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The Experimental Investigation of Wear Behaviour on Al 7075 T6 Coated with Nickel Chrome Carbide

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Abstract- **A fundamentally new family of thermal spray processes has emerged. These new processes, collectively known as very low pressure plasma spray or VLPPS, differ from traditional thermal spray processes in that coatings are deposited at unusually low chamber pressures, typically less than ~800 Pa (6 Torre). Depending upon the specific process, deposition may be in the form of AL 7075 T6 very fine molten droplets, vapour phase deposition, or a mixture of vapour and droplet deposition. Resulting coatings are similar in quality to coatings produced by alternative coating technologies, such as physical vapour deposition (PVD) or chemical vapour deposition (CVD), but deposition rates can be roughly an order of magnitude higher with VLPPS. With these new process technologies modified low pressure plasma spray (LPPS) systems can now be used to produce dense, high quality coatings in the 1 to 100 micron thickness range with lamellar or columnar microstructures. A history of pioneering work in VLPPS technology is presented, deposition mechanisms are discussed, potential new applications are reviewed, and challenges for the future are outlined.**

INTRODUCTION

All and its alloys find many applications in automobile, defence and aerospace due to their left weight, good corrosion resistance and thermal conductivity. However, they usually present poor trio logical performance, especially catastrophic wear rate. Nevertheless, their wear resistance can be improved through surface modification technique such as thermal spraying process. Metal matrix composite coatings are of great significance for industrial applications owing to their excellent combination of higher specific strength and improved wear resistance, compared with their base alloys. Recently plasma spraying (PS) technique has been widely investigated owing to its high deposition efficiency and volume production of coatings. Aluminium alloy 7075 is an aluminium alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability, but has less resistance to corrosion than many other Al alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable. 7075 aluminium alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than half a per cent of silicon, iron, manganese, titanium, chromium, and other metals. It is produced in many tempers, some of which are **7075-O**, **7075-T6**, **7075-T651**.

EXPERIMENTAL PROCEDURE

T6 HEATTREATMENT

QUENCHING TREATMENT

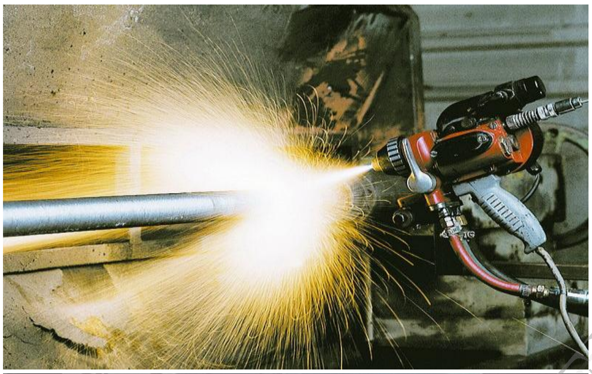
Heat Treatment is a process in which metals are alternately heated and cooled according to a preset schedule of time and temperature to improve the characteristics of the metal. T6 Heat Treatment is a specific heat treatment process which may be applied to aluminium copper / silicon alloys, such as hypereutectic, to increase the strength of the alloy by as much as 30%. In the case of T6 heat treatment, the process occurs in two phases. The First Phase of T6 heat treatment is called the Quench Phase. In this phase the alloy is heated to 920 degrees Fahrenheit for 9 hours causing the copper in the alloy to become dissolved in the aluminium and forming what is called a "Single Phase Alloy". If allowed to air cool naturally, the copper will tend to reconstitute, or reform itself within the alloy. However, when the heated alloy is cooled rapidly by water quenching the reformation of the copper is retarded and the aluminium, supersaturated with copper, is locked into the "Single Phase Alloy "state.

