Comparison Of Mechanical Properties And Calculation Of Cutting Force Between Uncoated Tungsten Carbide,Tin & Tialn Coated Tip Tungsten Carbide With The Help Of Lathe Tool Dynamometer

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ABSTRACT

The keyword for manufacturers of cutting tools and coatings for cutting tools is productivity: a 30% reduction of tool costs, or a 50% increase in tool lifetime results only in a 1 % reduction of manufacturing costs. But an increase in cutting data by 20% reduces manufacturing costs by 15%. In order to achieve higher productivity different approaches – High Performance Cutting (HPC) and High Speed Cutting (HSC) can be chosen. The performance of Carbide tools was studied to investigate the tool life and wear behavior at various machining parameters. This study presents tool wear characterization of carbide cutting tool inserts coated with titanium nitride (TiN) & titanium aluminum nitride (TiAlN)on a single point turning operation on copper, aluminum & mild steel. A set of experiments with conditions of cutting speed, depth of cut and feed rate were performed on a lathe machine. Force analysis is done on Lathe Tool Dynamometer. From the result, cutting speed was found to be the main factor to have significant effect on surface roughness. At the end of this study, optimization was made by suggesting the most suitable sets of parameter settings to produce minimum surface roughness. Suggestion on parameter settings to obtain minimum surface roughness made.

Keywords: TiN;TiAlN; Lathe tool dynamometer; Tungsten Carbide, Coated Tip

INTRODUCTION

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.[1]
Manufacturing industry is constantly striving to decrease its cutting costs and increase the quality of the machined parts as the demand for high tolerance manufactured. Nowadays manufacturing industries are constantly focused on lower cost solutions with reduced lead time and better surface quality in order to maintain their competitiveness and efficiency.[2] The goods are rapidly increasing. The increasing need to boost productivity, to machine more difficult materials and to improve quality in high volume by the manufacturing industry has been the driving force behind the development of cutting tool materials. Numerous cutting tools have been developed Continuously since the first cutting tool material suitable for use in metal cutting, carbon steel, was developed a century ago [3].
A lot of discussions and studies have been made to improve the quality and usage of a cutting tool [2]. One important aspect that is being vigorously researched and developed is the hard coating for cutting tools. These hard coatings are thin films that range from one layer to hundreds of layers and have thickness that range from few nanometers to few millimeters [3]. Cutting tools come in various types and shapes and various materials as well as various coating materials. These different characteristics of the cutting tool serve different types of applications. Cutting tool has to have certain aspect or criteria such as hardness, toughness and wear resistance. One of the most common cutting tool materials is carbide [4].

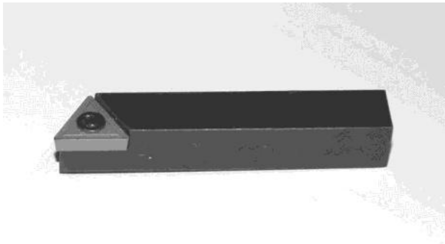


Fig. 1 TiN coated insert tool

Coated and uncoated carbide tools are widely used in the metal-working industry and provide the best alternative for most turning operations. When machining using carbide tools under conventional cutting conditions, the gradual wear on the flank and the rake face is the main process by which cutting tools failed. Wear mechanism could be classified as adhesion, abrasion, diffusion, oxidation and fatigue. Some authors say the flank wear in carbide tools initially occurs due to abrasion on the wear progresses. High speed cutting always generates high temperatures. This enhances diffusion and oxidation process carbide tool. The advantages of high speed machining are the ability to produce precise dimension high productive and good quality parts. Most of the heat generated was used to remove the chip while the temperature of cutting tools and work piece maintained at ambient temperature. The quality machined surface becomes more critical in view of very high demand to performance, Life time and reliability. The components that used in an automotive, aerospace and other industries were applied in highly stress and temperature. Hence the surface integrity of machined component becomes more important because it could cause sudden fatigue failure [5].Titanium and titanium alloys are used extensively in aerospace because of their excellent combination of high specific strength (strength-to-weight ratio), which is maintained at elevated temperature, their fracture resistant characteristics and their exceptional resistance to corrosion at high temperature [6].

