FEA And Wear Rate Analysis Of Nano Coated HSS Tools For Industrial Application

[1]Dr.Subramaniam D, [2]Ajithkumar M, [3]Elayaraja R
[1]Professor, [2]PG Schalor, [3]Assistant professor
Mahendra Engineering College,Mallasamudran

***Abstract* - Using several output parameters of the machining cycle, the machinability of a material can be measured, the tool life being without doubt the most important. The life of the tool depends primarily on the wear rate of the tool, which in effect depends very much on the prevailing wear mechanism. We plan to do our project work on the machining tool (HSS) to boost their performance here. The HSS method is to render nano coating with Zirconia and Chromium materials. Using the FEA method (ANSYS software), the material strength and wear rate of the proposed HSS device is analysed. Through suggesting this nano-coated tools it helps in enhancing the life of the machining machine. Via this present project research we may also propose the latest and most sophisticated machining method.**

***keywords* - ANSYS,NANO COATING,ZIRCONIA,CHROMIUM.**

I. INTRODUCTION

Now an afternoon, steel reducing is a vast enterprise in economically evolved international locations, although small in comparison to the client industries it serves. The vehicle, railway, shipbuilding, aircraft manufacture, domestic appliance, purchaser electronics and creation industries, these kinds of have large system shops with many heaps of personnel engaged in machining. It is estimated that 15% of the value of all mechanical components synthetic global is derived from machining operations. A thorough know-how of the material elimination method in steel reducing is vital in selecting the tool material and in design, and additionally in assuring steady dimensional accuracy and floor integrity of the completed product. Friction of metallic slicing impacts the cutting electricity, machining pleasant, device existence and machining fee.

When tool put on reaches a sure value, growing reducing force, vibration and reducing temperature because deteriorated surface integrity and size errors more than tolerance. The life of the cutting device involves an stop. Then the cutting device ought to be replaced or ground and the reducing manner is interrupted. The price and time for tool replacement and adjusting device tool increase the cost and decrease the productivity. Hence friction in steel cutting pertains to the economics of machining and prediction of friction is of terrific significance for the optimization of slicing process.

Although various theories were brought hitherto to give an explanation for the damage mechanism, the complicity of the strategies within the cutting sector hampers system of a valid concept of slicing device put on. The nature of tool put on in metal reducing, lamentably, isn't but clean enough no matter severa investigations completed over the past 50 years. Friction of steel reducing is a result of complex physical, chemical, and thermo-mechanical phenomena. Recently, the prediction of friction of steel cutting is finished by calculating device lifestyles according to experiment and empirical device existence equations.

Although the equation gives the easy dating among tool life and a sure reducing parameters, it offers handiest the statistics about device existence. For the researcher and tool manufacturer, tool put on development and tool wear profile also are regions of situation. Tool life equation offers no records about the wear and tear mechanism. But functionality of predicting contributions of numerous put on mechanism could be very useful for the design of reducing device cloth and geometry. In addition, such tool life equations are valid under very restrained cutting conditions. For example, when device geometry is modified, new equation have to be installed by way of making test.

Figure 1. Machining Operation

The relative motion among cutter and the paintings piece can be in any direction and as a result surfaces having any orientation may be machined in milling. Milling operation can be achieved in a single bypass or in multiple passes. Multi-skip operations are frequently desired to single pass operations for economic motives and are normally used to device stocks that cannot be removed in a unmarried pass. Various investigators have supplied optimization techniques, both traditional and non-conventional, for optimization of multi-bypass milling operation. Smith describes the International Standards Organization (ISO) requirements for milling cutter geometry. Mohan describes profile relieve cutters in milling contour surfaces Davies describes

bonding of carbide inserts to such equipment as stop-turbines as opposed to brazing them. Milling plays a primary function as a shape generating method in the machining of hollow forms. Such hole shapes are utilized in tools for presses, forges, and foundry paintings. Granger describes the selection of a milling cutter in phrases of common chip thickness instead of in feed/tooth. This technique relies upon on a aggregate of factors which includes cloth, thing layout, and energy, stress of fixturing, and sort and age of machine.

