Betterment of life of the cutting tool by process of heat treatment

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Abstract - In this investigation we found the desirable tool life of the cutting tool materials, where all materials have been undergone for heat treatment process. In this work as cutting proceeds the life span of the cutting tool goes on decreases. Here the cutting tool materials like Stainless steel of Grade SS440C, SS316, and Ti-6Al-4V were considered as the cutting tool materials where it is found that the Titanium has the highest tool life as compared to SS440C, SS316 cutting materials. This is due to variation of speed rate and chemical composition of an element. Here we made an attempt to investigate the life span of cutting tool material after heat treatment Process.

Keywords - SS440C, SS316, Ti-4V-6Al

I. INTRODUCTION

On the notions of Mechanical engineering, research works are going on several materials in order to know the advanced characteristics of worked materials. As part of our research work we have made an attempt o obtain desired results. Thus there are several investigations were made over different several cutting tool materials. The cutting tool materials are one which is used to perform cutting action in order to obtain required job. In this connection the knowledge of cutting tool is necessary to recounting the mechanical characterization of materials. Several researchers took different cutting tool materials where they made experiment by considering Machinability conditions and other parameters where they found desirable results [1]. As we know that different cutting tool materials will have different characteristics under room temperature. It is needed to recount that tool life a material when performing machining or cutting operation over given workpiece. There are various factors which are being affected over tool life those are namely Machinability factor, tool geometry, type of cutting fluids used, size and structure, when work material has fine grain structure the tool life will decrease, when the cutting tool has fine grain structure the tool life will increase [3]. In addition to these others factors can expound and tell about the tool life [5], By Increasing in the intermittent cuts it decrease the life of the cutting tool, by means of increasing the cutting speeds the tool life will decrease. By changing cutting forces results shortens the life of tool. By means of changing cutting temperature and modification in the quality of surface finish. These things are directly affected on life of the tool. Engineers are taken part into research work on cutting tool materials since very long time to overcome the problems which are being associated with tool life. So in this connection as a part of our research work we made cutting operations over mild steel and aluminum workpiece. And also we considered the three different cutting materials which have the characteristics of wear resistance, high thermal conductivity, specific heat, hot hardness, high coefficient of thermal expansion etc… As far as metal cutting knowledge is concerned, the metal cutting operation depends upon type of cutting tool material, type of workpiece, geometry of the tool, Machinability conditions. These factors are commonly taken into account where cutting action is progressing. So in this respect the cutting tools like Stainless steel of grade SS440C, Stainless steel of SS316, and Titanium grade of Ti-6Al-4V have been considered as cutting tool materials [4]. Presence of chromium in stainless enhance the corrosion resistance. Apart from these other alloying elements have been added to the aforementioned elements in order to improve cutting characteristics of cutting tool materials. Though investigations are made over different types of cutting tool material due to exceptional quality of aforementioned materials they have considered into account.

II. EXPERIMENTAL SET UP

A. Cutting Tool metal Selection

While performing any machining operation the adoption of cutting tool is necessary. So here firstly the all the materials which will undergo some manufacturing process like casting, forming and machining to obtain desired cutting tools and also it follows resemble procedure. The nominal compositions of Stainless steel of Grade SS440C, SS316 and Titanium have been mentioned in Table.1& Table.2 After obtaining the required results the material is cleaned from chemical solution in order avoid the deposition of unwanted particles over given workpiece. Then it was subjected to thermal or heat treatment process. This is to be studied in following section in detail.

Fig.1 Stainless Steel SS440C raw material

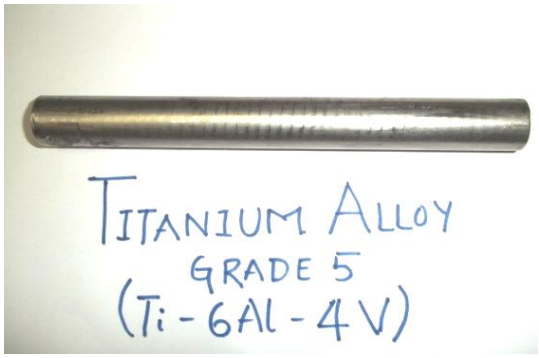

Fig.2 Ti-6Al-4V raw material

Table.1 Nominal chemical composition of SS440C and 316 alloys

Material	C	Mn	Si	Cr	P	Ni	S	Mo
Stainless Steel 440C	1.07	1.00	1.0	18.0	0.04	0.03	0.75	1.07
Stainless Steel 316	0.08	2.00	1.00	18.0	0.045	12.0	0.03	3.0

Likewise, the chemical composition of Titanium alloy (Ti-6Al-4V) are mentioned below table.2