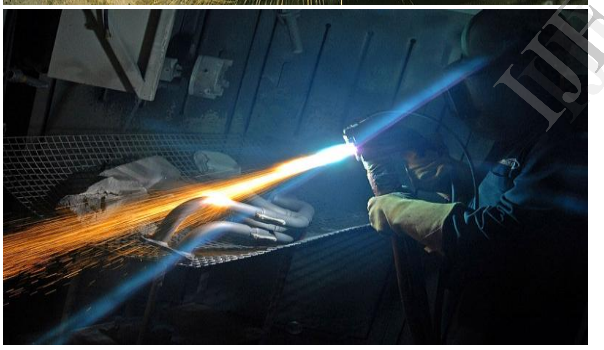
PERCIPITATION TREATMENT

In the Second Phase of the T6 heat treatment process, called the Aging Phase, the alloy is heated to 350 degrees Fahrenheit for 10 hours and then allowed to air cool. During this phase the copper combines with the aluminum in a process called "precipitation hardening" to form a copper aluminum crystal, CuAl2. It is the formation of these copper aluminum crystals which gives the alloy its strength. The key to maximizing alloy strength comes from controlling the size of the copper / aluminum crystals. Maximum strength is attained when the size of the crystals, or precipitated particles, is kept very small forcing them to conform to the structure of the aluminum. Not to be confused with the Quench Phase of Heat Treatment. A quench head piston is designed to increase chamber turbulence with an accompanying reduction in detonation. When assembled, the flat area of the piston should come within .040"-.045" of the flat area of the cylinder head for best results. The high performance race engine, by definition, indicates that limits are going to be pushed. As far as pistons are concerned, that limit is peak operating cylinder pressure. Maximizing cylinder pressure benefits horsepower and fuel economy. Considering the potential benefit, owners of non-race engines, from motorhomes to street rods, also look to increasing cylinder pressure. Increasing the compression ratio is one sure way of increasing cylinder pressure. But camshaft selection, carburetion and supercharging can alter cylinder pressures dramatically, also. Excessive cylinder pressure will encourage engine-destroying detonation and no piston is immune to it's effects. An important first step is to set the assembled quench (a.k.a. "squish") distance to .040". The quench distance is the compressed thickness of the head gasket plus the deck clearance (the distance your piston is down in the bore). If your piston height (not dome height) is above the block deck, subtract the overage from the gasket thickness to get a true assembled quench distance. The quench area is the flat part of the piston that would contact a similar flat area on the cylinder head if you had .000" assembled quench height. In a running engine, the .040" quench decreases to a close collision between the piston and cylinder head. The shock wave from the close collision drives air at high velocity through the combustion chamber. This movement tends to cool hot spots, averages the chamber temperature, reduces detonation and increases power. Take note, on the exhaust cycle, some cooling of the piston occurs due to the closeness of the water-cooled. Some non-quench engines, such as '68 and later Chrysler V8, A, B or RB's can be converted to quench type with pistons such asKB232, KB190, KB191, KB184, KB278, KB146 or KB236, KB215 and KB280. Most MO par cylinder heads recess the quench area into the head so a raised area on the piston is necessary to get the close collision. If you are building an engine with steel rods, tight bearings and pistons, modest RPM and automatic transmission, a .035" quench is the minimum practical to run without engine damage. The closer the piston comes to the cylinder head at operating speed, the more turbulence is generated. Unfortunately, the operating quench height varies in an engine as RPM and temperatures change. If aluminum rods, loose pistons (they rock and hit the head), and over 6000 RPM operation is anticipated, a static clearance of .055" could be required. A running quench height in excess of .060" will forfeit the benefits of the quench head design and can cause severe detonation. The suggested .040" static quench height is recommended as a good usable dimension for stock rod engines up to 6500 RPM. Above 6500 RPM, rod selection becomes important. Since it is the close collision between the piston and the cylinder head that reduces the prospect of detonation, never add a shim or head gasket to lower compression on a quench head engine. If you have 10:1 with a proper quench and then add an extra .040" gasket to give 9.5:1 and .080" quench, you will create more ping at 9.5:1 than you had at 10:1. The suitable way to lower the compression is to use a KB dish piston. KB dish (reverse combustion chamber) pistons are designed for maximum quench area. Having part of the combustion chamber in the piston improves the shape of the chamber and flame travel. In the past, detonation would break the 2nd and 3rd ring lands. The massive strength of the KB 2nd land now prevents this; however, all aluminum pistons will fail if heated excessively. By providing extra-strength ring lands we postpone piston failure due to detonation. We say postpone, rather than eliminate, because continued detonation leads into pre-ignition. Detonation occurs at 5 to 10 degrees after TDC (top dead center) . Pre-ignition occurs before TDC. Detonation damages your engine with impact loads and excessive heat. The excessive heat of detonation is what causes pre-ignition. Overheated combustion chamber parts start reacting as glow plugs. Pre-ignition induces extremely rapid combustion and welding temperatures. Melt down is only seconds away! For a successful performance engine, use a compression ratio and cam combination to keep your cylinder pressure in line with the fuel you are going to use. Drop compression for continuous load operation, such as motorhomes and heavy trucks, to around 8.3:1. Run a cool engine with lots of radiator capacity. Consider propylene glycol coolant and low temperature thermostats