Impact of heat treatment on HSS cutting tool (ASTM A600) and its behaviour during machining of mild steel (ASTM A36)

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Impact of Heat Treatment on HSS Cutting Tool (ASTM A600) and Its Behaviour during Machining Of Mild Steel (ASTM A36)

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Abstract:Carburization is one the best heat treatment that responded well to hardening with Palm Kernel Shell giving the best hardness value. This work studied the influence of carburization on HSStool(ASTM A600) and its behaviour during machining of mild steel (ASTM A36). Composition of the samples (12 pieces of 180 x 12 x12 mm) HSS tools were checked using UV-VIS spectrometer and the tools were carburized with PKS at holding temperatures and time of 800, 850, 900,950 ^{o}C and 60,90 120 minutes using muffle furnance. The micro structural analysis, surface and core hardnessof the treated samples gave better results than the untreated samples when checked withsoft driven and optical microscope. It wasalso observed that increase in the feed rate and depth for length of cut of 50 mm significantly reduces the wear progression and thereby gave best machining time at maximum carburizing temperature and time(950 ^{o}C / 120 minutes) when it was used to cut mild steelon the lathe machine.

INTRODUCTION

The modern challenges of all machining industries has been primarily centred on best way to achieve high quality machined product in terms of workpiece dimensional accuracy, finer surface finish, minimize cutting tool wear, breakages[1], improve production rate, machining cost saving, longer tool service life, as well as low environmental impact [2]. Monitoring of manufacturing processes and equipment conditions are essential part of a critical strategy that drives manufacturing industries towards being leaner and more competitive [3]. As a result of cutting tool technological advancement, cemented carbides were now being coated with titanium nitride (TiN), titanium carbide (TiC), Titanium carbonitride (TiCN) and aluminium oxide and other more advanced materials through either of powder vapour deposit (PVD) or chemical vapour deposit (CVD) coating process. Ibrahim, *et al.*, [4] had previously reported that the essence of coating are thus; an efficient way of improving their friction, cracking, wear resistance properties, higher hot hardness and impact resistance consequently increasing machining productivity. This account for its wide application in turning nodular, grey cast iron austenitic stainless steel, nickel-base alloys, titanium alloys, aluminium, free-machining steels, plain carbon steels, alloy steels, martensitic and ferrite stainless steels [5]. Investigation on wear mechanism showed microstructure defects and performance of some commercially available coated carbide insert under Scanning Electron Microscopy (SEM) [6].Tools made of case-hardened materials like case-hardened steels combine a highly wear resistant surface and a tough core [7]. Due to thesevaluable properties, such materials are broadly used in the manufacture of cutting tools, gears, connecting rods, bearings, turbine application, automotive components and shafts.Case hardened cutting tools are tools made of a metal or alloy whose surface has been hardened while permitting the core part of the metal remain soft [8]. The thin layer of harder metal at the surface of the metal is called the case.The hardness anddepth of the case usually varies and thisdepends on the process of surface hardening used, the temperature applied and the materials [9-10].

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Case hardening is used to improve the wear resistance of parts without affecting the softer, tough interior of the part [11]. Hardness is the resistance of a material to plastic deformation, therefore, the more challenging it is for a material to plastically deform while placed under load, the higher the hardness of that material. Hardness is directly related to the ultimate tensile strength (UTS) of a material, but inversely related to the ductility and toughness of the material. The bulk hardness of metals is often used as a guideline to their abrasive wear- resistance [12-17].

Wear resistance and hardness are the basic characteristics of case-hardened cutting tools. Cutting tools use shear deformation process in removing material from the workpiece. Cutting can be achieved by single-point or multipoint tools. Single-point tools are used in turning, shaping, planning and similar operations, and remove material by means of one cutting edge. Milling and drilling tools are often multipoint tools. Grinding tools are also multipoint tools [18]. Cutting tools must be made of a material harder than the material which is to be cut. Moreover, the tool must be able to withstand the generated heat during the metal-cutting process [19]. Also, it is mandatory the tool have a specific geometry, with clearance angles designed, this will enable the cutting edge in contacting the work piece without affecting the rest of the tool in dragging on the work piece surface [20]. The angle of the cutting face is also important, as is the flute width, number of flutes or teeth, and margin size, although some reports claim that there is no correlation between wear resistance and hardness [21].

This study evaluated surface and micro hardness of Case hardened cutting tools made of mild steel and High-Speed Steel (ASTM A600), and the existence of a correlation between these properties when machining low carbon steel. Thus, the performance of the cutting tools was assessed on the lathe machine [22].