CUTTING TOOL

Cutting tool substances are materials which can be used to make cutting equipment which might be utilized in machining (drill bits, device bits, milling cutters, etc.) but no different cutting gear like knives or punches. Cutting device substances must be harder than the cloth of the paintings piece, even at high temperatures all through the process.

Cutting tool customers can't manage to pay for to ignore the steady adjustments and improvements which are being made in the discipline of tool cloth generation. When a tool trade is wanted or predicted, a overall performance evaluation should be made before choosing the device for the activity.

Many styles of device materials, starting from high carbon steel to ceramics and diamonds, are used as slicing tools in today's metalworking industry. It is critical to be conscious that variations do exist among device substances, what these differences are, and the right utility for each kind of cloth.

II. LITERATURE REVIEW

Ivin S Bovas, Anoop M R, "Wear Rate Analysis of Nano-Coated Cutting Tool" Drilling is one of the metallic cutting operations which are extensively used production technique within the industrial international. In this manner, drill bits are the reducing tools which are used to create circular holes. The purpose of the present work is to reduce the tool wear charge by way of nano-coating TiAlN on the device surface. For that wear checks are performed at the pin-on-disc apparatus beneath dry sliding condition. The surface morphology of the gear became studied by way of the use of Scanning Electron Microscopy (SEM). With the help of ANSYS Workbench 14.0 the frictional strain and make contact with strain for both TiAlN covered and uncoated HSS pins were analyzed for distinctive varying masses. It become determined that TiAlN nano-coated device shows very much less wear fee than HSS reducing device.

M.Yugandhar, N.Harish Kumar - "Study of Mechanical and Tribological Properties ofCoated TiN and TiC on cutting tools by varying the composition of Nickel and Carbon" It has been nicely hooked up that superior surface coatings on cutting equipment improve wear resistance with the aid of modifying the touch situations among the chip and tool interface. As a end result of the recent traits in cutting tool industry, lined gear have made a huge contribution to the metallic cutting operations in terms of device lifestyles, reducing time and machining first-class. The undertaking of modern-day machining industries is focused in particular at the success of excessive exceptional, in terms of labor piece dimensional accuracy, surface finish, high production rate, less put on on the slicing gear, financial system of machining in terms of cost saving and growth the performance of the product .In wellknown, the maximum essential point in machining approaches is the productivity, achieved by reducing the very best quantity of cloth in the shortest time period the use of gear with the longest lifetime.

The gift studies paintings describes the improvement, Mechanical, Tribological overall performance of Nanomaterial coating of (Titanium Nitride), TiC (Titanium Carbide), on Tungsten Carbide reducing tool. The Mechanical, Tribological houses of Tin, TIC, are to be as compared with uncoated Tungsten carbide slicing tool. And additionally different coating strategies like Chemical Vapor Deposition, Physical Vapor Deposition Method, may be used for contrast. The gift paintings will assist to discover the tool life and put on conduct of the every coated device and it's going to help to locate the satisfactory tool coating relevant for the cutting device. The experiments of Mechanical, Tribological residences checks have to be performed as in keeping with ASTM requirements. Scanning Electron microscope (SEM) evaluation has to be carried out for investigating the surface morphology of Tungsten Cutting device. The coated slicing tools should be modeled the usage of suitable assumption and analyzed via finite element approach using ANSYS software. Both effects of Experimental and ANSYS software are to be as compared.

VikasPatidar, Prof. KamleshGangrade, Dr. Suman Sharma - "Wear Analysis of Multi Point Milling Cutter using FEA": The fabric removal manner uses slicing tools in order to produce the favored form of the work piece. Tool wear has been a problem for cutting gear, because cutting gear wear and wreck. Research has been achieved in the tool put on discipline for tool existence and more these days tool put on. The computer era has created a method to simulate the cloth elimination system. These laptop simulations version the cutting device response with the paintings piece. Many of the simulation models use finite detail analysis to calculate the reaction of the cutting device. Different finite detail fashions are getting used in the course of the world for research. In this Paper the layout components of surface milling cutter is analyzed. The objective taken into consideration is the layout and modeling of floor milling cutter and to research diverse pressure additives acting on it.

