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A Review of Various Low Friction Coating with HSS-T42 as Base Material

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Abstract— Cutting is very crucial aspect in a manufacturing situation & coating deposited on tool surface is to improving tribological properties of surface i.e. wear and coefficient of friction of the surface. Cutting life time of tool material depends on wear. In order to study the performance of various coating on tool material it is necessary to study its two properties viz. wear & coefficient of friction. The tribolgical properties are found by using pin on disc test. This paper focuses on various low friction coating such as TiN, CrN and DLC coating on High speed steel T-42 pin as a base material. The purposes to coating on tool surface in a cutting application are to increase cutting life time of tool, to improve the surface properties of component and to increase productivity. This paper deals with the study of performance parameters like speed, sliding distance and load compared between different coated HSS-T42 pin base material. Taguchi method are used under the performance parameter & L9 orthogonal array is selected to perform experiment on pin on disc of the specimen. The EN31steel material is selected as work piece material. The response value find out by using coefficient of friction which were obtained from pin on disc test. Scanning Electron Microscopy (SEM) analysis for compared different coated pin for microstructural test. This paper reviews different coating materials at different parameters & their effect on properties of metal.

Keywords – surface coating, HSS-T42 pin, wear, friction, pin on disc, Taguchi method.

I. INTRODUCTION

For producing any product or component or part, cutting tool is basic and vital parameter, the application of tool and its life is taken in to consideration the analysis of tribological properties i.e. wear and coefficient of friction is also that much important, so for that analysis the testing of wear & coefficient of friction is checked with different coatings on HSS (High Speed Steel) T-42 pin. The HSS T-42 grade tool material is mostly used and easily available at cheap rate compared to other graded tool material. To produce quality product, a cutting tool must have three properties viz. Hardness, Toughness, Wear resistance.

Cutting tool material must be harder than the work piece material which is to be cut and tool must be able to withstand high temperature in the metal cutting process. Single point cutting tool perform on lathe operations, shaper operations, planer, slotting machine operations & remove material by means of one cutting edge. Milling & drilling tool are multipoint tools used for gear cut, drilling, boring, reaming, slotting operations. The coating are used on tool material due to properties of high hardness, wear resistance, toughness, good chemical stability, refractoriness, antioxidation capability which may be high speed machining and metal forming industries. In high speed machining the major problem occurs is the high tool wear rate cause to reducing cutting tool life. This is due to highest temperature on tool tip and work piece material. With the growing industry of coating tools & new development of coating process, there is need to compare various low friction coating and select the best coating by performing experiment.

II. Literature Survey

[1] Venkatesh. R., et al. [2015], they studied wear analysis on silicon carbide coated HSS pin on SS disc substrate, This investigation focuses on the influence of Silicon Carbide nano coating on the HSS tool material. Silicon carbide powder was coated on the high speed steel pin by using physical vapour deposition (PVD) technique. The performance parameters like volume loss, wear rate, stresses developed and temperature rise were compared between coated high speed steel pin and uncoated high speed steel pin upon machining the stainless steel disc. The performance parameters were calculated by using coefficient of friction values which were obtained from the pin on disc test. Substantial resistance to wear has been achieved by the coating. Scanning electron microscope (SEM) Analysis and Energy dispersive analysis by X-ray (EDAX) were used as characterization techniques, the coating process that the metallic powder coating on the tool enhances the properties of the tool with increased productivity and increased tool life. It shows that coated pin is having less volume loss in the pin and disc. It is possible to machine the work piece which is harder than the tool after the coating process.