Table.2 Nominal chemical composition of Titanium alloy

Material	Al	V	Ti
Titanium	6.0	4.0	Balance

B. Heat treatment

Perhaps, other methods are available in order to enhance the properties of a metal. However, amongst all methods heat treatment method plays a significant role to achieve desired properties over any ferrous or non ferrous metal or alloy. So in this respect the various heat treatment operations can be performed over given material. However our objective is make test over cutting tool material after performing hardening operation. In this heat treatment process the three cutting tool materials were kept inside the furnace usually (muffle furnace). Then it is heated at required temperature then held at that temperature for a definite period of time. Then cooled back by means of water (for other materials oil/air) and it was allowed for cooling for some time as a result of that there is a massive changes have been taken place over cutting tool materials. The muffle type heat treated furnace has been shown in Figure.3.

Fig.3 Muffle Type of Heat Treated Furnace

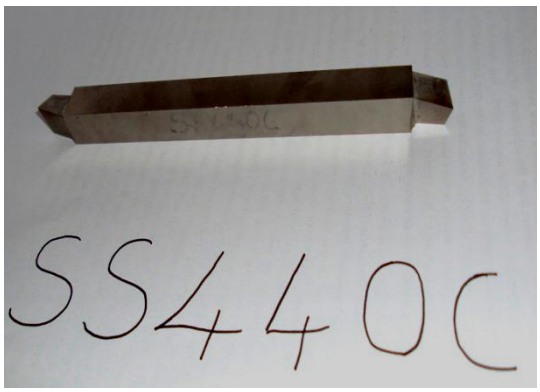

Fig.4 SS440C Heat Treated Finished Tool

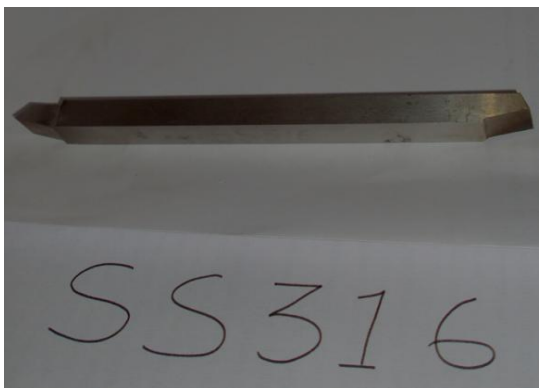

Fig.5 SS316 Heat Treated Finished Tool

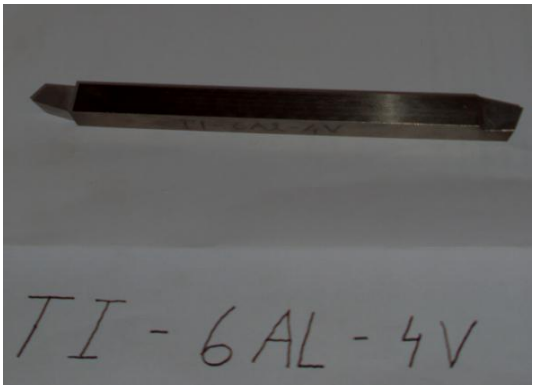

Fig.6 Ti-6Al-4V Heat Treated Finished Tool

III. MATERIAL CHARACTERIZATION

A. Hardness test

Fig.7 Rockwell Hardness Testing Machine

There are several methods are there to find out the hardness of a material amongst all hardness testing machines the Rockwell hardness testing machine was employed to know the hardness value of given cutting tool materials. Due to its simplicity and economical valuable, hence it is used in routine checking components. Here the hardness test was performed before heat treatment and after heat treatment. Before keeping the cutting tools inside the muffle furnace the hardness of the cutting tools were determined. After performing heat treatment operations again hardness of the cutting tools was determined. The hardness value of cutting tools before and after heat treatment has been shown in table.3. In this test the steel ball indenter were made to force onto the surface of the specimen results changes in the depth of penetration of an indenter. In this test the minor load of 150 kg applied over tested specimen. An indicating device, which follows the movements of the indenter and so responds to changes in depth of penetration of the indenter, is set to a datum position. In order to increase the depth of penetration a major load was applied when it attained equilibrium conditions the major load was removed. Removal of the additional major load allows a partial recovery, so reducing the depth of penetration. The permanent increase in depth of penetration, resulting from the application and removal of the additional major load is used to calculate the Rockwell hardness number.