Kyung Hee Park, "TOOL WEAR ANALYSIS IN VARIOUS MACHINING PROCESSES AND STUDY OF MINIMUM QUANTITY LUBRICATION (MQL)": The device put on analysis at the multilayer lined carbide inserts in turning and milling of AISI 1045 steels turned into executed the usage of superior microscope and photograph processing strategies. In turning procedure, the flank wear evolution, floor roughness and groove sizes on the coating layers have been analyzed to understand the flank put on mechanism(s) involved. The dominant wear phenomenon become abrasion and, after carbide become uncovered, adhesion took over. For flank wear prediction, 2-body abrasion version became used alongside the interface conditions from finite detail (FE) version, which gives the temperature on the cutting device. In a face milling take a look at, multilayer slicing equipment, double (TiN/TiAlN) and triple (TiN/Al2O3/TiCN) layered lined carbide, processed by bodily vapor deposition (PVD) and chemical vapor deposition (CVD) respectively, were evaluated in phrases of numerous cutting conditions. Similar to the turning case, abrasion turned into found to be the maximum dominant device put on mechanism in milling. Edge chipping and micro-fracture have been the tool failure modes. Overall, the double layer coating changed into

superior to the triple layer coating beneath numerous slicing situations because of the benefit coming from the coating deposition processes themselves.

PROBLEM STATEMENT:

The tool wear happens while machining process, the wear rate is based on the material properties. By this problem, the time and cost of production affects in manufacturing unit. Here, we do work to reduce the problem of tool wear by using nano coated materials.

PROPOSED METHODOLOGY:

The nano coating process of HSS tool with Zirconia and chromium materials because the life of high-speed steel can be prolonged by coating the tool. A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative, functional, or both. The coating itself may be an all-over coating, completely covering the substrate, or it may only cover parts of the substrate.

Effect of Tool Coatings:

The machining of hard and chemically reactive materials at higher speeds is improved by depositing single or multi-layer of hard coating material on carbide cutting tool to combine the beneficial properties of coating and traditional tool materials.

OBJECTIVE OF THIS PROJECT:

- ✓ The main aim of this project is to analysis the HSS tools by nano coating process.
- ✓ Also to check tool wear rate for machining tool life and suggest advanced machining tool.

III. MATERIAL SELECTION

Tool steel refers to an expansion of carbon and alloy steels which are mainly nicely-proper to be made into tools. Their suitability comes from their distinct hardness, resistance to abrasion and deformation, and their capacity to hold a cutting edge at increased temperatures. As a result, device steels are applicable for use in the shaping of other substances.

With carbon content between zero.5% and 1.Five%, tool steels are synthetic underneath cautiously controlled situations to provide the specified first-rate. The presence of carbides of their matrix plays the dominant function inside the characteristics of device steel. The 4 most important alloying factors that form carbides in tool metallic are: tungsten, chromium, vanadium and molybdenum. The charge of dissolution of the exceptional carbides into the austenite form of the iron determines the excessive-temperature performance of steel (slower is higher, making for a warmth-resistant metal). Proper heat remedy of those steels is vital for good enough overall performance. The manganese content is regularly kept low to decrease the possibility of cracking in the course of water quenching.

There are six organizations of tool steels: water-hardening, bloodless-work, surprise-resistant, excessive-speed, warm-paintings, and unique motive. The choice of institution to pick depends on value, operating temperature, required floor hardness, power, shock resistance, and sturdiness requirements. The extra severe the provider situation (higher temperature, abrasiveness, corrosiveness, loading), the higher the alloy content and consequent quantity of carbides required for the tool metallic.

High-pace metallic (HSS or HS) is a subset of device steels, generally used as reducing device fabric.This belongings lets in HSS to cut quicker than high carbon metallic, consequently the name excessive-pace steel. At room temperature, in their usually encouraged warmness treatment, HSS grades usually display excessive hardness (above Rockwell hardness 60) and abrasion resistance (normally linked to tungsten and vanadium content regularly used in HSS) compared with commonplace carbon and device steels.