[2] Piska Miroslav et al. [2015], they studied surface parameters, tribological tests and cutting performance of coated HSS taps, internal threads are frequently used in a multitude of technical applications. There standard technology for production is cutting, but cold forming seems also to be a challenging technology due to chip less production, better tensile strength of the threads and superior corrosion and fatigue resistance of the contact surfaces a study of 2D surface parameters, Coulomb´s coefficient of friction and cutting/forming performance of selected PVD coated HSS taps when machining of carbon steel C45 and forming of hardened steel 42CrMo4V. The main attention is focused on the analysis of physical parameters of loading (torque moment, total energy and specific energy) of the taps measured with the pieso-electrical dynamometer. The quality of machined thread surfaces and tool life of the taps and the tribological and surface parameters has been found. The results showed a safe and stabilized cutting and forming with excellent quality of threads for HSSE with the TiN/DLC coating. The combination of PVD TiN+DLC surface coatings can be recommended for a very effective and safe tapping in the steels, even in the hardened state.

[3] Sahu Supriya, et al. [2015], they investigated coated tools are used to improve the performance in machining applications, such as high-speed machining and machining of hard materials. Surface roughness and tool wear prediction plays a significant role in machining for proper planning and control of machining parameters and optimization of cutting conditions. The present work studies the performance of multi-layer TiN coated tool in machining of hardened steel (AISI 4340 steel) under high speed turning, which has also been compared with that of uncoated tool. The influence of cutting parameters (speed, feed, and depth of cut) on surface roughness have been analyzed using Taguchi methodology. Finally, scanning electron microscopy (SEM) images are used to observe the surface morphology and to predict the tool wear. It has been found that the machining of hard materials at higher speeds and lower feeds is improved by using coated tools.

[4] Jadhav Suraj R. et al. [2015], they studied the use of coated cutting tools in the machining of various materials. Cutting tools are subjected to high stresses in modern machining practice like dry, high-speed or high performance machining. The cutting tool is one of the important elements in realizing the full potential out of any metal cutting operation, Cutting tools are mostly assessed in terms of wear studies during and after the manufacturing processes. Developments in coating equipment and processes now enable us to produce a wide range of different hard nitride, carbide and oxide films and to deposit them on various tool substrates as monolayer, multilayer, or composite coatings. Machining efficiency is improved by reducing the machining time with high speed machining. But the softening temperature and the chemical stability of the tool material limits

the cutting speed. When cutting ferrous and hard to machine materials such as steels, cast iron and super alloys, softening temperature and the chemical stability of the tool material limits the cutting speed. Therefore, it is necessary for tool materials to possess good high-temperature mechanical properties and sufficient inertness, this work considered some ways to improving cutting tool life by means of coating method. The performance of coated cutting tool is better than the conventional cutting tool. Tool coating improves properties of cutting tool such as surface roughness, Chemical stability, anti-welding and anti-diffusivity, thermal conductivity, Surface lubricity and anti-seizure. Tungsten Carbide coated cutting tool cuts about 3 to 5 times faster than conventional cutting tools.

[5] Waseem B.et al. [2015], they investigated optimization and characterization of adhesion properties of DLC coatings on different substrates. The Diamond Like Carbon coatings (DLC) are gaining prime importance in the field of surface engineering especially cutting tools technology. The self-lubricating property of these coatings makes them unique among other coatings like TiN, TiAlN, CrN etc. Unlike other coatings, DLC coatings give better surface finish and their self-lubrication reduces the wear of a part to large extent. In present work, different substrates were selected to study the wear and adhesion behavior of DLC coatings. The coating was produced by physical Vapor Deposition (PVD) technique and the adhesive properties of DLC coatings were analyzed under ambient conditions using nano scratch testing. Scanning electron microscope (SEM) was used to observe the scratches and their mechanisms. The comparisons of penetration depth and acoustic emission curves shows that high strength steel and die steel show the best adhesion with DLC coating. It can be concluded that harder substrates shows better adhesion properties with DLC coating than the softer ones.

