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Study of Mechanical and Tribological Properties of Coated TiN and TiC on cutting tools by varying the composition of Nickel and Carbon

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ABSTRACT

It has been well established that advanced surface coatings on cutting tools improve wear resistance by modifying the contact conditions between the chip and tool interface. As a result of the recent developments in cutting tool industry, coated tools have made a significant contribution to the metal cutting operations in terms of tool life, cutting time and machining quality. The challenge of modern machining industries is focused mainly on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product .In general, the most important point in machining processes is the productivity, achieved by cutting the highest amount of material in the shortest period of time using tools with the longest life time.The present research work describes the development, Mechanical, Tribological performance of Nano material coating of (Titanium Nitride),TIC(Titanium Carbide), on Tungsten Carbide cutting tool. The Mechanical, Tribological properties of Tin, TIC, are to be compared with uncoated Tungsten carbide cutting tool. And also different coating methods like Chemical Vapour Deposition, Physical Vapour Deposition Method, can be used for comparision. The present work will help to find the tool life and wear behavior of the each coated tool and it will help to find the best tool coating applicable for the cutting tool. The experiments of Mechanical, Tribological properties tests have to be conducted as per ASTM standards. Scanning Electron microscope (SEM) analysis has to be done for investigating the surface morphology of Tungsten Cutting tool. The coated cutting tool have to be modelled using suitable assumption and analyzed by means of finite element method using ANSYS software. Both results of Experimental and ANSYS software are to be compared.

***Keywords**: Nano coatings,Titanium Nitride, Titanium Carbide ,NanoFireX ,Mechanical and Tribological Properties,ANSYS.*

I. INTRODUCTION TO PROBLEM IDENTIFICATION

The cutting tool industries are constantly facing the very common industrial challenge of reducing cost of machined parts and at the same time improving the quality of the machined surface. These issues are generally addressed by improving cutting tool materials, applying advanced coating, improving the geometry and surface characteristics of the cutting tools, optimising machining parameters The need for the use of newer cutting tool materials to combat hardness,wear situation has resulted in the emergence surface coatings,which contributes in reducing cost per machined parts through increasing productivity and extending tool life .The benefits of advanced coatings are of higher hardness, low friction at the chip tool contact, higher wear resistance, high hot hardness and high thermal and chemical stability. The machined surface quality with the coated cutter can also be improved by avoiding any built-up edge due to the reduced friction between the tool and work piece.Based on the abundant advantages of surface coatings and the requirement of industrial development and requirement ,it is necessary to develop TiN,TIC, coatings on Tungsten carbide cutting tool . Based on these driving force, it is necessary to do surface coating of TiN,TIC, on Tungsten Carbide cutting tool to give good mechanical and tribological properties.

1.1. 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.

II. LITERATURE REVIEW

The purpose of literature review is to provide background information of the issues to be considered in this work and to emphasize the relevance of the present study. **Thakur Prasad Yadav [1]**Synthesis of nanomaterials by a simple, low cost and in high yield has been a great challenge since the very early development of nanoscience. Various bottom and top down approaches have been developed so far, for the commercial production of nanomaterials. Among all top down approaches, high energy ball milling, has been widely exploited for the synthesis of various nanomaterials, nanograins, nanoalloy, nanocomposites and nano -quasicrystalline materials. Mechanical alloying techniques have been utilized to produce amorphous and nanocrystalline alloys as well as metal/non-metal nano-composite materials by milling and post annealing, of elemental or compound powders in an inert atmosphere. Mechanical alloying is a non-equilibrium processing technique in which different elemental powders are milled in an inert atmosphere to create one mixed powder with the same composition as the constituents. In high-energy ball milling, plastic deformation, cold-welding and fracture are predominant factors, in which the deformation leads to a change in particle shape, cold-welding leads to an increase in particle size and fracture leads to decrease in particle size resulting in the formation of fine dispersed alloying particles in the grain-refined soft matrix. By utilizing mechanical milling various kind of aluminium/ nickel/ mag-nesium/ copper based nanoalloys, wear resistant spray coatings, oxide and carbide strengthened aluminium alloys, and many other nanocomposites have been synthesized in very high yield. The mechanical milling has been utilized for the synthesis of nanomaterials either by milling and post annealing or by mechanical activation and then applying some other process on these activated materials. This review is a systematic view of the basic concept of mechanical milling, historical view and appli-cations of mechanical milling in the synthesis of various nanomaterials, nanosomposites, nnaocarbons and nano quasicrys-talline materials.

Nai-chao CHEN, Fang-hong SUN[2] Aluminum−silicon (Al−Si) alloy is very difficult to machine and diamond tools are considered by far the best choice forthe machining of these materials. Experimental results in the machining of the Al−Si alloy with diamond coated inserts are presented.Considering the fact that high adhesive strength and fine surface morphology play an importance role in the applications of chemicalvapor deposition (CVD) diamond films, multilayer technique combining the hot filament CVD (HFCVD) method is proposed, bywhich multilayer diamond-coating on silicon nitride inserts is obtained, microcrystalline diamond (MCD)/ nanocrystalline diamond(NCD) film. Also, the conventional monolayer NCD and MCD coated inserts are produced for comparison. The as-depositeddiamond films are characterized by field emission scanning electron microscopy (FE-SEM) and Raman spectrum. All the CVDdiamond coated inserts and uncoated insert endure the aluminum−silicon alloy turning to estimate their cutting performances. Amongall the tested inserts, the MCD/NCD coated insert exhibits the perfect behavior as tool wear due to its very low flank wear and nodiamond peeling.

M. Narasimha et al.,[3] There are different types of cutting tools in use for machining various materials for the multiple operations in order to produce components. For the past several years the materials of the cutting tools are the same, but due to continuous improvements in enhancing the life of the cutting tools, different methods/process are in progress for produc ing the tools. The cutting tool manufacturers with their rich R&D experience and continuous innovations, carrying on their production activity to meet the challenges of the market demand. Solid carbides are the most popular and most common high production tool Nanoscience and Nanotechnology 2012, 2(3): 22-48 DOI: 10.5923/j.nn.20120203.01 materials available today. The productivity enhancement of manufacturing processes is the acceleration of improved cutting tools with respect to the achievement of a superior tribological attainment and wear -resistance . This resulted in developing hard coating for cutting tools; these hard coatings are thin films of one layer to hundreds of layers. These hard coatings have been proven to increase the tool life by as much as 10 folds through slowing down the wear phenomenon of the cutting tools. This increase in tool life allows for less frequent tool changes, therefore increasing the batch sizes that could be manufactured and in turn, not only reducing manufacturing cost, but also reducing the setup time as well as the setup cost. In addition to increasing the tool life, hard coating deposited on cutting tools allows for improved and more consistent surface roughness of the machined work piece.

K.Subramanyan et al.,[4] The challenge of modern machining industries is mainly focused on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product with reduced environmental impact. Surface roughness plays an important role in many areas and is a factor of great importance in the evaluation of machining accuracy. Hard turning is a process, in which materials in the hardened state (40-60 HRC) are machined with the single point cutting tools. The traditional method of machining the hardened materials includes rough turning, heat treatment, and then grinding process. Hard turning eliminates the series of operations required to produce the component and thereby reducing the cycle time and hence resulting in productivity improvement. The various advantages of hard tuning are the higher productivity, reduced set up times, surface finish closer to grinding and ability to machine the complex parts.