Coating of Tool:

The lifestyles of excessive-velocity steel may be prolonged via coating the device. One such coating is TiN (titanium nitride). Most coatings usually growth a device's hardness and/or lubricity. A coating allows the slicing edge of a tool to cleanly pass via the material while not having the cloth gall (stick) to it. The coating additionally facilitates to decrease the temperature associated with the reducing manner and increase the lifestyles of the tool.The choice of materials for applying coating of reducing tool which includes

- ✓ Zirconia
- ✓ Chromium

ZIRCONIA (Zr):

Zirconia is a white powdered material normally used to supply dental frameworks for dental substructures which includes crowns, bridges, and so on. Unlike fashionable ceramics that have a tendency to be brittle and difficult, Zirconia has extraordinary wear resistance and power, and springs with a flexibility that is far better than the ones of other technical ceramics.Unlike other ceramic substances, zirconium oxide (ZrO_2 –also known as zirconia) is a fabric with very excessive resistance to crack propagation. Zirconium oxide ceramics additionally have very excessive thermal enlargement and are consequently often the material of preference for becoming a member of ceramic and metallic.

Pure zirconia is located in three crystal stages at special temperatures and that they consist of Monoclinic, Cubic and Tetragonal. The fine grain length permits the material to have sharp edges and very easy surfaces. In order to save you and control structural changes, numerous extraordinary oxides can be dispersed into the zirconia crystal structure all through production. These oxides consist of Ceria, Magnesia and Yttria.

Zirconia-primarily based ceramics are also used in many other programs. For example, they may be used as auxiliaries in welding techniques, as gear for wire forming, as oxygen dimension cells, as insulating rings in thermal approaches, and as materials for crowns and bridges inside the dental industry, as cited above. These ceramics were evolved to such an volume that

limitless designs of micro structure at the moment are feasible via controlling fabrication direction, composition, thermal remedy, and very last machining.

CHROMIUM:

Chromium is a chemical detail with Cr as its image. It belongs to institution 6, periodic quantity 4 of the periodic table. Its atomic variety is 24.Chromium is a steely-grey lustrous, brittle, hard metal. It is thought to have excessive corrosion resistance. When polished, it profits a very vibrant surface, that's used to plate other metals on the way to shape a defensive and attractiveprotecting.

Chromium is mined as chromate ore. Globally this ore is to be had in India, South Africa, Finland, Zimbabwe, Kazakhstan and the Philippines. Commercially, chromium is constituted of chromite the use of silicothermic or aluminothermicreactions. Roasting and leaching methods are also used.

IV. FINITE ELEMENT ANALYSIS

The finite element approach (FEM) is a numerical method for fixing troubles of engineering and mathematical physics. Typical problem areas of interest consist of structural analysis, heat switch, fluid flow, mass transport, and electromagnetic capacity. The analytical answer of those troubles generally requires the answer to boundary fee problems for partial differential equations.

The finite element approach components of the hassle effects in a device of algebraic equations. The approach approximates the unknown function over the domain. To solve the trouble, it subdivides a massive device into smaller, simpler components which are known as finite elements. The easy equations that version these finite factors are then assembled into a bigger machine of equations that fashions the complete trouble. FEM then makes use of variation methods from the calculus of variations to approximate a solution by minimizing an associated mistakes function.

MODELING & ANALYSIS

The 3D model of HSS tool is designed by using the use of CREO software. CREO, one of the quality three-D integrated software and choice of mechanical modeling paintings. It creates better visualization of three-D version of aspect and plays first-rate for FEA work.

The Finite Element Analysis work is executed with the ANSYS software. The structural evaluation is accomplished with the proposed HSS device.