[6] Rasool G., et al. [2014], they investigated Wear maps for TiC composite based coatings deposited on 303 stainless steel. Dry sliding wear (pin-on-disc) tests were carried out under ambient conditions at room temperature for TiC coated and uncoated 303 stainless steel, using alumina as a counter face. The composite coating which was developed by Tungsten Inert Gas (TIG) methods increased the surface hardness of the substrate and the sliding wear resistance of the substrate. Wear maps for both uncoated and coated materials were developed on the basis of tests results. These maps show that the mild wear regime for the composite coating extended to a high range of sliding speeds and normal loads, than that for the uncoated steel. The differences in wear mechanisms as identified on the wear maps for both coated and uncoated steel. The results indicate that the uncoated steel exhibited poor wear resistance, while the TiC coating increased the wear resistance of the substrate considerably.

[7] Tanabe Ikuo et al. [2014], they studied development of innovative tool using taguchi methods. The software for innovative tool using Taguchi-methods is developed and evaluated. There are two trials in the innovative tool using Taguchi-methods; First trial is accomplished for selecting important control factors and its optimum region, and second trial decides the optimum combination of the control factors by more detail trial using only important control factors. The optimum condition regarding cooling system for cutting was investigated for evaluating this innovation tool in the experiment. It is concluded from the result that innovative tool using the Taguchi methods was useful for development with short-term and lower cost, and this tool could quickly and exactly decide the optimum cooling condition. Now, innovative development with short-term, low cost, labor saving and energy saving is also required in the world. Therefore, in this research, the software for innovative tool using Taguchi-methods is developed and evaluated. At first, first trial investigates rough functions regarding all levels of all control factors, then important control factors and meaningless control factors were sorted with the several comments for the second trial. At that time, maximum, intermediate and minimum values for each lever of the each control factor should use for pursuit of all possibilities. Then second trial decides the optimum combination using the levels of the control factors by more detail trial using only important control factors.

[8] Kuttianimattom Wringle Joseph et al. [2014], they studied property analysis of PVD deposited DLC, TiAlN, CrAlN, TiN coating on gray cast iron, Gray cast iron is a type of cast iron that has graphitic microstructure. It is named after the gray colour of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight, wear of materials are inevitable, it should be minimized as far as possible. Diamond like Carbon (DLC), Titanium Aluminium Nitride (TiAlN), Chromium Aluminium Nitride (CrAlN). DLC coatings are often used to prevent wear due to its excellent tribological properties. Aluminum Titanium Nitride (AlTiN) or Titanium Aluminum Nitride (TiAlN) is a thin film coating that was developed from Titanium Nitride. TiAlN offers higher temperature resistance than TiN. CrAlN performs well in corrosive environments and in sliding wear applications. Hardness, abrasion wear and surface roughness test of the specimens was conducted DLC proved to be the best coating with highest hardness, improved surface roughness and minimum wear. TiAlN, TiN showed the next best results. Among the four coatings CrAlN was the least effective coating.

[9] Liew Willey Y. H. et al. [2013], they investigated the frictional and wear behaviour of AlCrN, TiN, TiAlN single-layer coatings, and TiAlN/AlCrN, AlN/TiN nano multilayer Coatings in dry sliding. The factors controlling the frictional behaviour of materials include mechanical stresses, temperature and oxidation phenomena. The complexity of sliding friction arises from the fact that all these three controlling factors are interrelated and influenced by load and sliding velocity as well as the sliding environment. Comparative studies on the coatings sliding in air and vacuum environment at different speeds provided important insight on the effect of oxidation and temperature on the frictional and wear behaviour of the coatings. Among all the single layer coatings tested in vacuum, TiN gave the lowest coefficient of friction (COF), followed by TiAlN and AlCrN. The characteristics of the COF produced by AlCrN/TiAlN and AlN/TiN in vacuum and air was similar to those produced by TiAlN and TiN, respectively, suggesting that the COF of the nano-multilayer coatings was governed by TiAlN and TiN. The COF and wear reduced with increased speed, except for the test involving AlCrN in air where the COF increased with increased speed. This needs further investigation. In air at 10 m/min, the wear resistance of the coatings can be well distinguished. AlCrN exhibited the shortest running-in process and lowest steady-state COF was found to have the least wear. TiAlN suffered the most severe wear as a result of long running-in process and high steady-state COF, and relatively low hardness in comparison to the nano-coatings. TiN, TiAlN/AlCrN and AlN/TiN which exhibited similar wear resistance, had lower wear resistance than AlCrN but higher wear resistance than TiAlN.