The tool material should have a set of properties that will enable it to work in various conditions. The requirements posed to cutting tools include:

• High hardness and compression, tensile, torsion, and bending strength;
• High wear resistance (abrasion, adhesion, and diffusion, chemical);
• High mechanical and thermal fatigue resistance;
• Significant resistance to change of the machining capability at elevated temperature and ductility;
• Good thermal conductivity and high specific resistance.

None of the tool materials available on the market currently possesses all the desired properties. This has been the reason for establishing the domains of applications for the particular material groups, for which minimizing of wear, and in consequence extension of the tool edge life, features the main selection criterion for the particular material [7].

An ability to predict the tool life during machining is necessary for the design of cutting tools and the determination of cutting conditions and tool change strategies. The extensive research in this area during the past century or so has contributed greatly to our understanding of the problem. However, there is as yet no machining theory to provide adequate relationships between tool lives and cutting conditions, tool geometrical parameters and, work and tool material properties. Some of the major difficulties are: (I) the complexity of the machining process which involves extreme conditions of very high strains, strain-rates and temperatures, and (II) lack of suitable data. Moreover, tool life depends on a number of variables which include the machine tool, tool material and geometry, work material and cutting conditions. The situation is further compounded by the continuous development and introduction of new tool materials, work materials & by changes in machining conditions [8].

TiN & TIAlN as a coating for tool steel has been available widely since the last decade and is enjoying increasing attention and applications in tools industries. In practice, the degree of extended tool life and /or increased productivity attained with coated tools depends on primarily on the tool and its applications, the work piece material and the operating parameters. Keeping all these conditions equivalent, tool life improvement can be evaluated by comparing the increase in number of work pieces machined by a TiN insert tool with number of work pieces machined by an uncoated tool [9]

EXPERIMENT SETUP

- Mount lathe tool dynamometer on lathe machine.
- Before mounting the dynamometer on lathe, make sure that the mounting surface is flat and clean Connect dynamometer to supply.

EXPERIMENT PROCEDURE

- The experiment was carried out on single point TiN & TiAlN coated insert carbide tool.
- Coated inserts was made by PVD process.
- Take different work piece Aluminum, Copper & Mild Steel having same diameter of 25 mm and same length of 6 inch.
- Experiment was done on a lathe machine tool with the help of a lathe tool dynamometer. Set

initially dynamometer to zero reading (little error possible).