TOOL DESIGN:

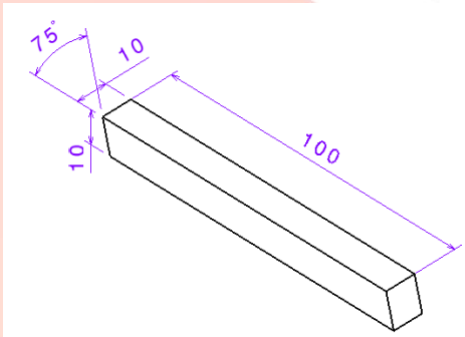

Figure 2: 2D Design

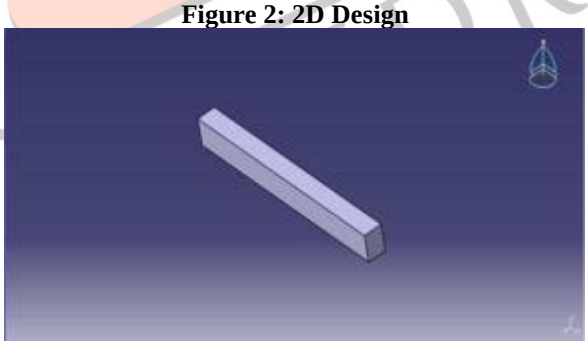

Figure.3 Specimen without Coating

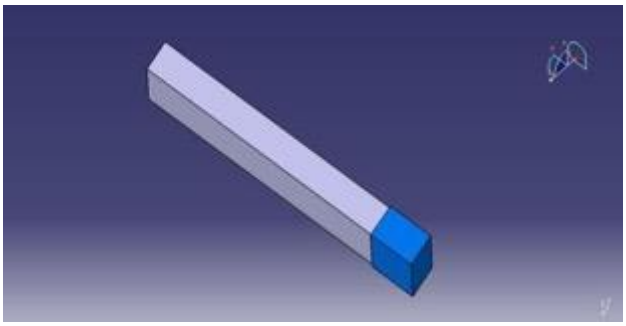

Figure.4 Specimen with Coating

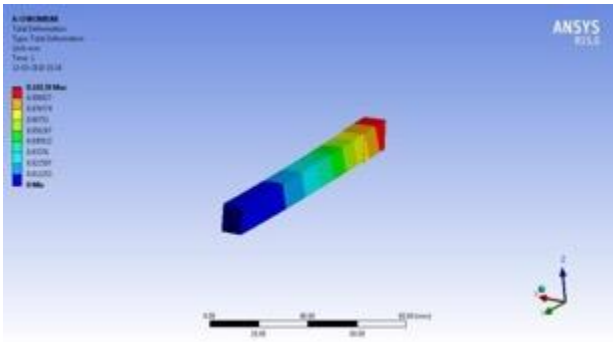

Figure.5. Mesh Geometry (Uncoated Specimen)

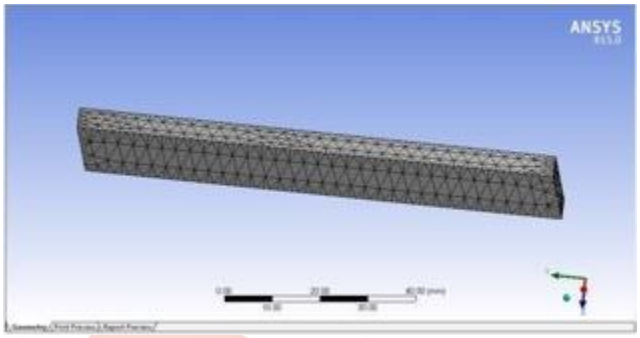

Figure 6.Deformation of Zirconia Material

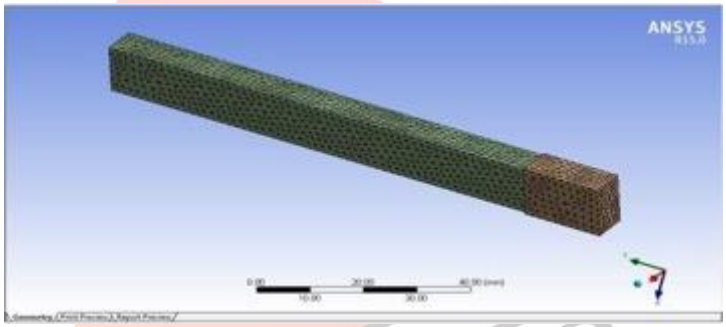

Figure 7. Deformation of Chromium Material

V. RESULT & DISCUSSION

HSS Tool Results without Coating

Materials Without coating	Total Deformation Mm	Stress (Mpa)	Strain
Hss Without coating	0.114	42.85	0.0023