where legal. Reduce total ignition advance 2 to 4 degrees. A setting that gives a good Hp reading on a 5 second dingo run is usually too advanced for continuous load applications. Normally aspirated drag race engines have been built with high RPM spark retard. The retard is used to counter the effect of increased flame travel speed with increased engine heat. "Seat of the pants" spark adjustment at low RPM will almost always cause detonation in mid- to high compression engines once they are rung out and start making serious Hp. Accumulator Groove is the groove between the 1st and 2nd compression ring. It does make the piston lighter, but the real purpose is more abstract. Pressure spikes that get trapped between the 1st and 2nd compression rings tend to unseat the top ring. This action encourages ring flutter and loss of piston ring seal. Past efforts to reduce ring unseating pressure have included increasing the second ring end gap. Now, with the addition of the accumulator groove, ring flutter can be controlled in all engines. The void created by this groove between the rings tends to average the normal pressure present, keeping the pressure low enough to prevent lifting the top ring while maintaining some preload on the 2nd (oil scraping) ring. Top Ring End Gap is often a major player when it comes to piston problems. Most top land damage on race pistons appears to lift into the combustion chamber. The reason is that the top ring ends butt and stick tight at TDC. Crank rotation pulls the piston down the cylinder while leaving at least part of the ring and top land . Actual end gap will vary depending on the engine heat load. Lean mixture, excessive spark advance, high compression, low capacity cooling system, detonation and high Hp per c.i. all combine to increase an engines' heat load. Most new generation pistons incorporate the top compression ring high on the piston. The high ring location cools the piston top more effectively, reduces detonation and smog, and increases Hp. If detonation or other excess heat situations develop, a top ring end gap set towards the tight side will quickly butt, with piston and cylinder damage to follow immediately. High location rings require extra end gap because they stop at a higher temperature portion of the cylinder at TDC and they have less shielding from the heat of combustion. At TDC the ring is above the cylinder water jacket. If a ring end gap is measured on the high side, you improve detonation tolerance in two ways: One, the engine will run longer under detonation before ring butt. Two, some leak down appears to benefit oil control by clearing the rings of oil build up. Clean, open oil rings are necessary to prevent oil from reaching the combustion chamber. A small amount of chamber oil will cause detonation and significant Hp loss. The correct top ring end gap with KB pistons can be 50% to 100% more than manufacturer's specifications. The Special Clearance Requirements for KB Pistons chart gives minimum recommended top ring end gaps based on expected operating combustion chamber temperatures. For 2nd ring end gap follow ring manufacturer's specs. Ring Options of 1/16" or stock 5/64" are offered on most of the KB Series. The 1/16" option reduces friction slightly and seals better above 6500 RPM, while being considerably more expensive. Stock (usually 5/64" compression rings) work well and help with the budget. Please see the Numerical/Ring Reference Piston to Bore Clearance for KB Performance Pistons were dyno tested at wide open throttle with .0015", .0020", .0035" and .0045" piston-to-bore clearance. After 7-1/2 hours, the pistons were examined and all looked as new, except the tops had normal deposit color. Even with 320 degrees oil temperature, the inside of the piston remained shiny and completely clean. Excess clearance has been shown to be safe with KB pistons (no reported cracks in four years). The added skirt stiffness of the KB pistons reduces piston rock, even if it is set up loose. Loose KB pistons over .0020" do make noise. As they get up to temperature they still make noise because they have very restricted expansion rate and do not swell up in the bore. Our hypereutectic alloy not only expands 15% less, it insulates the skirts from combustion chamber heat. A short term Hp improvement can be had by running additional piston clearance because friction is reduced. To obtain actual piston diameter, measure the piston from skirt to skirt level with the balance pad. See The Special Clearance Requirements for KB Pistons. Pin Oiling should be done at pin installation. Either pressed or full floating, prelube the piston pin hole with oil or liquid prelube, never use a grease (if you are using a pressed pin rod be sure to discard the spiral pin retainers). All KB Performance Piston sets supplied from the factory include a tube of Torso/MPZ engine assembly lube. A smooth honed pin bore surface with a reliable oil supply is necessary to control piston expansion. A dry pin bore will add heat to the piston rather than remove heat. Pistons are designed to run with a hot top surface, and cool skirts and pin bores. High temperature at the pin bore will quickly cause a piston to grow to the point of seizure in the cylinder. Marine Applications generally require an extra .001"-.003" clearance because of the possible combination of high load operation and cold water to the block. A cold block with hot pistons is what dictates the need for extra marine clearance. See our clearance chart on The Special Clearance Requirements for KB Pistons.