Various work materials which can be machined by the hard turning process include high speed steels, die steels, bearing steels, alloy steels, case hardened steels, white cast iron and alloy cast iron. Rigid machine tools with adequate power, very hard and tough tool materials with appropriate tool geometry, tool holders with high stiffness and appropriate cutting conditions are some of the prerequisites for hard turning.

Titus .B. Watmon et al.,[5] Many papers have been presented before which show coating of cutting tools often yield decreased wear rates and reduced coefficients of friction. Although different theories are proposed in those literatures covering areas such as; hardness theory, diffusion barrier theory, thermal barrier theory, reduced friction theory, most have not dealt with the question of how and why coating of tool substrates with hard material such as Titanium Nitride (TiN), Titanium Carbide (TiC) and Aluminium Oxide transforms the performance of cutting tools. The paper discusses the complex interrelationship that encompasses the thermal barrier function and the relatively low sliding friction coefficient of TiN. It concludes by saying that, the coating on tools lowers the friction coefficient and increase wear resistance long after the original coating-substrate interface, has been penetrated.

Overall, the main aim of applying a TiN coating to a metal cutting tool is a cost-cutting measure to reduce tool replacement costs and produce good surface finish. Many authors have discussed the performance of turning, drilling, and tapping HSS tools coated with thin layers of titanium nitride by PVD method. TiN coatings were found to be most beneficial when turning at high speed but of little value on taps which cannot be operated at speeds high enough to take advantage of this coating . Obviously, all these depend on the fundamental requirement of sufficient adhesion to the substrate in order that the tool can be able to have enhanced wear resistance.

The requisite of high wear resistance tools is usually essential in a metal machining environment to help keep replacement and changeover costs low. Most metal cutting people know that it is the wear resistance of the substrate, and not the inherent wear resistance of the coatings that matters. Consequently, the coating should be able to yield maximum protection at the critical contact point between the tool and work piece in order to enhance the wear resistance capability.

The capability to cut at much higher speeds has generated more interest to metal machining industry than reduced tool wear that is associated with the tool cost and the tool change time, which normally amounts to less than 3% of the total machining cost . Cutting edges of coated tools have improved properties with the ability to increase the cutting speed, the feed, and the depth of cut or any combination of these parameters. The ability to increase productivity makes more sense than reduced tool wear

The cutting performance of tools includes cutting and thrust forces, chip appearance and the resulting surface finish. Improvement in the innovative properties allows the cutting speed to be increased and the feed too, this leads to increased productivity. The whole idea is to increase production to a higher rate rather than to obtain an increased tool life. The basic requirement for the efficient rough machining of steel is a tool material that exhibits the toughness of the tungsten carbide while giving the superior wear resistance of titanium nitride. For this reason, much interest is being shown in the coating of cemented carbides with a thin layer of harder material. These coatings are between 5 and 8 µm thick and are found to practically eliminate inter-diffusion between the chip and the tool . Eventually, when the coating is worn off by abrasion, the tool wear rate becomes the same as that for the uncoated conventional tool. Successes have been reported with coatings of titanium carbide , titanium dioxide , and titanium nitride . Although not demonstrated, it was assumed the best results would be obtained with a TiN coating on a solid tool. The TiN coating significantly reduces the wear rate of cutting tools when sliding against a work piece. The PVD techniques make it possible to extend by 50 – 100% the life of tools made from hot work steels.

In early 1980s, coating of Tungsten tools with TiC by PVD process was introduced, while TiN coatings about 1985 and both types of coatings enabled higher cutting speeds. There is conclusive evidence to say that coating with hard substances like TiN, TiC and Al203 improves cutting tool capabilities. Hence, the tools can therefore, cut at higher speeds for improved productivity with reduced power requirements.

J. Wang et al., [6] In this paper, the effects of multiple layer hard surface coatings of cutting tools on cutting forces in steel turning are presented and discussed based on an experimental investigation with different commercially available carbide inserts and tool geometries over a range of cutting conditions. The cutting forces when turning with surface coated carbide inserts are assessed and compared qualitatively and quantitatively with those for uncoated tools. It shows that hard surface coatings reduce the cutting forces, although the reduction is marginal under lighter cutting conditions. The cutting force characteristics for surface coated tools are also discussed and show similar trends to those of uncoated tools.

Machining is a versatile shaping process of major importance for component manufacturing. The need for improving the technological performance of machining operations as assessed by the forces, power, tool-life and surface finish has long been recognized to increase the economic performance of the machining operations. As such, continual improvements in the technological performance of machining operations have been sought through research and development including new and more wear resistant tool materials as well as new geometrical tool designs. One of the important cutting tool improvement in recent years has been the introduction of hard surface coatings on the substrates such as carbides. Hard coatings such as TiN, TiC and Al2O3have been used and claimed to significantly improve the tool-life, enabling components to be machined at higher ‘economic’ speeds. It has also been claimed that such coatings reduce the forces and power due to lower friction coefficients on the rake face. However, it is interesting to note that the investigations on hard surface coatings of cutting tools were predominantly orientated towards the various aspects of wear patterns. Little has been reported on the quantitative assessment and information of hard surface coatings in terms of cutting forcesto guide the selection and design of machine tools, cutting tools and fixtures as well as the selection of economic cutting conditions.

M. Sarwar et al.,[7] The benefits of applying advanced coatings on both single point and multipoint cutting tools such as improvement of productivity, tool life, machined surface quality etc. have been realized by the surface engineering researchers , commercial coaters and end users . The demand for advanced coatings in cutting tool industries is continually growing to meet the challenges of high speed machining, dry machining, near net-shape machining, machining of hard-to-cut materials etc. Advance coatings with excellent properties on flat coupon in a laboratory deposited by modern deposition technologies should not be taken for granted in improving the performance of complex shaped cutting tools in aggressive cutting environments. This is because the end performance of coated cutting tools is not only dependant on the coating itself but also on the substrate material, geometry, surface finish and cutting edge conditions prior to coating deposition. The paper presents case studies with examples of successes and failures of advanced coatings on different multipoint cutting tools (e.g., milling cutters, bandsaws, circular saws, holesaws etc.). The future strategy for developing successful coating technology for cutting tools should be directed towards adopting a systems approach to bridge the communication gap amongst the cutting tool manufactures, tool coaters and end users.