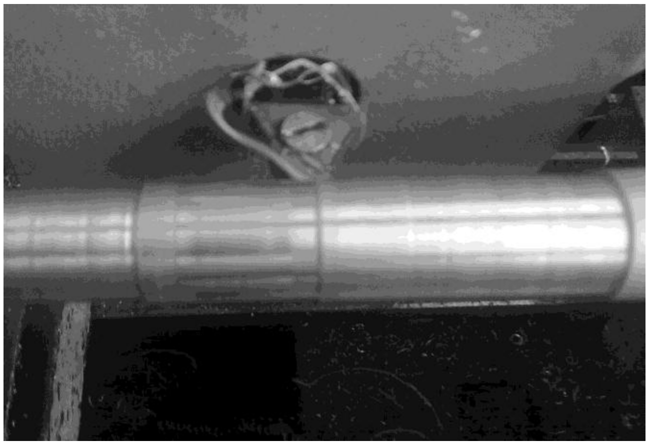


Fig.2 TiN coated insert turning on Aluminum work piece

Depth of cut	**Copper**			**Aluminum**			**Mild Steel**		
	F_v	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.5	27	2	12	17	1	9	24	5	8
1	46	6	12	37	8	19	46	12	14
1.5	70	16	16	49	15	23	75	23	25
2	96	28	40	63	27	31	100	33	40
2.5	122	44	38	80	39	33	125	46	53
RPM	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
250	60	10	10	40	6	11	57	10	12
400	58	10	5	37	9	17	59	10	7
600	46	6	12	37	8	19	46	12	14
900	92	24	12	36	12	21	62	20	25
Feed	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	36	4	7	19	4	5	57	10	12
.18	47	7	8	40	6	11	114	25	42
.35	60	10	10	55	9	26	35	10	13
Feed	**F_v**	**F_f**	**F_v**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	48	11	13	20	5	5	59	10	7
.18	50	8	17	37	9	17	114	20	4
.35	68	7	9	64	9	35	28	3	4
Feed	**F_v**	**F**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	38	9	6	28	8	9	46	12	14
.18	47	8	5	37	8	19	89	13	40
.35	64	4	10	60	9	27	23	3	5
Feed	**F_v**	**F**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	41	9	6	24	8	9	62	20	25
.18	56	10	6	36	12	21	64	8	33
.35	54	5	8	54	11	38	28	8	5

OBSERVATIONS

- TiN coated insert

Depth of cut	**Copper**			**Aluminum**			**Mild Steel**		
	F_v	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_t**
.5	22	1	1	13	1	5	18	2	6
1	33	5	3	21	6	5	44	12	3
1.5	48	9	6	38	12	5	60	19	4
2	76	18	14	46	16	5	79	25	6
2.5	102	27	18	60	26	7	99	33	1
RPM	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
250	33	5	3	11	2	3	40	10	4
400	33	5	3	16	4	6	43	14	2
600	33	5	3	16	5	5	44	12	3
900	34	5	9	21	6	5	43	14	2
Feed	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	35	10	4	36	8	9	20	8	0
.18	33	5	3	11	2	3	40	10	4
.35	50	3	4	14	3	4	60	8	9
Feed	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	32	8	5	15	4	3	22	8	0
.18	33	5	3	16	4	6	43	14	2
.35	51	3	4	33	7	2	60	10	11
Feed	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	30	7	4	13	4	3	25	10	1
.18	33	5	3	16	5	5	44	12	3
.35	48	4	5	36	9	9	64	12	6
Feed	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	62	7	6	15	5	4	28	12	0
.18	34	5	3	21	6	5	43	14	2
.35	26	5	4	37	9	4	50	10	8

- For TiAlN coated insert

Depth of cut	**Copper**			**Aluminum**			**Mild Steel**		
	F_v	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.5	28	4	10	17	2	9	22	2	8
1	62	11	12	27	6	12	50	8	16
1.5	80	20	23	45	17	24	75	17	34
2	133	54	30	57	25	29	98	24	40
2.5	169	68	48	72	31	32	118	33	51
RPM	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
250	73	16	25	40	10	14	50	8	13
400	60	15	13	45	13	19	50	8	13
600	62	11	12	27	6	12	50	8	16
900	61	12	13	32	13	20	54	11	26
Feed	**5**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	62	15	15	19	5	8	31	6	5
.18	73	16	25	40	10	14	50	8	13

- For Uncoated carbide tip

.35	76	5	21	46	8	20	72	9	23

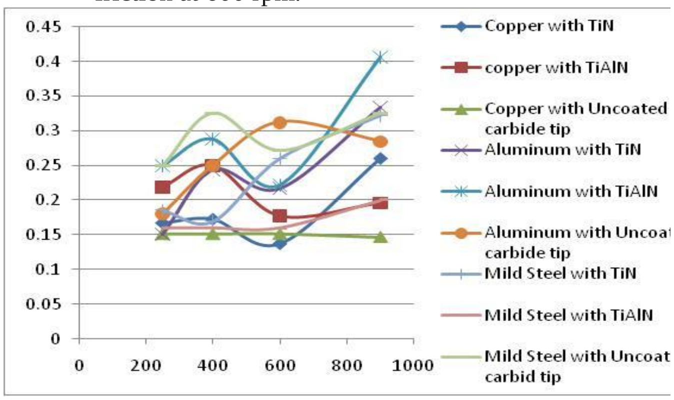
Feed	**F_v**	**F_f**	**F_v**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	56	15	13	21	6	10	28	6	3
.18	60	15	15	45	13	19	50	8	13
.35	71	6	23	42	8	26	82	2	8
Feed	**F_v**	**F**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	48	12	12	22	8	10	29	6	2
.18	62	11	12	27	6	12	50	8	16
.35	76	6	22	45	9	27	55	2	22
Feed	**F_v**	**F**	**F_r**	**F_v**	**F_f**	**F_r**	**F_v**	**F_f**	**F_r**
.095	35	6	7	24	9	10	42	8	13
.18	61	11	13	32	13	20	54	11	26
.35	56	5	23	60	23	38	74	14	28