PLASMA SPRAYING

A plasma spray system installed at spray met surface technologies pvt.ltd with a commercial spray gun has used. Higher pressure compressed air was used as a powder carrier gas at pressure of 100-120 LPM. The standoff distance from the nozzle exit to A1 7075





subtracted was 50-75mm.A nickel carbide (60%) powder and a commercial chromium (40%) powder were used by using these powder combination composite coatings were prepared and applied on the surface of the material with different thickness like 20µm,40µm and 60µm.

WEAR TEST PROCEDURE

Friction tests were performed on a Pin-on-disc CSM tribe meter under an ambient environment.(Before Friction test, all coating surfaces were polished) to mean the friction co-efficient was computed when the friction force was divided by the applied load. For the 20µm coated specimen, the applied load was 10N and the sliding velocity 0.1 m/s, For again the test was conducted For the same specimen with 15N load. For the 40µm coated specimen, the applied load was 10N and the sliding velocity, again the test was conducted for the same specimen for with 15N load.For the 60µm coated specimen, the applied load was 15N and with the sliding velocity of 0.1 m/s, again the same test was calculated for this specimen with an applied load of 20N.

RESULT AND DISCUSSION

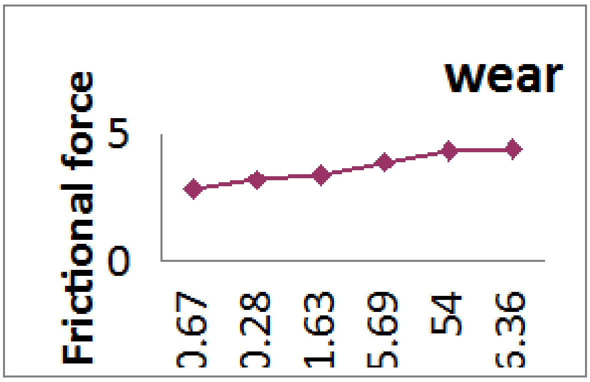
The wear resistance property of the A1 7075 76 coated with nickel chrome carbide material with the different thickness of 20µm,40µm and 60µm was studied. The wear resistance rate increases as the coating thickness increases. The mass loss due to wear was determined by precession electronic balance and wear rate was calculated using the following relation.

$$wear\ rate = \frac{weight\ loss}{sliding\ distance}(mgm-^{1})$$

Wear behaviour of composite coating. There are three samples were tested and the corresponding weight loss function was founded, the given design represent the wear rate of the material coated under different thickness.

WEAR VALUE OF 20µ COATED SPECIMEN UNDER 10 N LOAD

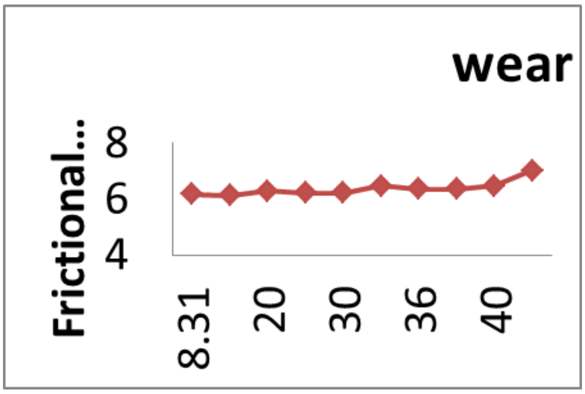
In this graph we have shown that the wear resistance of the coated plate are deformed with applying 10KN load. The coating plate thickness is 20µm.