In addition to the well-established monolayer single-phase coatings such as TiN, TiC etc., efforts have been made in developing several new coating architectures such as multicomponent, multiphase, multilayer, gradient, superlattice, nanocomposites etc., which promise better performance for tough machining applications. With the success of monolayer coating, numerous multicomponent coatings have evolved in response to the demand from cutting tool industries (e.g., higher wear and oxidation resistance). AlTiN and AlCrN are the prime examples that are being applied in high speed and dry machining applications owing to their high wear resistance at elevated temperatures (1000° C). The multilayer coating is more resistant to cracking which makes the coating stronger on cutting edges that experience mechanical shock from difficult-to-machine materials and in interrupted cutting (Milling, Hobbing etc.). Multilayer PVD coatings have already seen greater use in industrial applications. The envelope has been pushed even further with superhard nanostructured composite coatings, a new branch of materials that offer the opportunity to design unique physical and mechanical properties for specific application areas. Nanocomposite coatings have proven to deliver high hardness of 40 to 50 GPa and high heat resistance of up to 1,100° C, making them suitable for dry and high speed machining . The nanocomposite coatings are becoming available in the commercial production for machining applications. Hard-solid lubricant based coatings, which combine low friction soft material (e.g., MoS2, WS2, diamond-like carbon) and wear resistant hard material (e.g., TiN, TiAlN etc.) in the form of bilayer, multilayer or composite, are also promising for dry machining. There is also considerable interest in developing crack-free, defect-free, smooth and thin PVD Al2O3 coating to outperform thick CVD Al2O3 coatings.A variety of superhard coating materials have also been developed such as cubic boronnitride, diamond-like carbon (DLC), carbon nitride and polycrystalline diamond.Despite having superhardness nature of these coatings, they have found limited machining applications due to lack of thermodynamic stability, high internal stress leading to poor adhesion and high chemical affinity in machining ferrous materials .It is well established that the properties of workpiece material particularly yield stress dictates the chip formation mechanism, which also influences the cutting forces, tool tip temperature, cutter performance and finally the cutter life . The end users of cutting tools should assess workpiece properties beforehand to select the compatible coating for optimum machining. Surface coatings are clearly valuable in extending the life of cutting tool by arresting or slowing down wear and in improving the quality of the machined surface. The extension of tool life with coatings even when operated at the conventional machining parameters reduces cost associated with tool and tool changing time, but it has very little contribution in increasing the productivity or reducing the machining cost, as cutting tool cost is only 3-5% of total machining cost . A user of coated tools will financially benefit (lower the cost of the operation by reducing cycle times) only when the coated tool is used at high feeds and speeds. As a rule of thumb, cutting parameters can be increased from 20% to 50% with a coated tool depending on the type of machining and workpiece material to be machined. Improved machine tool stability is vital to fully exploit the potential of coated tools by operating at high metal removal rates. Wear modes (crater, flank and notch wear) and mechanisms (abrasive, adhesive and diffusive wear) in cutting tools for a particular application need to be evaluated to select the appropriate coating. Ideally, the coating on the cutting tool should fail by gradual wear associated with predictable and reliable tool performance, but not by adhesive or cohesive failures, macro-/micro-chipping etc., which rapidly raises cutting forces and tool tip temperatures leading to a premature tool failure. Finite element modeling could be used as a potential supplementary tool in addition to the experimental investigation to simulate stress and heat generation in coated cutting tools.Examples of machining test results demonstrated that TiN coating applied on multipoint cutting tools could deliver considerable improvement in machining performance and product quality. However, it is apparent that manufacturing method and quality control of multipoint cutting edges must be fine-tuned before realising substantial improvement in performance and reliability with advanced coating applied onto them. Undoubtedly, TiN coating on cutting tool will continue to be a choice in the cutting tool industry, while the other more advanced coatings such as TiN, TiC, will slowly enter into the cutting tool industry where high wear and oxidation resistance are primary concerns. Current trends suggest that in the next few years the cutting tool industry will see widespread application of advanced nanocomposite coatings, which offer the possibility of tailored made multifunctional properties (e.g., super-hardness, toughness and oxidation resistance) for particular applications. In order to gain maximum benefit from surface engineered tools, a total systems approach based on substrate materials, tool design, manufacturing processes and quality control are absolute vital Machining performance of Titanium carbide(TiC) as Tool coating Machining performance of tool coating is subjected to investigate the capabilities and limitations of coating material to different substrate (base material of cutting tool) in machining .To achieve the machining performance of tool coating ,tool’s material must possess high strength at elevated temperature ,good oxidation resistance ,low coefficient of thermal ,resistant of wear ,chemical reactance resistance and high conductivity and can withstand for a long time for machining.In addition to increasing the tool life,hard coating deposited on cutting tools allows for improved and more consistent surface roughness of the machined workpiece. The surface roughness of the machined workpiece changes as the geometry of the cutting tool changes due to wear and slowing down the wear process means more consistency and better surface finish.

3.Detailed Experimental Procedure:-

TiN and TiC are deposited on a tungsten carbide cutting tools by physical vapor deposition by cathodic arc (arc-PVD) using a system Bias and Cathodic Arc Evaporation (Oerlikon-Balzers). For the deposition of the coating, TiN and TiC (wt%) alloy was used in a controlled nitrogen atmosphere. The deposition time was adjusted to obtain a layer with a predetermined thickness of(2 μm-20 μm) . The deposition of coating was made under a nitrogen atmosphere to ensure the nitriding of the compound and, next, the sample was subjected to a heat treatment at a temperature of 500 °C during 4 hours under an inert atmosphere. Heat treatment was made with the aim of modifying the coating microstructure, extending the diffusion of nitrogen, and leading to the formation and growth of TiN precipitates. Additionally, heat treatment is very beneficial to eliminate the amorphous phases formed during coating processes and the phases could become more crystalline and also could improve adhesion between coating and substrate. Besides, heat treatment also helps to obtain an improvement of structural integrity and a reduction of stress and fragility in coatings. The morphological characterization of the cross-section of the coated and uncoated tool was performed by two scanning electron microscopes:The elemental chemical analysis was done using an Energy Dispersive X-ray detector (EDXS) with a detection limit of 0.1 wt%. The crystalline structure was characterized by X-ray diffraction (GI-XRD PANalytical X'Pert PRO MRD) with grazing incidence from 20° to 80° and angle of incidence of 0.5°.

Hardness tests :-Hardness tests were conducted by means of a MicroVickers Clemex MMT-X7 indenter equipped with a pyramidal diamond tip Berckovich applying 1 kgf during 10 seconds.

The readings will be taken for tungsten carbide cutting tool coted with TiN and TiC for various cutting tools of varying wt% (2 µm -20µm).and after stdying the readings,the wt% of Tin and TiC will be recommended.

Tungsten carbide coated with (TiN)	Vicker Hardness number	modulus of elasticity	Remarks
TiN **wt%-2**	2400	251 GPa	
TiN **wt%-4**	2450	248GPA	
TiN **wt%-8**	2500	239 GPA	
TiN **wt%-10**	2485	251 GPa	
TiN **wt%-12**	2584	248GPA	
TiN **wt%-14**	2767	269 GPA	
TiN **wt%-16**	2423	251 GPa	
TiN **wt%-18**	2560	238GPA	
TiN **wt%-20**	2523	259 GPA	

TABLE-1 Hardness test results

Tungsten carbide coated with (TiC)	VickerHardness number	Remarks
TiC wt%-2	2423	251 GPa
TiC wt%-4	2560	238GPA
TiC wt%-6	2523	259 GPA
TiC wt%-8	2485	251 GPa
TiC wt%-10	2584	248GPA
TiC wt%-12	2767	269 GPA
TiC wt%-14	2485	251 GPa

TiC wt%-16	2584	248GPA
TiC wt%-18	2767	269 GPA
TiC wt%-20	2523	259 GPA

TABLE-2 Hardness test results

3.1. Wear Test Procedure

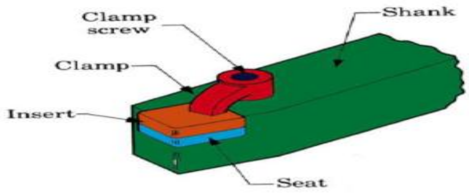
A pin-on-disc device with round tool inserts was applied to conduct friction and wear tests in which both the friction coefficient and the linear wear of the tribo-pairs were continuously recorded versus sliding distance. The volumetric wear rate was used to compare the wear resistance of the tribo-pairs tested. Light microscopy (LOM), scanning electron microscopy (SEM) and X-ray microanalyses by EDAX were applied for observations of wear scars and wear products. The investigations of coating microstructures by optical microscopy (MO) and transmission electron microscopy (TEM) were performed. The examination of fun blades after the exploitation and the analysis of the obtained results was correlated with the performed microstructure observations and microhardness data of coatings. Though high-speed steel retains its importance for such applications as drilling and broaching, most metal cutting is carried out with carbide tools.