- ✓ Tables shows various readings of cutting forces under different conditions by TiN coated insert, uncoated carbide tip & TiAlN coated insert.
- ✓ In a table there are six segments first varying depth of cut at feed of .18mm and cutting speed 600 rpm, second varying cutting speed at feed .18mm and constant depth of cut 1mm and rest of four varying feed .095,.18 & .35 with varying cutting speed 250,400,600 & 900 rpm respectively with constant depth of cut 1mm.

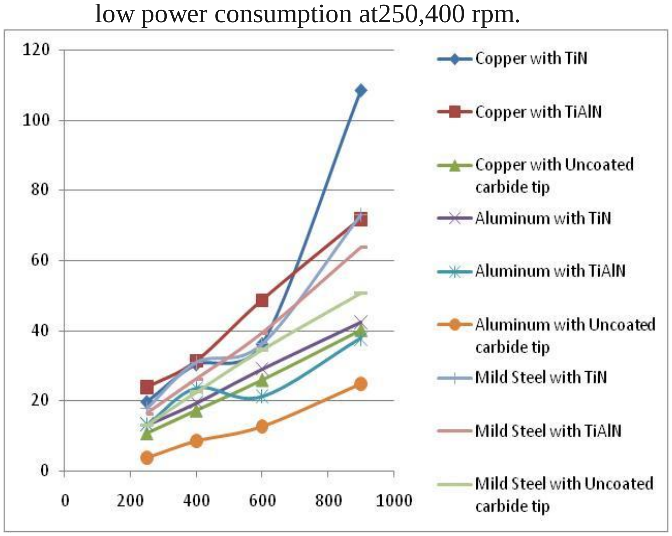
RESULTS

- Graph plotted between ***Coefficient of friction v/s Cutting speed*** in RPM for work pieces Copper, Aluminum & Mild Steel.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN Copper has low coefficient of friction at 600 rpm, for Aluminum has low coefficient of friction at both 250 and 600 rpm & for Mild Steel has low coefficient of friction at 250 rpm.
- In TiAlN coated tool, the coefficient of friction is comparatively low(0.175) at speed 600 rpm for copper and it is constant (0.16) for 200 rpm to 600 rpm for mild steel but good surface finish at cutting speed 400 rpm and for aluminum 600 rpm.

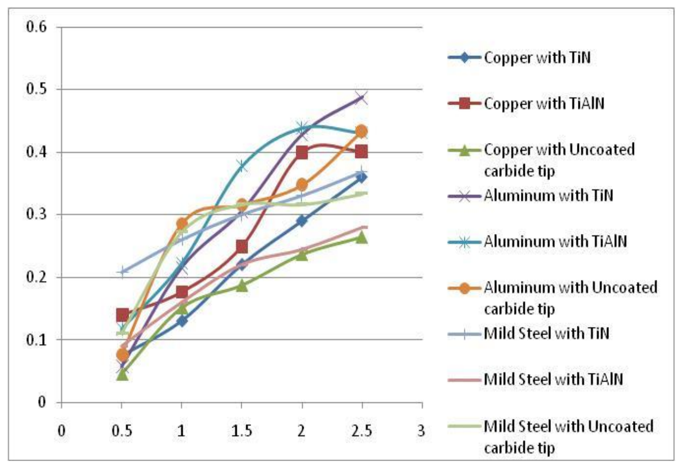
- For Uncoated Tool Copper has low coefficient of friction at 250 rpm but also well at 900 rpm and Aluminum has low coefficient of friction at 900 rpm and for mild steel has low coefficient of friction at 600 rpm.