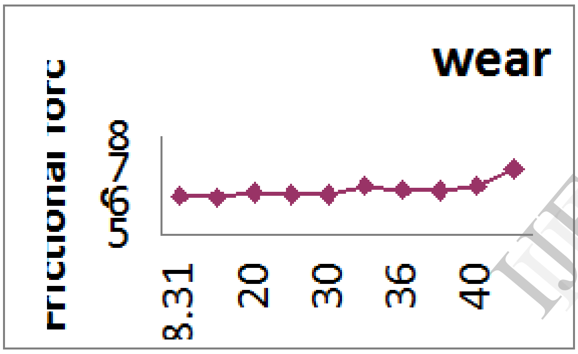
WEAR BEHAVIOR OF 20 µ COATED SPECIMEN (load 15N)

In this graph we have shown that the wear resistance of the coated plate are deformed with applying 15KN load. The coating plate thickness is 20µm.

WEAR BEHAVIOR OF 40 µ COATED SPECIMEN (load 10N)

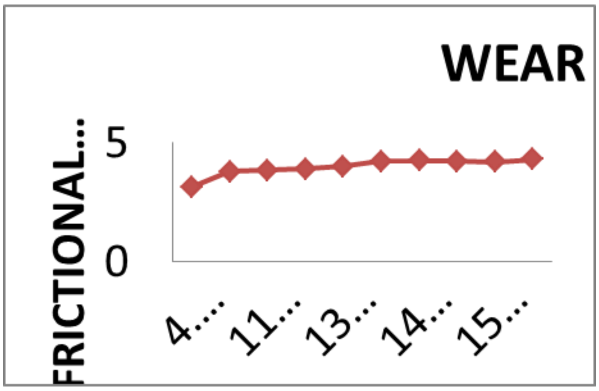


In this graph we have shown that the wear resistance of the coated plate are deformed with applying 10KN load. The coating plate thickness is 40µm.



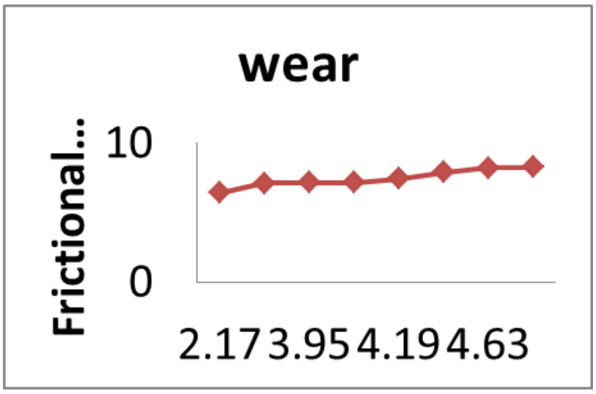
WEAR BEHAVIOR OF 40 µ COATED SPECIMEN (load 15N)

In this graph we have shown that the wear resistance of the coated plate are deformed with applying 15N load. The coating plate thickness is 40µm.



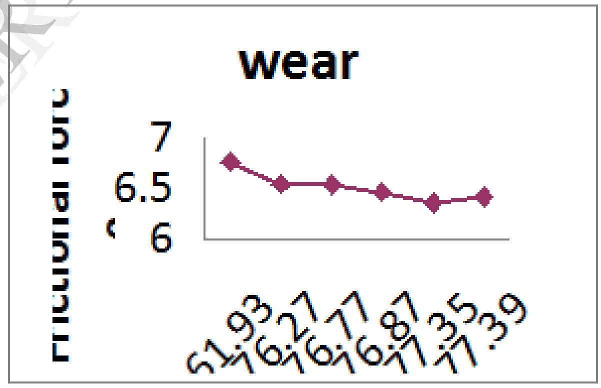
WEAR BEHAVIOR OF 40 µ COATED SPECIMEN (load 15N)

In this graph we have shown that the wear resistance of the coated plate are deformed with applying 15N load. The coating plate thickness is 40µm.



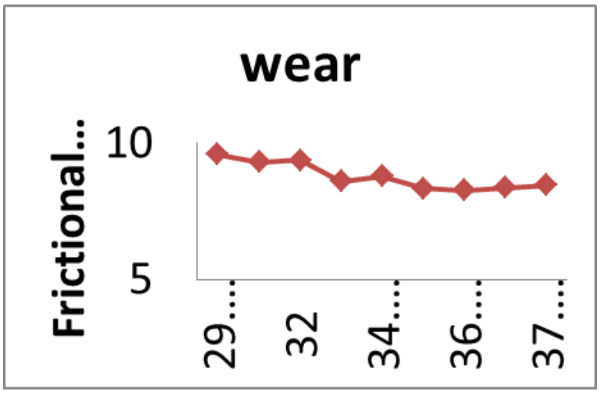
WEAR BEHAVIOR OF 60µ COATED SPECIMEN (load 15N)

In this graph we have shown that the wear resistance of the coated plate are deformed with applying 15N load. The coating plate thickness is 60µm.