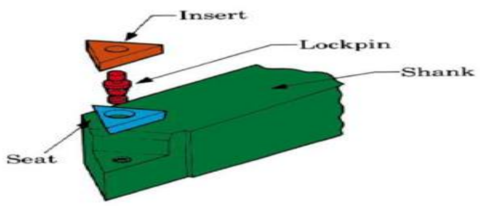
Wear test will be carried out on CSM Instruments Tribometer by pin-on-disk test in dry.The values of the coefficient of friction (μ) were obtained directly from the installed Tribox 4.1software. Sapphire ball with a diameter of 6 mm, roughness Ra = 0.02 μm and hardness of 2,300 HV was slid on the WC-Co substrate coated with the TiN. Surface roughness measurements were carried out with a Confocal Microscope Carl Zeis Axio CSM-700 on the coating surface; the average value of AlCrN-T sample was Ra = 0.86 μm. For the pin on disk test, the sapphire ball was fixed on the load arm and the sample was placed on a rotating disc with a rotating radius of 3 mm. The standard contact loads used were 1, 5 and 10 N. The sliding speed was 0.10 m/s with an acquisition rate of2.0 Hz and a distance of 1,500 m for the complete test. The temperature during the test was maintained at 26 ± 1 °C with a relative humidity of 30%–40%. The wear test results wil be noted down and the wear which shows less wear for that wt% coating will be recommended for practical application.

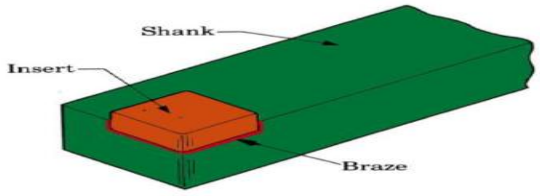
Property	**Minimum Value (S.I.)**	**Maximum Value (S.I.)**	**Units (S.I.)**	**Minimum Value (Imp.)**	**Maximum Value (Imp.)**	**Units (Imp.)**
Atomic Volume (average)	0.0062	0.0064	m^3/kmol	378.347	390.552	in^3/kmol
Density	15.25	15.88	Mg/m^3	952.027	991.357	lb/ft^3
Energy Content	150	200	MJ/kg	16250.8	21667.7	kcal/lb
Bulk Modulus	350	400	GPa	50.7632	58.0151	10^6 psi
Compressive Strength	3347	6833	MPa	485.441	991.043	ksi

Ductility	0.005	0.0074		0.005	0.0074	NULL
Elastic Limit	335	530	MPa	48.5876	76.87	ksi
Endurance Limit	285	420	MPa	41.3357	60.9158	ksi
Fracture Toughness	2	3.8	MPa.m$^{1/2}$	1.82009	3.45818	ksi.in$^{1/2}$
Hardness	17000	36000	MPa	2465.64	5221.36	ksi
Loss Coefficient	5e-005	0.0001		5e-005	0.0001	NULL
Modulus of Rupture	482	820	MPa	69.9082	118.931	ksi
Poisson's Ratio	0.2	0.22		0.2	0.22	NULL
Shear Modulus	243	283	GPa	35.2442	41.0457	10^6 psi
Tensile Strength	370	530	MPa	53.664	76.87	ksi
Young's Modulus	600	686	GPa	87.0226	99.4958	10^6 psi
Glass Temperature			K			°F
Latent Heat of Fusion	330	560	kJ/kg	141.874	240.755	BTU/lb
Maximum Service Temperature	1000	1050	K	1340.33	1430.33	°F

Melting Point	3000	3193	K	4940.33	5287.73	°F
Minimum Service Temperature	0		K	-459.67		°F
Specific Heat	184	292	J/kg.K	0.14239	0.225967	BTU/lb.F
Thermal Conductivity	28	88	W/m.K	52.4169	164.739	BTU.ft/h.ft^2.F
Thermal Expansion	4.5	7.1	10^{-6}/K	8.1	12.78	10^{-6}/°F
Breakdown Potential			MV/m			V/mil
Dielectric Constant						NULL
Resistivity	41.7	100	10^{-8}ohm.m	41.7	100	10^{-8} ohm.m





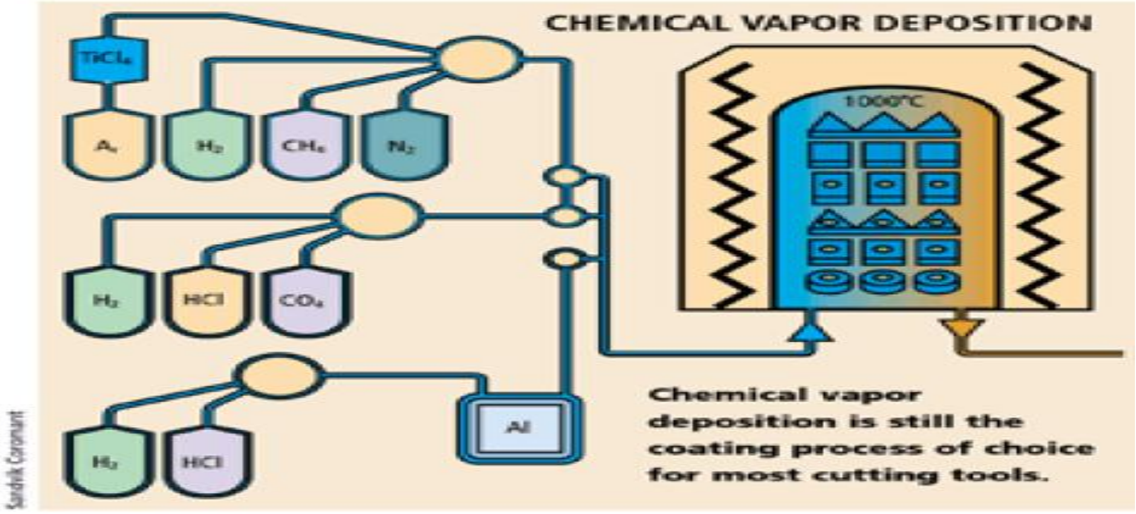


Ceramic and metallic (cermet) powders with microstructures engineered at the nano scale enable producing coatings having enough hardness, wear resistance, and durability to serve as a cost-effective replacement

4.Coating technique

4.1Chemical Vapor Deposition (CVD)

CVD will be used to coat TiN,TiC on tungsten carbide cutting tool. In the CVD process, the tools are heated in a sealed reactor to about 1000ºC (1830ºF). Gaseous hydrogen and volatile compounds supply the metallic and nonmetallic constituents of the coating materials, which include titanium carbide (TiC), titanium nitride (TiN). Thickness of CVD coatings can range from 2µm to 20µm.The high process temperature used in CVD ensures good bonding between the tungsten carbide cutting tool and the coating material. This increases the, toughness results in minimal.. chipping and improved surface finish. when machining stainless steels and other materials that are prone to causing built-up edge on the cutting tool.