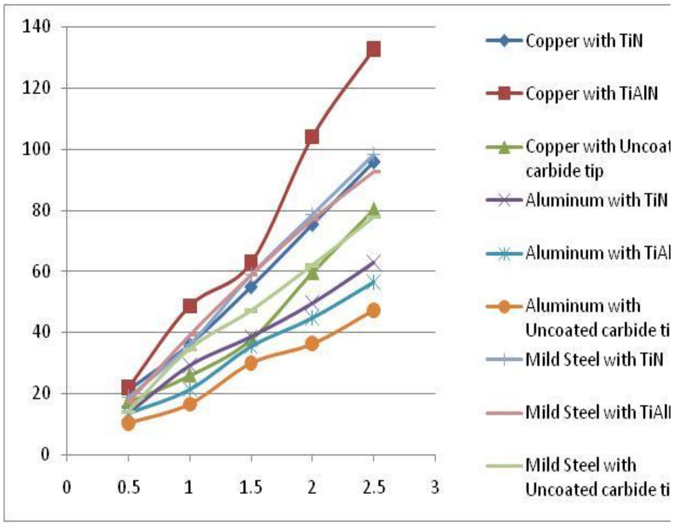
- Graph plotted between ***Power consumption v/s Cutting speed*** in RPM for work pieces Copper and Aluminum.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN Copper has low power consumption at 250 and 600 rpm, Aluminum has low power consumption at 250, 400 and 600 rpm and Mild steel has low power consumption at 250 rpm.
- For TiAlN Copper,aluminum and mild steel have low power consumption at250 rpm.
- For Uncoated tool Copper & mild steel have low power consumption at 250 rpm, aluminum has low power consumption at250,400 rpm.



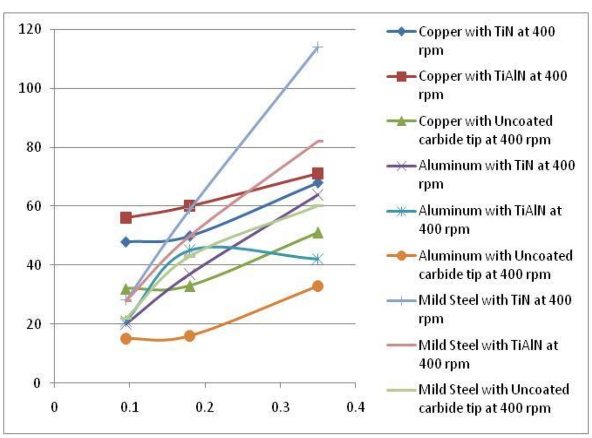
- Graph plotted between ***Coefficient of friction v/s Depth of cut*** in mm for work pieces Copper and Aluminum.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN copper has low coefficient of friction at .5,for mild steel low coefficient of friction at .5 & 1 depth of cut and for aluminum has low coeffieicnt of friction at .5 depth of cut.
- For TiAlN copper has low coefficient of friction at .5 and 1, mild steel has low coefficient of friction at.5 and 1, aluminum has low coefficient of friction at .5 depth of cut.
- For Uncoated carbide tip copper has low coefficient of friction at .5 and 1, aluminum & mild steel have low coefficient of friction at .5 depth of cut.



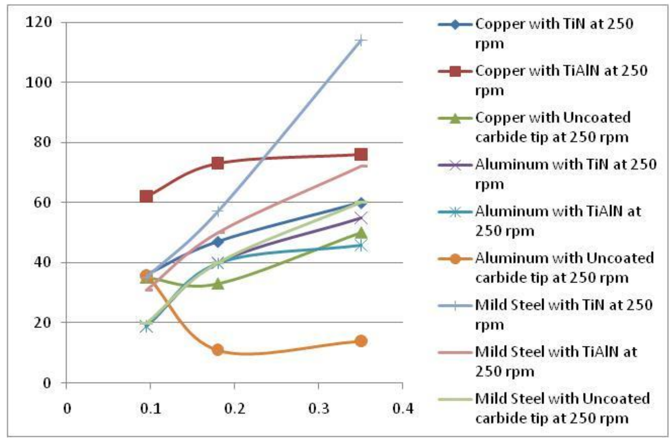
- Graph plotted between ***Power consumption v/s Depth of cut*** in mm for work pieces Copper and Aluminum.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN copper,aluminum & mild steel have low power consumption at .5 depth of cut.
- For TiAlN copper and mild steel have low power consumption at .5, aluminum has low power consumption at .5 and 1 depth of cut.
- For Uncoated carbide tip copper and aluminum have low power consumption at .5 & 1, mild steel has low power consumption at .5 depth of cut.