HSS Tool Results With Coating

Materials Coating	Total deformation	Stress (Mpa)	Strain(Mpa)
Zirconia	0.1013	42.245	0.000211
Chromium	0.1012	42.154	0.00014
Zr-Cr	0.1012	41.996	0.00016

VI. CONCLUSION

Only a few days in economically developing countries, metal cutting is a significant industry, albeit limited relative to the consumer industries it represents. The automobile, rail, shipbuilding, aircraft manufacturing, home appliances, consumer electronics, and construction industries all have large machine shops with several thousands of employees engaged in machining. Maximum deformation of the HSS instrument without coating is 0.114 mm, stress is 42.85 Mpa and strain is 0.0023. Total deformation of the HSS tool with zirconia covering is 0.1013 mm, stress is 42.245Mpa and strain is 0.000211. Total deformation of the HSS tool with chromium cover is 0.1012 mm, stress is 42.154Mpa and strain is 0.00014. The gross deformation of the HSS instrument with Zr-Cr coating is 0.01012 mm, Stress is 41.996Mpa, and Strain 0.00016. Here the proposed device HSS tool will provide better machining efficiency. Via this present project research we may also propose the latest and most sophisticated machining method.

VII. REFERENCES

[1]. Ivin S Bovas, Anoop M R, "WEAR RATE ANALYSIS OF NANO COATED CUTTING TOOL" – IJARSE (Vol – 4, Nov-2015).
[2]. M.Yugandhar, N.Harish Kumar - "Study of Mechanical and Tribological Properties of Coated TiN and TiC on cutting tools by varying the composition of Nickel and Carbon".
[3]. Vikas Patidar, Prof. Kamlesh Gangrade, Dr. Suman Sharma - "Wear Analysis of Multi Point Milling Cutter using FEA". Kyung Hee Park, "TOOL WEAR ANALYSIS IN VARIOUS MACHINING PROCESSES AND STUDY OF MINIMUM QUANTITY LUBRICATION (MQL)".
[4]. "Coatings of Cutting Tools and Their Contribution to Improve Mechanical Properties: A Brief Review", IJAER (Vol – 13, 2018) pp.11653-11664.
[5]. L. Ninga, S.C. Veldhuis, K. Yamamoto. "Investigation of wear behavior and chip formation for cutting tools with nano-multilayered TiAlCrN/NbN PVD coating". International journal of Machine tool and Manufacture 48 (2008) 656-665, 13 November 2007.
[6]. T. Cselle, O. Coddet, C. Galamand, P. Holubar, M. Jilek, J. Jilek, A. Luemkemann, M. Morstein."Triple Coatings –New Generation of PVD-Coatings for Cutting Tools". Scientific society for Mechanical Engineering, 20th December 2008.
[7]. Guojia Ma, Liliang Wang, Haoxiang Gao, Jie Zhang, Tom Reddy hoff. "The friction coefficient evolution of a TiN coated contact during sliding wear". Applied surface science 345 (2015) 109-115, 31 March 2015.
[8]. Faissal Chegdani, Sabeur Mezghani, Mohamed EL Mansori. "Experimental study of coated tools effects in dry cutting of natural fiber reinforced plastics". Surface and coatings technology, July 2014.
[9]. T. Sampath Kumar, S. Bala sivanandha Prabu, Geetha Manivasagam. "Metallurgical Characteristics of TiAlN/AlCrN Coating Synthesized by the PVD Process on a Cutting Insert".
[10]. Samir Khamel, Nouredine Ouelaa and Khaider Bouacha. "Analysis and prediction of tool wear, surface roughness and cutting forces in hard turning with CBN tool".