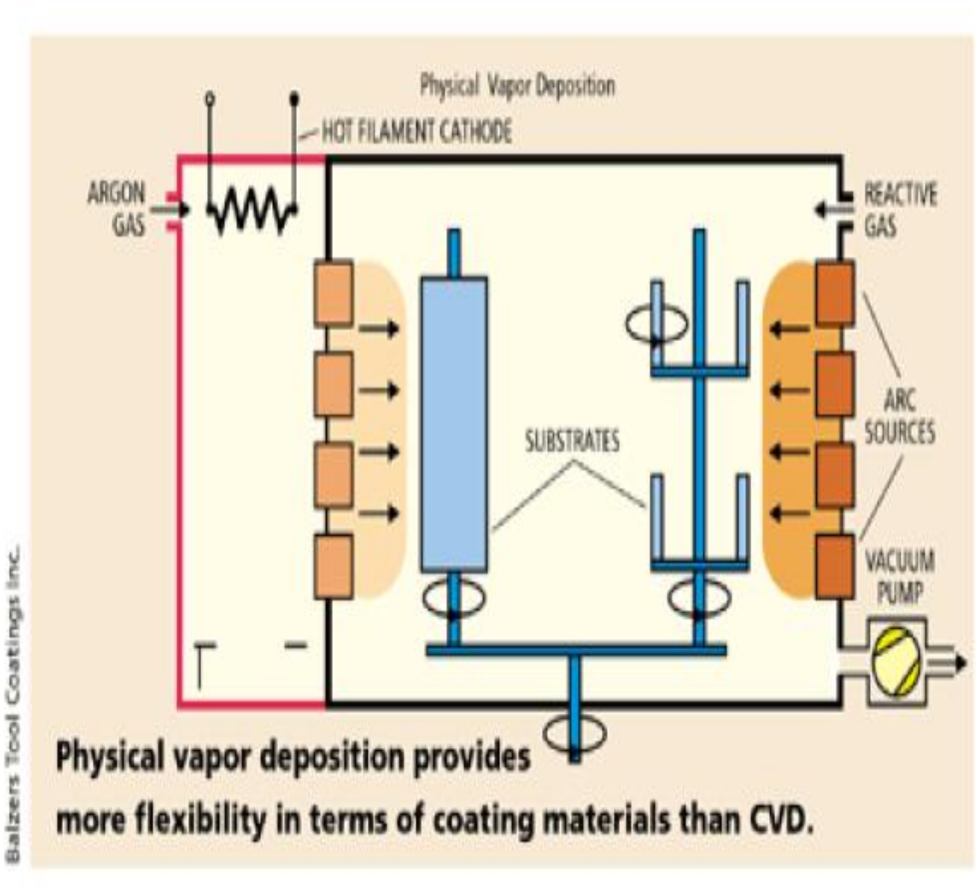


Chemical vapor deposition is still the coating process of choice for most cutting tools.

4.2.Physical Vapor Deposition (PVD)

PVD is the other major process used to produce cutting tool coatings. In PVD, the coating is deposited in a vacuum. The metal species of the coating ,obtained via evaporation or sputtering, reacts with a gaseous species (nitrogen or ammonia, for example) in the chamber and is deposited onto the substrate. Because PVD is a low-pressure process, the coating atoms and molecules undergo relatively few collisions on their way to the substrate. PVD is therefore a line-of-sight process that requires moving fixtures to ensure uniform coating thickness .The main difference between PVD and CVD is the former's relatively low processing temperature of PVD which is 500ºC (930ºF).

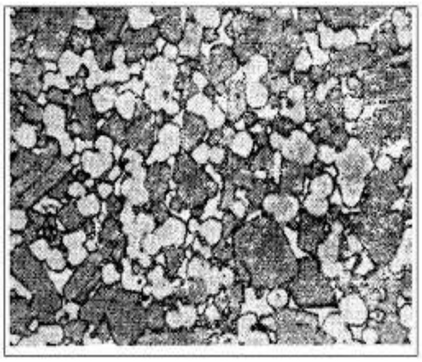
This lower processing temperature resulted in multiple benefits for PVD coatings. PVD coatings are essentially free of the thermal cracks that are common in CVD coatings. In PVD, processing temperatures are low enough that eta-phase formation is eliminated, allowing deposition of PVD coatings on sharp edges. Ability to coat sharp edges is also enhanced by PVD coatings' relative thinness versus CVD. Coating microstructures depend on processing conditions. Adjusting process parameters in PVD allows modification from a columnar to an equi-axed structure. PVD coatings also have very high built-in compressive stresses that help them resist crack initiation and propagation. Minimizing crack formation and propagation can help prevent premature tool failure, improving tooled security.



Surface roughness: It is done by using the Profilometer .The profilometer gives the out put with the help of graph.