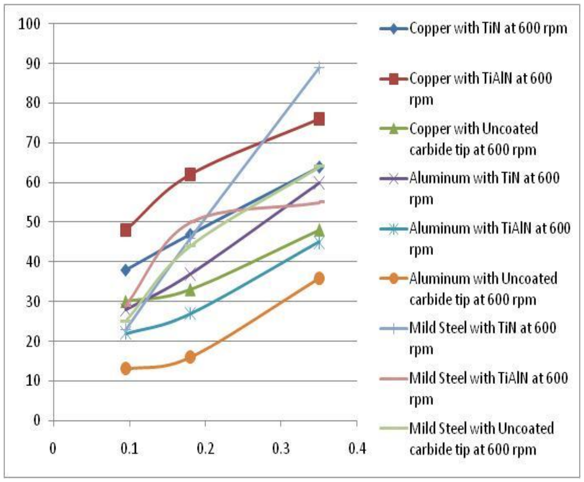
- Graph plotted between ***Cutting force v/s feed*** at 250 rpm with constant depth of cut of 1mm.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN copper, aluminum and mild steel have low cutting force at feed 0.095 rev/mm.
    - Graph plotted between ***Cutting force v/s feed*** at 250 rpm with constant depth of cut of 1mm.
    - Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
    - For TiN copper,aluminum and mild steel have low cutting force at 0.095 rev/mm feed.
    - For TiAlN copper has low cutting force at 0.095,.18 & mild steel and aluminum have low cutting force at 0.095 rev/mm feed.
    - For Uncoated carbide tip copper, aluminum have low cutting force at 0.095,.18 & mild steel has low cutting force at .095 rev/mm feed.



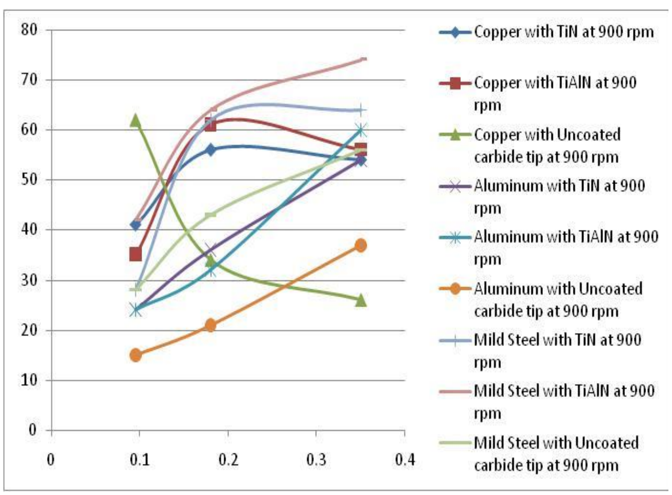
- For TiAlN copper,aluminum & mild steel have low cutting force at feed 0.095 rev/mm.
- For Uncoated carbide tip copper has low cutting force at 0.095,0.18 rev/mm, mild steel has low cutting force at 0.095 rev/mm feed and aluminum has low cutting force at .18,.35 rev/mm feed.



- Graph plotted between ***Cutting force v/s feed*** at 600 rpm with constant depth of cut of 1mm.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN copper,aluminum & mild steel have low cutting force at 0.095 rev/mm feed.
- For TiAlN copper and mild steel have low cutting force at 0.095, aluminum has low cutting force at .095,.18 rev/mm feed.
- For Uncoated carbide tip copper and aluminum have low cutting force at .095,.18 & mild steel have low cutting force at .095 rev/mm feed.