MATERIALS AND METHODS

Composition of the samples (12 pieces of 180 x 12 x12 mm) HSS tools (ASTM A600) was checked using UV-VIS spectrometer with results shown in Table 1 below and the tools were carburized with PKS at holding temperatures and time of 800, 850, 900,950 ^{o}C and 6,90 120 minutes using muffle furnance shown in Table 2 The micro structural analysis, surface and core hardness of the treated was also checked with soft driven and optical microscope shown in figure 10. The results for thecomparison of temperature with time in case hardening process, surface and micro hardness variation with Time of cut was shown in Table 3. The work piece material was a low carbon (ASTM A36) ofsteel cylindrical bars having 25 mm diameter and length of 100 mm. low carbon steel was selected due to its wide applications in the area of manufacturing industries.

The machining operations on the work piece were conducted under dry machining conditions on a universal lathe with the following machining parameters spindle speedof 380 rpm,cutting speed of 29.85 mm/min,feed rate of 19 mm/min, depth of cut 2 mm,diameter of the work piece 25 mm and length of cut of 50 mm were usedto actually assess the performances of each of the case hardened tool insert on the machined work material ASTM A36.

RESULTS AND DISCUSSION

The behavioral trends of the dependency of the treatment with case hardening temperature tend to have slight increase in surface hardness shown in figures 1 to 3 above. Carburisation of cutting tool has a relatively increase in the surace hardness inrespect to incraese in case hardening time. Considering figure 1 been carburized at 60 mins at 800 ^{o}C gave the minimum surface hardness of 36.9, follow by figure 2 that gave better surface hardness of 61.1 at caburizing time of 950 ^{o}C while in figure 3 gave the best surface hardness of 76.8 at 950 ^{o}C. Carburizing the samples enhance the modification of the increase in its hardness, wear resistance of both surface and core layers of the cutting tool. The core and surface hardness values of the cutting tools vary on the degree of concentration from the reaction of palm kernel shell as a carburizer and Barium trioxocarbonate (v) oxide as energizer. It was observed from the research that the sample carburized at 950^{o}C held for 120 minutes has the highest surface hardness of 76.8HR and micro hardness of 47.9HR, this show that the higher the carburizing temperature with longer holding time the higher the hardness of both core and layer.

The cutting tool developed has highest micro hardness and surface hardness that show the significant of the tools developed in cutting operation. Increase in hardness value is effective as a result of palm kernel shell has enough proportion of carbon to penetrate into the layers of the tools which agreed with research carried out by us

Table 1: Results of Surface and Micro hardness variation with Time of cut

SAMPLE	SURFACE HARDNESS	MICRO HARDNESS	TIME OF CUT (min)
1	36.9	38.0	1.50
2	49.9	35.5	1.47
3	52.3	29.1	1.49
4	55.7	25.1	1.50
5	56.7	42.5	1.44
6	57.7	40.7	1.50
7	59.0	31.0	1.49
8	59.7	38.1	1.38
9	61.1	39.1	1.20
10	63.5	35.3	1.22
11	65.7	45.2	1.24
12	76.8	47.9	1.19