V. METHODOLOGY

5.1Coating of nano powder on Tungsten Cutting tool



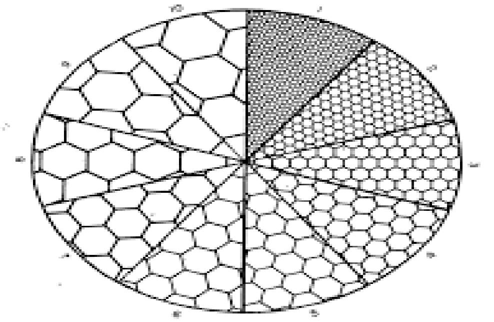
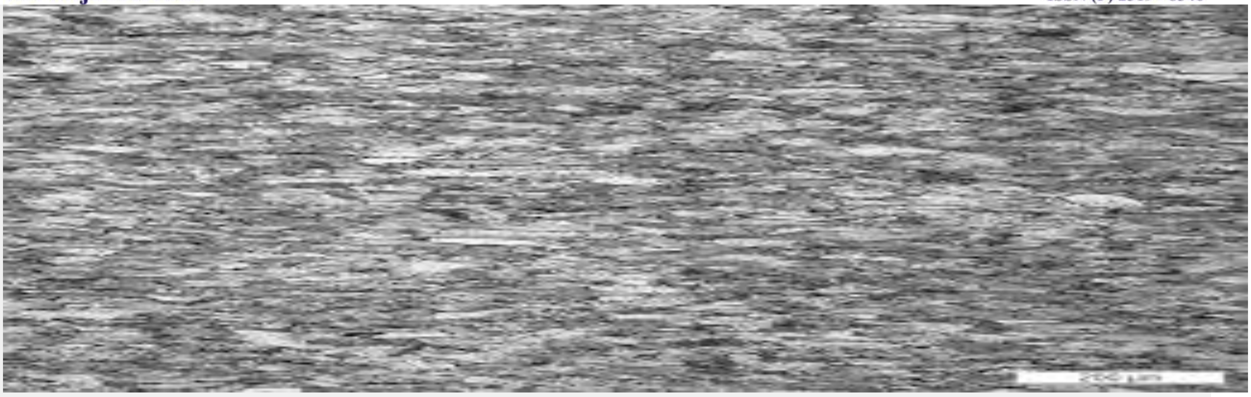
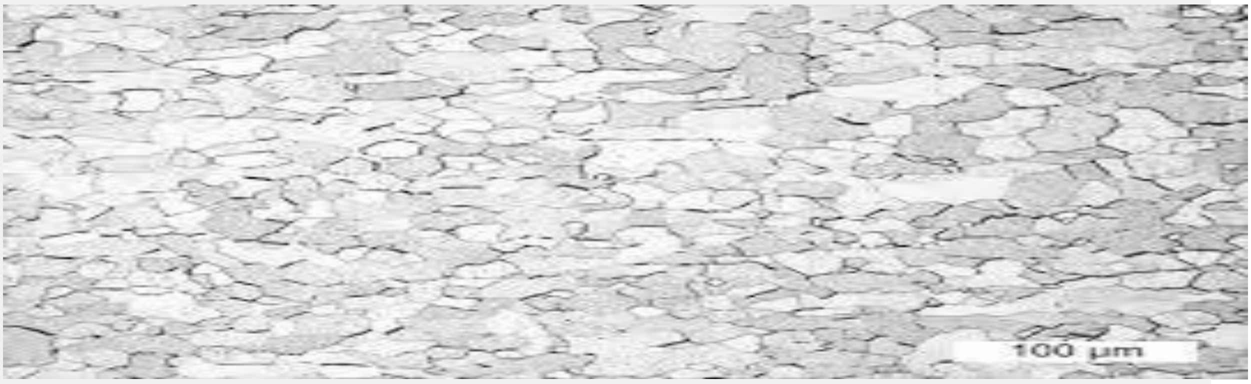
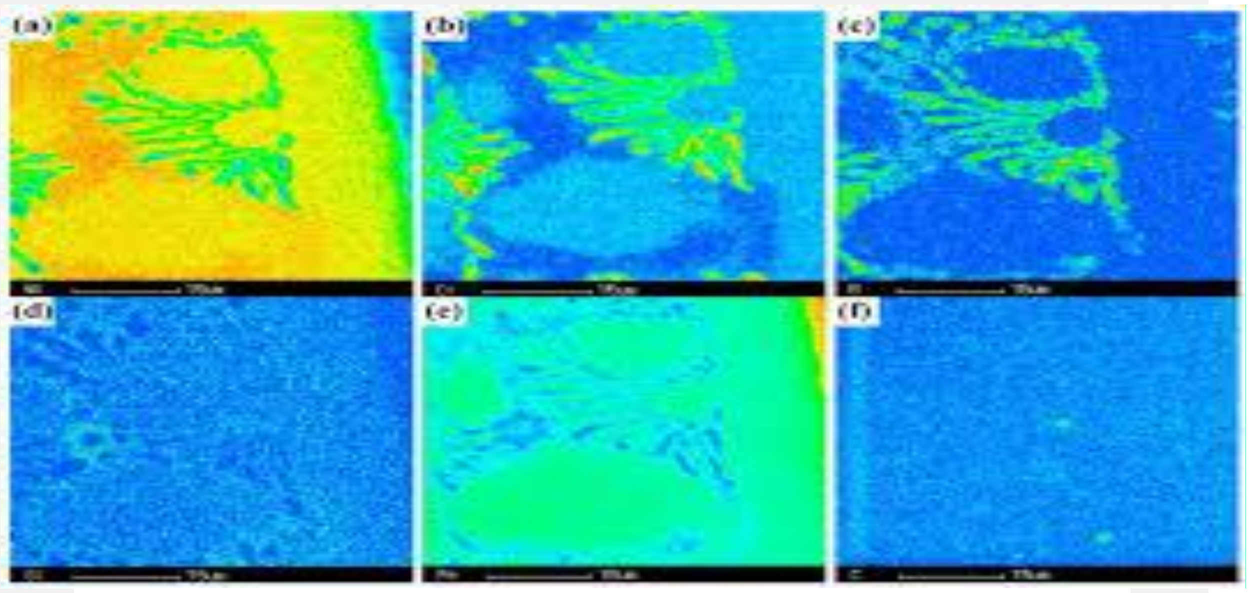


FIG. 3—CARBIDE GRAIN SIZE CHART, 1–10 μm AT 1500x
(1 μm = 0.00003937 in.)





Sem Pictures



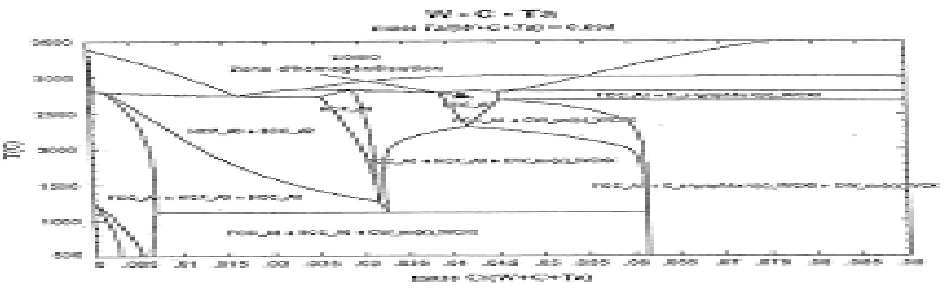


FIG. 12
(PRIOR ART)