- Graph plotted between ***Cutting force v/s feed*** at 900 rpm with constant depth of cut of 1mm.
- Tools are uncoated carbide tip and tool with TiN & TiAlN coated insert.
- For TiN copper,aluminum and mild steel have low cutting force at 0.095 rem/mm feed.
- For TiAlN copper,mild steel have low cutting force at .095 and aluminum has low cutting force at .095,.18 rem/mm feed.
- For Uncoated carbide tip copper has low cutting force at 0.18,0.35, for mild steel has low cutting force at .095 and aluminum has low cutting force at .095,0.18 rev/mm feed.



CONCLUSION

- ✓ *All results are presenting here, they are based on experiment performed on lathe tool dynamometer. Work pieces were copper,mild steel and aluminum. All three turned by uncoated carbide tip and coated TiN& TiAlN insert. Graphs between coefficient of friction and cutting speed, power and cutting speed, coefficient of friction and depth of cut, power and depth of cut and cutting force and feed.*
- ✓ *For copper with TIN insert shows minimum coefficient of friction, minimum power consumption, minimum cutting force at 600 rpm and depth of cut is 0.5 mm is good & with Uncoated carbide tool it shows minimum coefficient of friction at 900 rpm but shows minimum power consumption, minimum cutting force at 600 rpm and depth of cut is 0.5 mm is good and with TiAlN it shows low coefficient of friction, power at 0.5,1 depth of cut, 250 & 400 rpm cutting speed and feed 0.35 rev/mm conditions.*
- ✓ *For aluminum with TiN shows minimum coefficient of friction, minimum power consumption, minimum cutting force at 600 rpm and depth of cut is 0.5 mm is good & with Uncoated carbide tool its it shows minimum coefficient of friction at 900 rpm but shows minimum power consumption, minimum cutting force at 600 rpm and depth of cut is 0.5 mm is good and with TiAlN its shows low coefficient of friction,power at 0.5,1 depth of cut, 250 & 400 rpm cutting speed and feed 0.35 rev/mm conditions.*
- ✓ *For mild steel with TiN shows low coefficient of friction, power at 0.5 depth of cut, 250,400 rpm,0.095 rev/mm feed. With Uncoated carbide tip its shows low coefficient of friction,power at 0.5 depth of cut,250,400,600 rpm,0.095,0.35 rev/mm feed. With TiAlN its shows low coefficient of friction,power at 0.5 & 1 depth of cut ,250 & 400 rpm cutting speed,0.095 & 0.35 rev/mm feed.*
- ✓ *For all three work pieces cutting speed 400, depth of cut 0.5mm and feed 0.095 rev/mm is good.*

DISCUSSION

Primary purpose of this work was to investigate:
1. Comparison of TiN & TiAlN coated insert with Uncoated Carbide tip on the basis of Power consumption, coefficient of friction, depth of cut and cutting forces by setting different cutting parameters.
2. Analysis of cutting forces via both uncoated and coated tool.
The results presented indicate that these purposes were accomplished. In the following sections, the results are summarized and conclusions are then drawn from these results.

This study evaluates the machining performance of available cutting tool inserts in turning of aluminum, mild steel and copper. Uncoated carbide tip and TiN & TIAlN coated tools were examined and the resultant machined work piece surface finish was analyzed. In the case of the machined surface roughness, all the coated tools produced lower surface roughness than that produced by the uncoated tool. Reliable quantitative models for predicting machining performance of cutting tools do not exist due to the large number of parameters involved and the complex interactions between these parameters. Machining performance of cutting tools are made by conducting actual machining tests. This study contributes to the large data bank of cutting tools performance. The tool considered was single layer coated tool. This research may be extended to study the effects of multi-layer coatings on cutting tool performance. Multi layers are composed of alternating layers of two different materials that can vary in number from few up to tens of thousands. Multi layers are believed to offer very high strength, hardness, heat resistance, and many new properties that could greatly enhance the performance of the cutting tools. And so it would be interesting to examine the machining performance of multi layer coated tools and how the number and thickness of the alternating layers affect the wear resistance of the cutting tool and the surface roughness of the work piece.

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