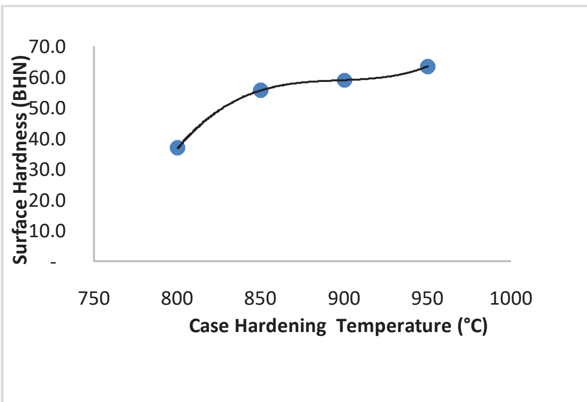

Figure 1: Surface Hardness at 60 minutes

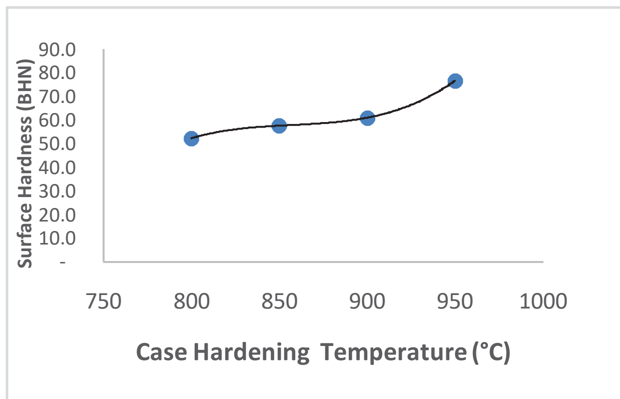

Figure 2: Surface Hardness at 90 minutes

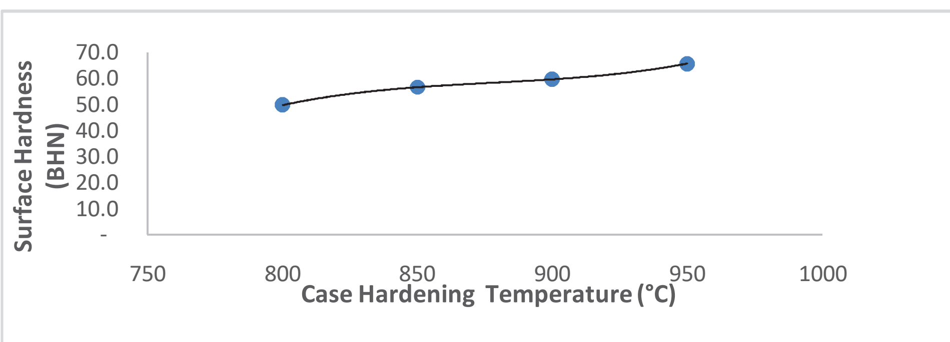

Figure 3: Surface Hardness at 120 minutes case hardening time

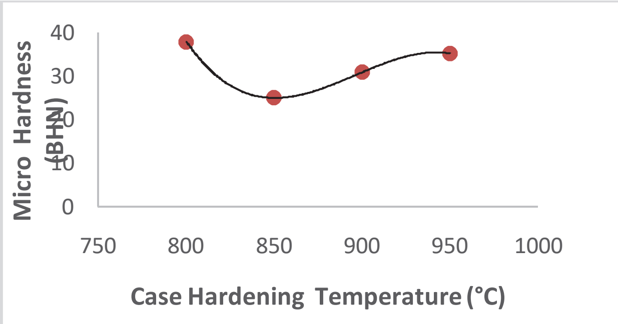

Figure 4: Micro hardness at 60 minutes

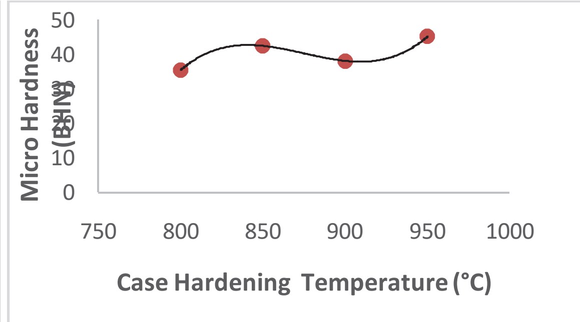

Figure 5: Micro hardness at 90 minutes

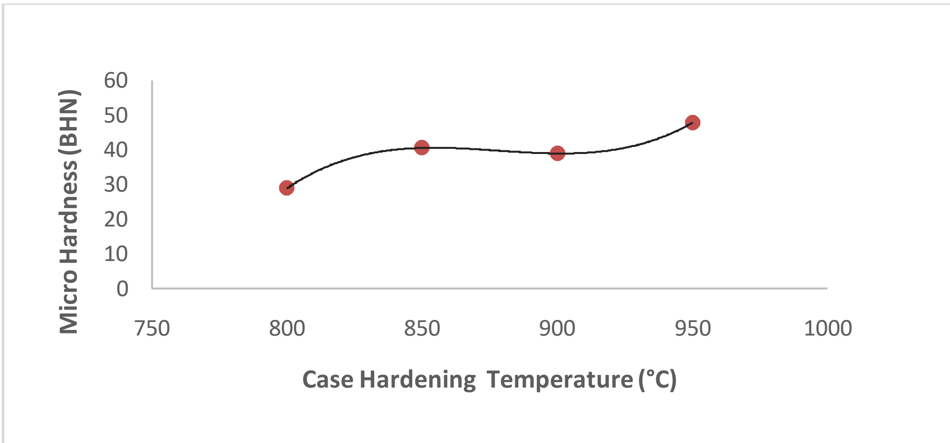

Figure 6: Micro hardness at 120 minutes case hardening time

Considering the trends of the figure 4 to 6, It was clear that the performance of the sample 1 to 3 in figure 4 has an decrease in micro hardness test from 38.0 to 29.1 inrespect to increase in case hardening time with temperature which was in reverse to the cases in figures 5 and 6 where the micro hardness increases inrespect to increase in case hardening time and temperatures.This was caused as aresult of heavy deposition of the carbon concentrates in the core layer of the materials with gradual declination and sudden rise due to elevated temperatures with tme.