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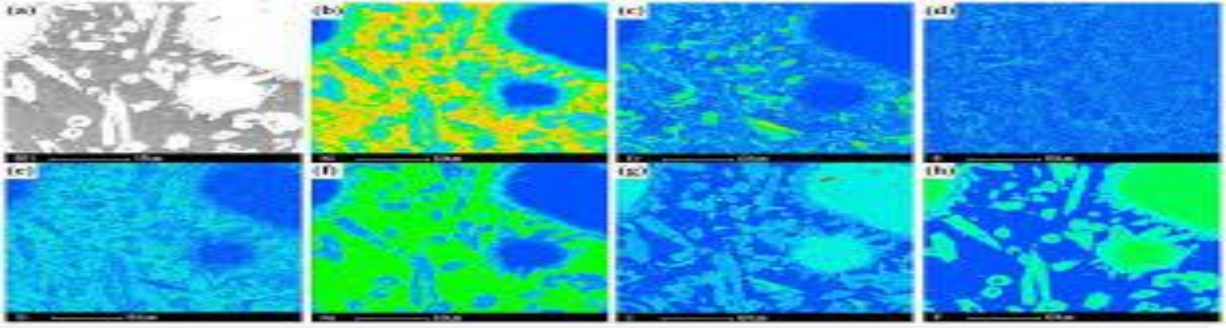
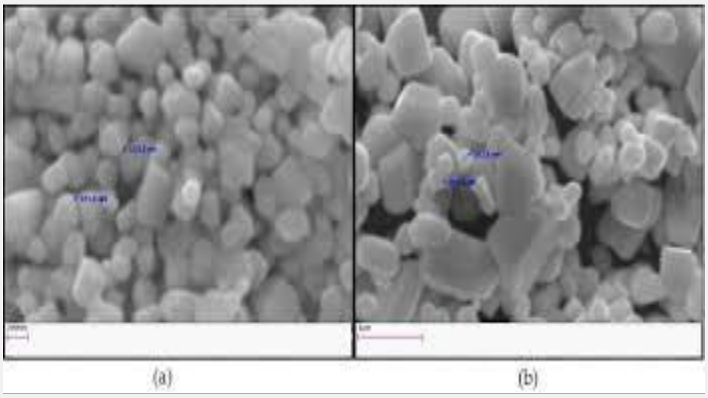
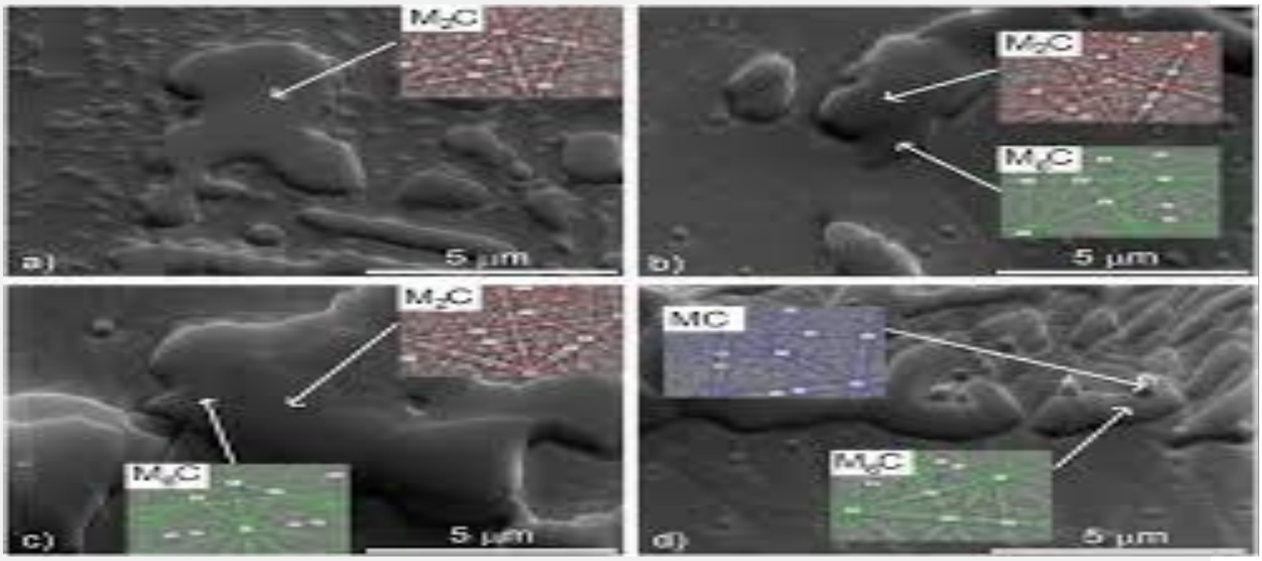
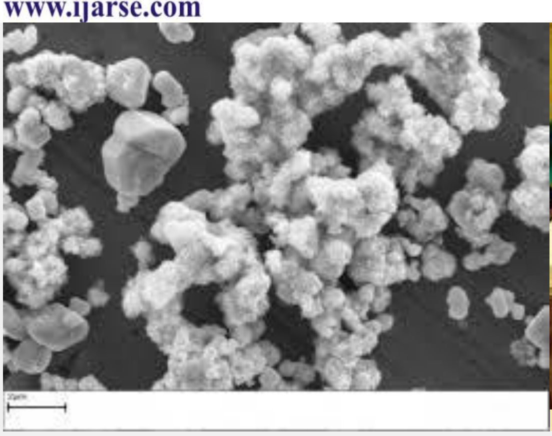
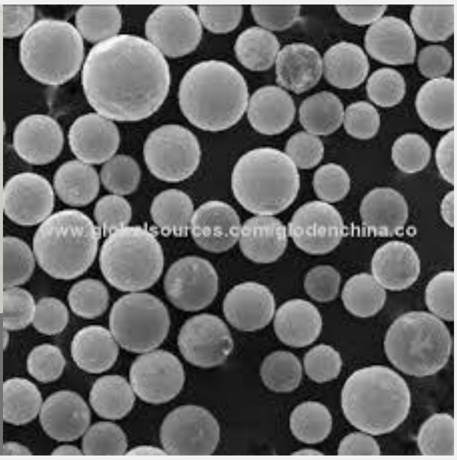



(a)

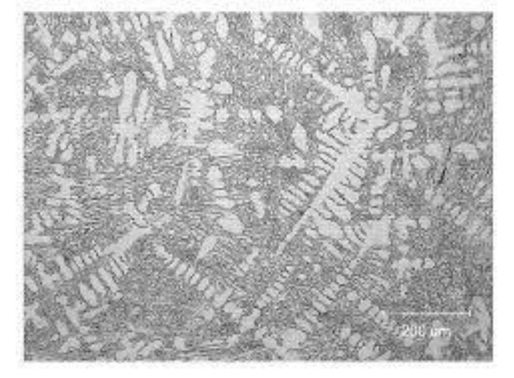
(b)







TOOL STRUCTURES AND Atoms bonding



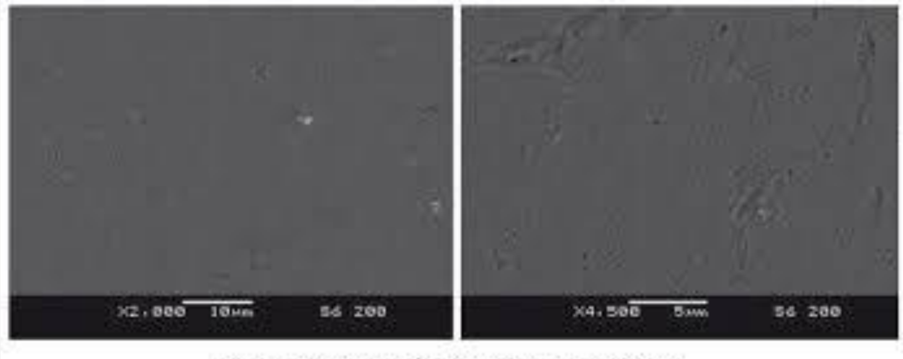
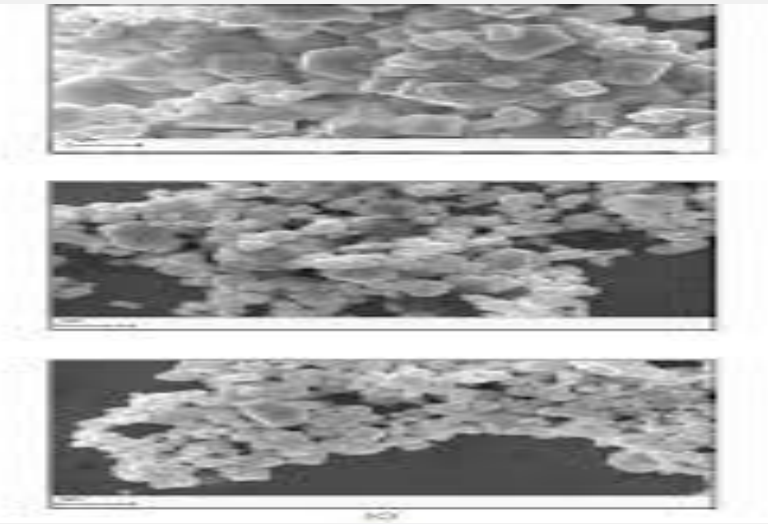
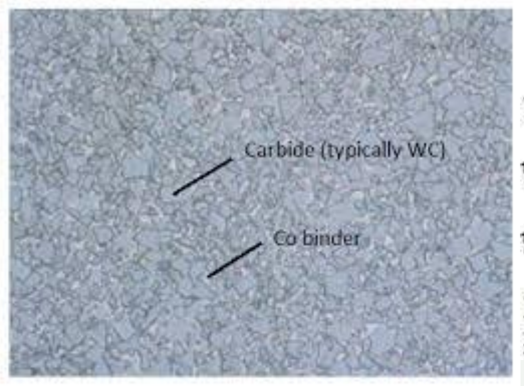
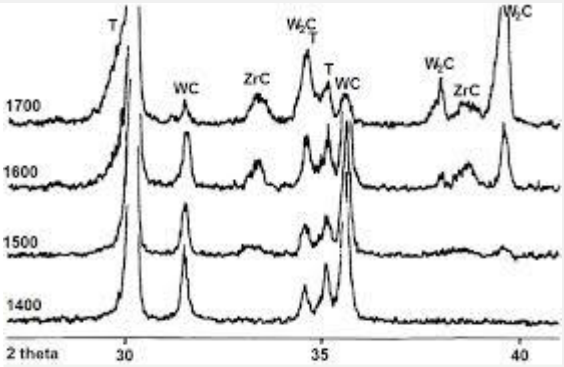