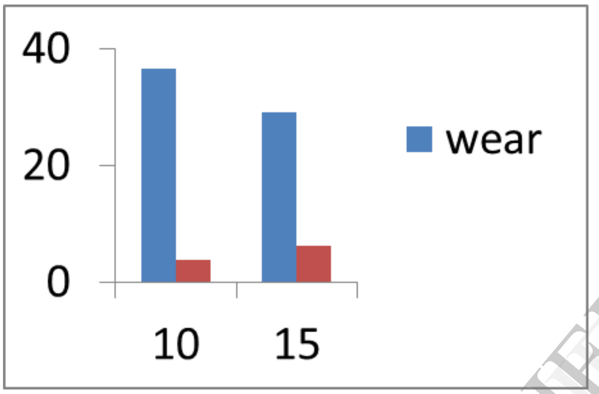
WEAR BEHAVIOR OF 60µ COATED SPECIMEN (load 20 N)

In this graph we have shown that the wear resistance of the coated plate are deformed with applying 20N load. The coating plate thickness is 60µm.



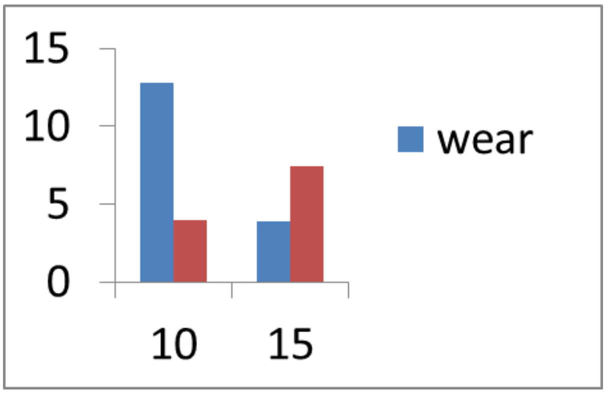
COMPARISON OF WEAR BEHAVIOR OF 20 μ COATED SPECIMEN (10 & 15 N LOAD)

In this graph we have shown that comparisons of the wear resistance of the coated plate are deformed with applying 10&15N load. The coating plate thickness is 20μm.



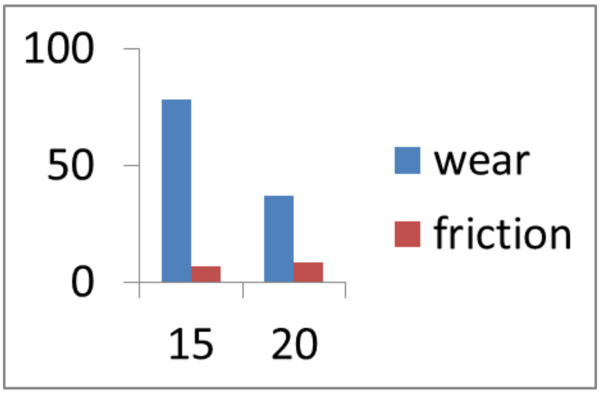
COMPARISON OF WEAR BEHAVIOUR OF 40 μM COATED SPECIMEN (10 & 15 N LOAD)

In this graph we have shown that comparisons of the wear resistance of the coated plate are deformed with applying 10&15N load. The coating plate thickness is 40μm.



COMPARISON OF WEAR BEHAVIOR OF 60μ COATED SPECIMEN (15 & 20 N LOAD)

In this graph we have shown that comparisons of the wear resistance of the coated plate are deformed with applying 15&20N load. The coating plate thickness is 60μm.



CONCLUSION

Thus we compare aluminium 6061 and 6082 with mechanical and metallurgical properties of material. In this the material 6061 is particularly strong when compare to aluminium 6082.Due to prepaid structure the stress and strain can be varied and accurate result can be taken due the correct welding in TIG. Thus the aluminium alloy of 6061 is very much suitable for TIG welding.

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