[10] Bouzakis Konstantinos-Dionysios et al. [2012], they investigated cutting with coated tools: coating technologies, characterization methods and performance optimization. Coated tools constitute the majority of the tools applied in material removal processes, rendering the employment of uncoated ones as an exception. A broad growing market of coated cutting tools has been developed. Moreover, numerous material- and manufacturing-engineers have joint their expertise, aiming at developing coatings meeting the needs for processing the most difficult-to-cut materials at the most extreme cutting conditions. The emerging of new work piece, tool and film materials, the evolution of sophisticated coatings characterization methods and the continuous need for higher productivity rates. Coated tools have compound material structure, consisting of the substrate covered with a hard, anti-friction, chemically inert and thermal isolating layer, approximately one too few micrometers thick. As such, coated tools compared to uncoated ones, offer better protection against mechanical and thermal loads, diminish friction and interactions between tool and chip and improve wear resistance in a wide cutting temperature range.

[11] Kivak Turgay, et al. [2012], they studied taguchi method based optimization of drilling parameters in drilling of AISI 316 steel with PVD monolayer and multilayer coated HSS drills. This

paper focuses on the optimization of drilling parameters using the Taguchi technique to obtain minimum surface roughness (Ra) and thrust force (F_f). A number of drilling experiments were conducted using the L16 orthogonal array on a CNC vertical machining center. The experiments were performed on AISI 316 stainless steel blocks using uncoated and coated M35 HSS twist drills under dry cutting conditions. Analysis of variance (ANOVA) was employed to determine the most significant control factors affecting the surface roughness and thrust force. The cutting tool, cutting speed and feed rate were selected as control factors. After the sixteen experimental trials, it was found that the cutting tool was the most significant factor on the surface roughness and that the feed rate was the most significant factor on the thrust force. The results of the confirmation experiments showed that the Taguchi method was notably successful in the optimizations of drilling parameters for better surface roughness and thrust force.

[12] Arroyo José Manuel, et al. [2010], they studied Wear performance of laser precoating treated cemented carbide milling tools. Coated cemented carbide is a key material for cutting tools and its manufacturing includes pretreatment of the substrate surface before coating deposition. To obtain a durable tool edge, this pretreatment must achieve two objectives: high adhesive strength of the substrate-coating interface and low coating surface roughness to reduce friction with the work piece and the chips removed during the machining process. Several methods have been researched for substrate surface pretreatment, including micro sand blasting in the standard industrial procedure, which is an economic and effective process. In this work, a laser substrate surface treatment was examined as an alternative to micro-sandblasting, because the laser process does not produce waste material flux, allows for the selective treatment of surface areas, and involves a potentially shorter processing time per piece.

III. CONCLUSION & DISCUSSION

After reviewing various papers it is concluded that-
In order to study tribological properties of different coated pin using pin on disc type friction & wear apparatus is most suitable. Wear rate of different coated pin depends on speed, sliding distance and load on materials. The different common materials that are used in the tool for machining operations of the different base work piece material, the HSS T-42 is commonly used tool material. Tool life is very major factor in order to increase the machining life of the tool and to reduce the cost of machining so in order to increase the life of tool, the tool should coated with some coating material with different methods, the coated specimen will be tested on pin on disc machine by selecting number if parameter & their levels by taguchi method of design of experiment (DOE)The optimization of parameter of Diamond like coating (DLC), Chromium nitride coating on High Speed Steel were remaining so in this paper this coating are selected and the parameters & their levels are select by using the method of design of experiment i.e. Taguchi method & relation of parameters will be determine by ANOVA method & microstructural study of the samples will be carry out this work.

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