Table.3 Hardness Values of Selected Cutting Tools

Tool material	Hardness Number(HRC) (before hardening)	Hardness Number(HRC) (after hardening)
Stainless Steel SS440C	51	58
Titanium Alloy(grade 5) Ti-6Al-4V	40	51
Stainless Steel SS316	38	38

IV. RESULTS AND DISCUSSIONS

A. Tool Life

As we know that life of the tool depends upon cutting time. It is needed to say that the time period between two successive cutting operations. As cutting proceeds the gradual wear of material shall takes place. So in this respect life of the tool can be expressed by means of time unit, volume of the material removed by tool while performing cutting action and number of work pieces machined. There are several methods which are used to measure life of tool; the following figures show the life of tool material and respective tool life of a material has been tabulated.

Table.4 Experimentally obtained Tool Life of cutting materials

Speed (rpm)	Feed (mm/rev)	Depth of Cut (cm)	Tool Life in Min.		
			Stainless Steel SS440C	Stainless Steel SS316	Titanium alloy Ti-6Al-4V

45	0.4	1.0	20	22	31.8
71	0.4	1.0	14	17.5	27
112	0.4	1.0	6.67	14	19

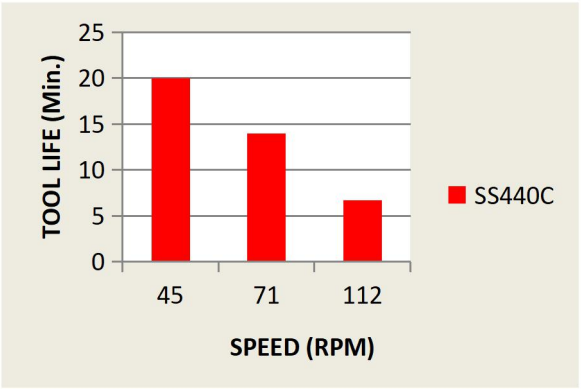

Fig.8: Tool life of Stainless Steel SS440C

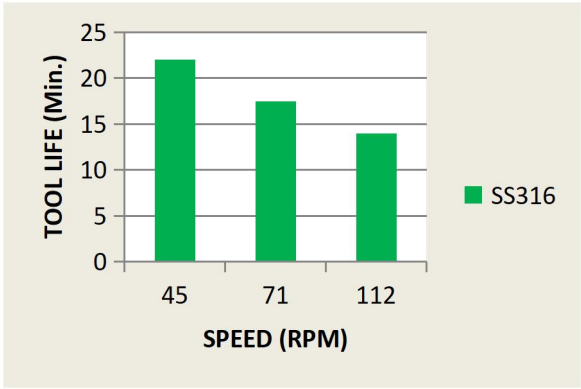

Fig.9: Tool life of Stainless Steel SS316

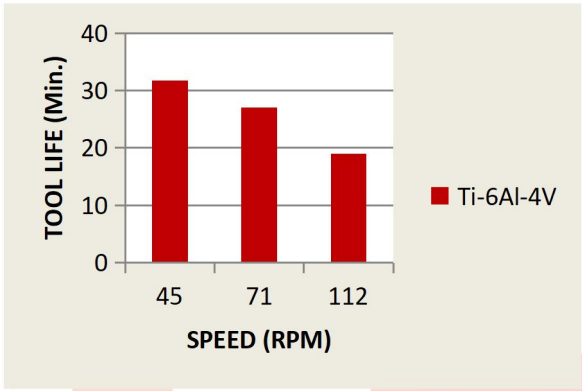

Fig.10: Tool life of Titanium alloy Ti-6Al-4V

One can notice that while measuring out of tool life of a material, it is needed maintain constant feed and depth of cut for all cutting tool materials. However, there is a fluctuation shall takes place only for speed of a material. From the graph one can observe that at the rate of speed 45 RPM the Titanium material has the highest tool life compared to rest of the materials. Further increasing the speed rate to 71 RPM the Titanium material has the highest tool life compared to Stainless steel Grade of SS440C, SS316. Finally, at the high rate of speed 112 RPM again the Titanium alloy has shown highest tool life as compared to rest of the cutting tool materials. Eventually, it was concluded that the tool life of SS316 has higher value than SS340C. The Titanium material has highest tool life compared to SS340C and SS316. Therefore as cutting speed increases the life span of the tool will decrease.

CONCLUSION

Based on the investigations following conclusions were drawn.

1. The life of the cutting tool material has fully increased after Heat Treatment.
2. Titanium cutting tool has highest tool life, so, it can be used to cut hard material.
3. As the speed rate increases the tool life goes on decreases. And it is more found in Stainless steel of Grade SS440C.
4. The tool wear rate is least for SS316; however, Titanium has high tool wear rate.
5. Hardness of Stainless steel of Grade SS440C has the highest value than Titanium (Ti-6Al-4V).

FUTURE SCOPE

1. Comparison of study results with FEM analysis.
2. Performing heat treatment process further it can increase the hardness of the given material.

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