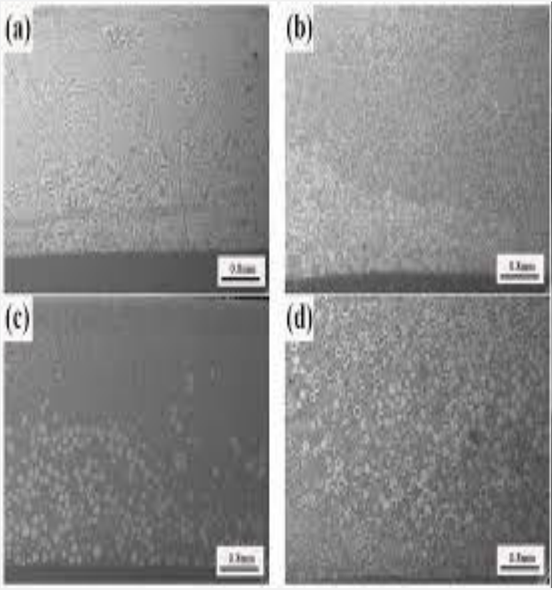
Figure 9. Microstructure of CoCrWC alloy coatings. I (A): 200.

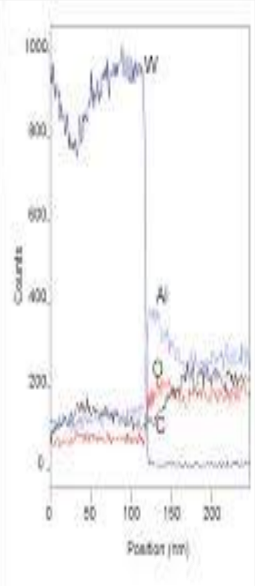


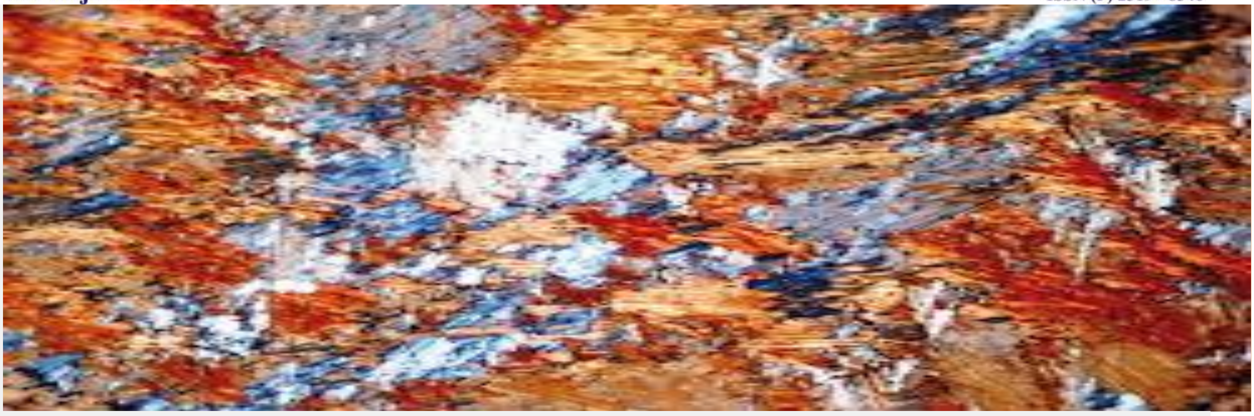


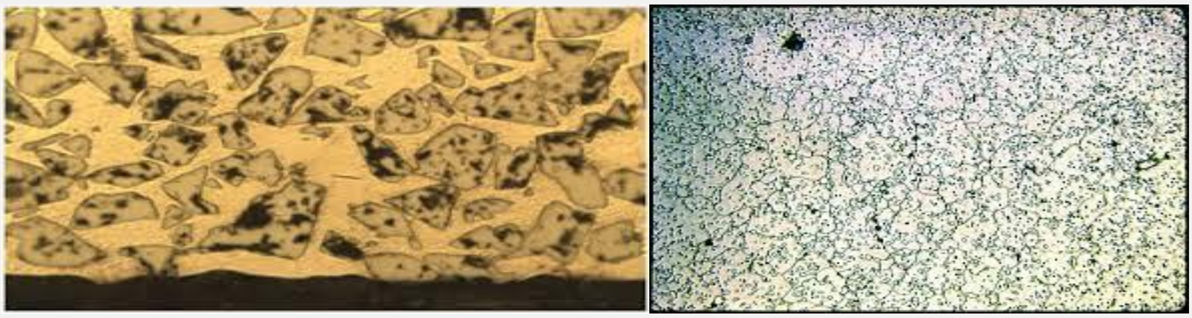


Anova Analysis









Scanned photos

This can be achieved by depositing a thin layer (typically 2-20 µm) of coating of suitable material over the surface of the tool. Coatings act as diffusion barrier between the tool and the sliding chip, they increase wear resistance of the tool, prevent chemical reactions between the tool and work material, reduce built-up edge formation, decrease friction between the tool and chip, and prevent deformation of the cutting edge due to excessive heating.

5.2. Nano Coating Testing on Tungsten Carbide Cutting Tool

Mechanical and Tribological tests should be conducted according to ASTM standards,which are listed below for the developed Nano coating Inserts.

HardNess Test ASTM E10

surface Test ASTM E9

Tension Test ASTM E8-82

Wear Test ASTM G99-95

5.3. Analysis

After conducting Mechanical and Tribological testings,Surface morphology of the tested Nano coated Inserts should be done.The inserts should be modelled using suitable assumption and analyzed by means of finite element method using ANSYS .

VI. POSSBLE OUTCOME

The developed Nano Coated Inserts would have good Mechanical ,Tribological properties when compared with without coated cutting tool and also out of different coated Cutting tools,one which will be having the best mechanical,Tribological property can be recommended.and among three methods of coating ,the best method can be recommended.

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