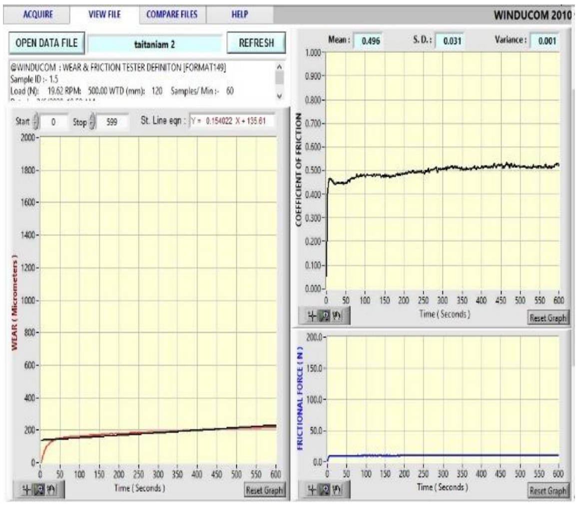
WEAR SPECIMEN (FIG 4.2.1)



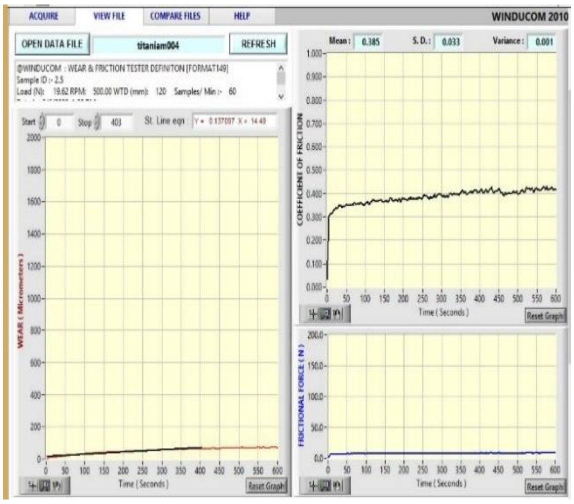


NANO TITANIUM 1.0 (FIG 4.2.2)

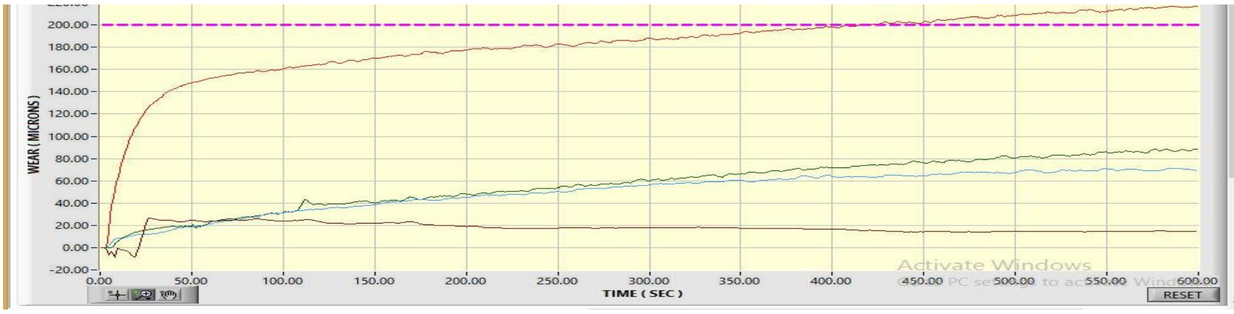
NANO TITANIUM 2.0 (FIG 4.2.3)



NANO TITANIUM 1.5 (FIG 4.2.4)



NANO TITANIUM 2.5 (FIG 4.2.5)



COMPARISION OF NANNO TITANIUM 1, 1.5, 2, 2.5 SAMPLES (FIG 4.2.6)

- From the comparisons among four compositions, the highest wear rate of 217 m^3/m for 1.5 gram of nano titanium.
- Lowest wear rate is obtained for 1.0 grams of nano titanium is 45 m^3/m
- The specimen used for wear test is 12mm dia and 40mm length.
- For to perform the wear test, The following parameters are kept constant

  Load – 2kg

  Samples/min- 60

  Speed- 500 RPM

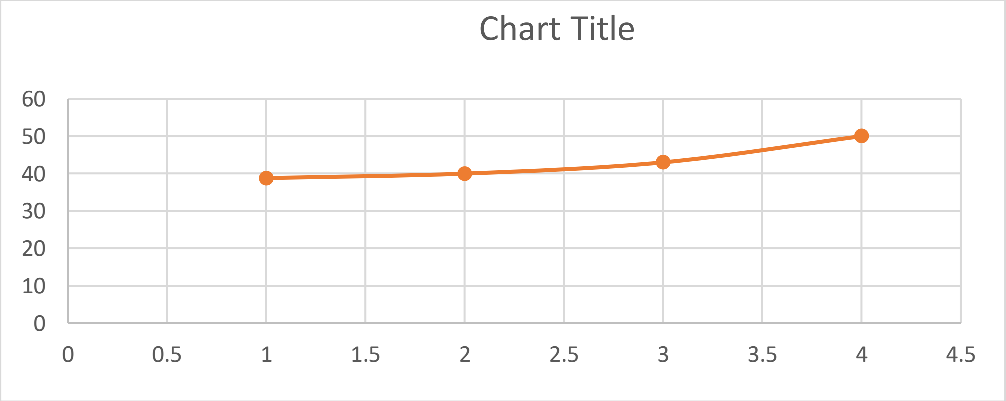
  Track Día – 120mm

  Time – 10min

And these are all performed on Disc Type Material EN 31 Hardened to 60HRC.