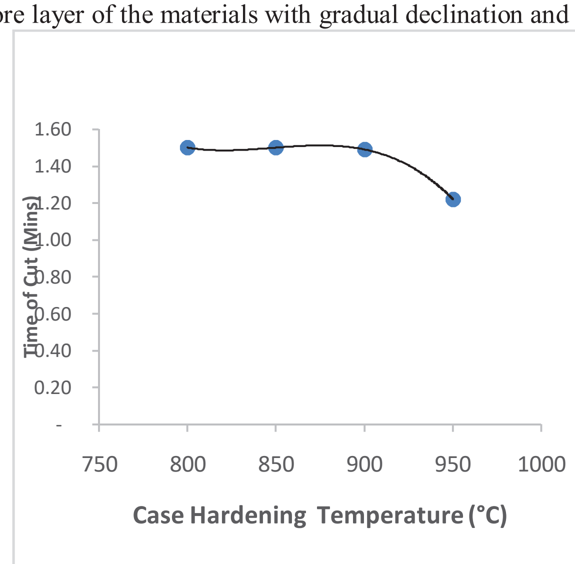

Figure 7: Time of Cut at 60 minutes

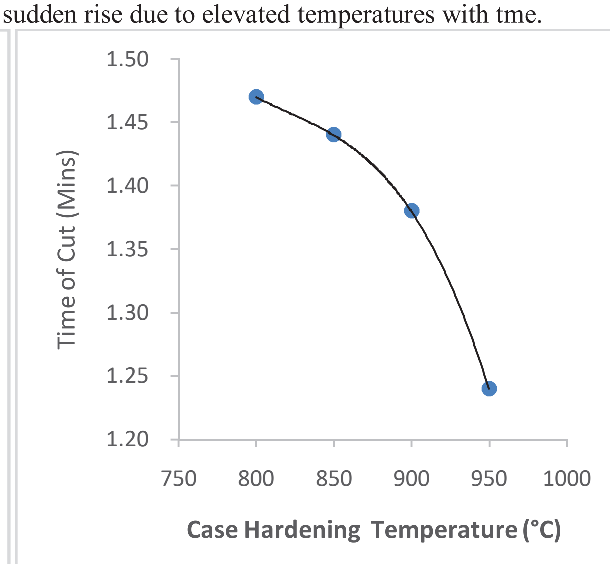

Figure 8: Time of Cut at 90 minutes

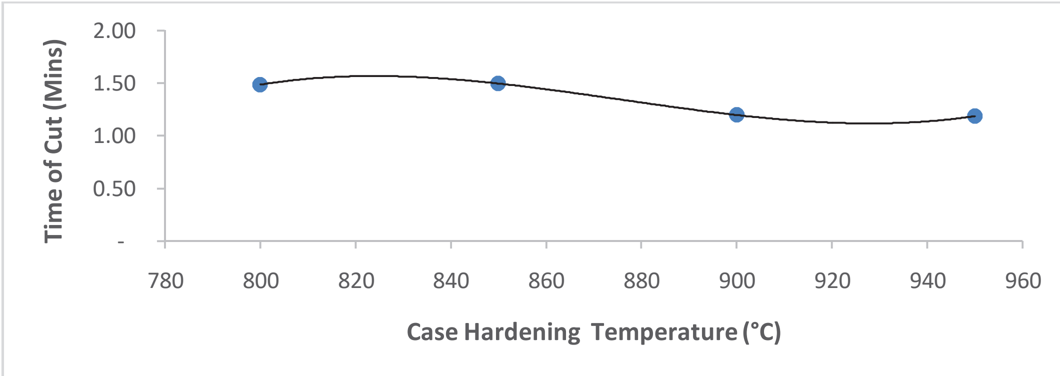

Figure 9: Time of Cut at 120 minutes case hardening time.

Figures 7 to 9 showed the polynomial trends of machining time consumed and behavioral performances of using carburized ASTMA A600 cutting tool to machining ASTM A36 materials for length of cut 50 mm. Considering figure 7, there was a slight ratio of decrease in time of cut with an increase in carburizing temperature due to slight increase in the surface and core hardness of the tools. Figure 8shown the best performance variation in time of cut with case hardening temperature and this gave the reflection of higher the surface and micro hardness the lower the time of cut during machining. The polynomial trend of the performance in figure 9 with lowest time of cut gave a conclusion of high dependence ratio of machining time of cut on the carburizing temperature.

CONCLUSION

The following conclusions can be made from the research work;

1. The best performance variation in machining time of cut with maximum case hardening temperature and time gave the reflection of the higher the surface and micro hardness the lower the time of cut during machining.
2. It was also observed that increase in the feed rate and depth for length of cut significantly reduces the wear progression and thereby gave best machining time at maximum carburizing temperature and time
3. The rates of carburizing temperature and time affected the mechanical properties of the material and this also enhance an increase in proportion with the rise in concentration of carbon deposition that dissolved in austenite due to transformation of austenite into martensite compare with untreated sample.
4. At higher carburizing temperature and time, higher surface and micro hardness recorded.

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