4.3 CHARPY IMPACT TEST:

IMPACT SPECIMENS (FIG 4.3.1)



Graph: Composition vs Impact

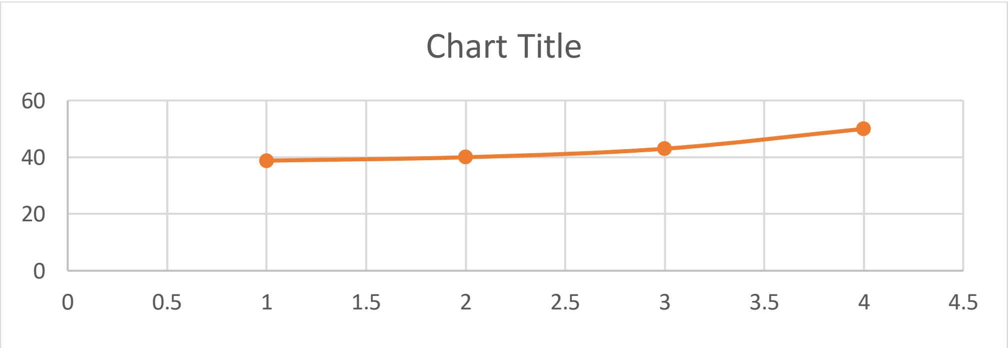
Titanium1	Titanium 1.5	Titanium 2	Titanium 2.5
Impact load: 24 J	Impact load: 12 J	Impact load: 11 J	Impact load: 9 J

Table: 3 Impact Loads of Nano Titanium Samples

- From the comparisons among four compositions, the highest impact energy of 24 J for 1.0 gram of nano titanium.
- Lowest impact strength is obtained for 2.5 grams of nano titanium is 9 J.
- The specimen used for impact strength is 9mm width, 9mm thickness and 55mm length.

4.4 ROCKWELL HARDNESS TEST ("B" SCALE):

FIG 4.4.1 (HARDNESS SPECIMENS)



Graph: Composition vs Hardness

Titanium1	Titanium 1.5	Titanium 2	Titanium 2.5
38.8 HRB	40 HRB	43 HRB	50 HRB

Table: 4 Rockwell Hardness Number of Nano Titanium Samples

- From the comparisons among four compositions, the highest Rockwell hardness value is obtained for 2.5 gram of nano titanium is 50HRB.
- Lowest Rockwell hardness value is obtained for 1.0 grams of nano titanium is 38.8HRB.

CONCLUSION:

Phosphor bronze composite containing the copper (93.95%), tin (5.56%), phosphorous (0.49%) with Titanium nano particles have improved strength.

The series of mechanical experiments on casted phosphor bronze and titanium nano particles compositions by varying weight of titanium nano particles, The observations on the tests for the phosphorous bronze when nano titanium is added is varying such that the maximum tensile value is 226 N/mm^2 occurs at 0.163%, the minimum wear is 15 Volume loss per Unit distance at 0.163%, the maximum impact value is at 0.163% and the maximum hardness value is 61 HRB occurred at 0.163%.

According to the titanium nano particle samples of 0.163%, 0.244%, 0.3257%, 0.4068%, 0.163% sample gives the maximum tensile strength, minimum wear resistance, maximum hardness and impact load. Hence sample 1 is recommended and can be safely used in large variety of industrial applications.

REFERRENCES:

[1] Durowoju M. O. and Babatunde I. A._ The Effect of Varying the Composition of Phosphorus on the Microstructure and Mechanical Properties of Tin-Bronze Composite s.

[2] Strength of materials, by Pakirappa and V. Naresh, Page No. 1.8... 1.6.1- Tensile Test.

[3] Seiki Sakuyama and Michinori Kutami, __Substitute materials for complete elimination of Hazardous substances –Study of whisker growth on Lead-Free plating

[4]CDA publication no. 206 – This paper conducted different compositions of copper composite s.

[5] Midlands and wales_ phosphor bronze, Columbia metals www.columbiametals.com.

[6] M. Aksoya, V. Kuzucub , H. Turhanc a Faculty of Engineering, Department of Metallurgical and Material Engineering, University of Firat, Elazig, Turkey_ copper composite s.

[7] Synthesis of Nano particles by Using RF-Plasma System, Baris Daryal, Levent Kartal, Istanbul Technical university.

[8] Reinforcement of starch/polyvinyl alcohol blend using nano‒titanium dioxide- PA Sreekumar, Mamdouh A Al-Harthi and SK De_ Nano TiO_2 properties and results.