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Investigation of Wear Land and Rate of Locally Made HSS Cutting Tool

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Abstract: Production technology and machining are inseparable with cutting operation playing important roles. Investigation of wear land and rate of cutting tool developed locally (C=0.56%) with an HSS cutting tool (C=0.65%) as a control was carried out. Wear rate test was carried out using Rotopol –V and Impact tester. The samples (12) of locally made cutting tools and one (1) sample of a control HSS cutting tool were weighed to get the initial weight and grit was fixed at a point for the sample to revolve at a specific time of 10 mins interval. Approach of macro transfer particles that involved mechanism of abrasion and adhesion which was termed as mechanical wear to handle abrasion adhesion processes was used in developing equation for growth wear at flank. It was observed from the wear test that best minimum wear rate of 1.09 $x10^{-8}$ and 2.053$x10^{-8}$ for the tools developed and control were measured. MATLAB was used to simulate the wear land and rate under different conditions. Validated results of both the experimental and modeling showed that cutting speed has effect on wear rate while cutting time has predicted measure on wear land. Both experimental and modeling result showed best performances of tools developed over the control.

INTRODUCTION.

The life span of a tool depends and influenced by the temperature generated. Surface treatment of cutting tools reduced the gravity of tools wear and development in the heat treatment equipment[1].This process give room in producing a wide range of various tool substrates as monolayer and multilayer irrespective of whether cutting tool material are coated or not, the utmost concern is to regulate and optimize cutting tool properties[2].

Several years back the Finite Element Method (FEM) has become the popular techniques used for analyzing physical and it can be used to find out facts or study the process in a way that no other tool can accomplish [3].In some years back, High speed steels was discovered and it was observed that it cut four times faster than the carbon steels and it has over 30 grades available. Since 1960s the development of powdered metal coatings especially Titanium Nitrate allows high speed steel tool to cut faster and last longer due to its high surface hardness and wear resistance. Jacobson *et al* [4] described physical properties of Titanium Nitride coating of HSS and carbide tools as probably the most interesting because it is often considered to play the role of thermal barrier coating by protecting the heat sensitive tool substrate from thermal softening [6-8]. In order to increase life span of a cutting tool, surface engineering treatments will bring extensive rearrangements of atoms in metals and alloys structure with a corresponding marked variation in properties. The major and most valuable one of these methods is heat treatment processes such as immersion hardening, induction hardening and case carburizing. These are generally applied to enhance the hardenability of materials by improving the surface hardness. Carburization as one of the heat treatment methods is better compared with other methods due to carbon penetration to the depth which can make the material harder and improve its wear resistance [9].

Chemical composition of a cutting tool can be improved and its microstructure can be modified through carburization using palm kernel shell as carbon additives. Tool wear of a tool is significantly influenced by

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temperature generated at the cutting zone especially zone of lower thermal conductivity [10]. It was observed that increase in the feed rate and depth significantly affects the tool life and promotes wear progression [11]. The stress and deformation at the tool during machining usually increases as the tool wear increases. Wear always occur during the cutting process of the cutting tool since tool wear may resulted to poor dimensional accuracy, deterioration of surface integrity of the work piece and damages to work piece itself [12].Crater wear occur when there is diffusion where atoms of one material diffuse over to another material and its affect the mechanics of the process by increasing the rake angle to ease the cutting operation but it could weaken the tool wedge as well increase the chances of tool breakages[13-14]. This mainly occurs under high temperature and is therefore a common wear mechanism in mechanical cutting with high feeds and cutting speed relatively small concern. It is believed that diffusion causes the tool to be depleted of its atoms responsible for its hardness, and therefore becoming more sensible for Abrasive and Adhesive wear [15-16]. As a result of this, wear is located on the chip rake face of the tool, and has the form of a crater and the rake face suffers severe pressure and temperature loads and for control, the Investigation of wear rate and land of locally made HSS cutting tools was carried[17]

WEAR TEST

The test was carried out on the following equipment; Rotopol –V and Impact tester. 12 samples of developed cutting tool (C=0.65%) and imported HSS cutting tool (control) were used. The samples were weighed to get the initial weight and grit which was fixed at a point for the sample to revolve at a specific time of 10 mins interval. Weight loss was now calculated by subtracting the final weight from the initial weight of each sample.

The machine, Rotopol -V has provision for carrying out wear resistance on any material. It is simple to use but the surface of the sample to be tested must be parallel to the surface of the rotating disc of the machine. Care was taken to ensure that the sample under test is firmly held to the surface of the rotating disc during the test so that the sample does not fling out while running the test and wear volume for each sample was measured at particular time interval of 10 mins during cutting.[17-19].

RESULT AND DISCUSSION

The wear rates of the 12 samples of locally made cutting tool and one (1) sample of HSS cutting tool were shown in Table 1. Investigation of wear land and rate of the developed tools and HSS cutting tools were carried out. Considering Figures 1 to4, it was observed that the higher the cutting speed in relation with time the more its effects on wear land under different conditions of elastic layer elastic lump, plastic layer and plastic lump of the work piece materials.

Comparative analysis studies of the wear land and rate of the developed tools and imported HSS cutting tools were carried out. Considering Figures 1 to 4, it was observed that the higher the cutting speed in relation with time the more its effects on wear land under different conditions of elastic layer elastic lump, plastic layer and plastic lump of the work piece materials. The experimental behavioral of the turning operation under plastic deformation has dominant effects which was considered as the principal wear factor which could occur from high compressive stress.

Table 1: Results for Wear Rate

S/N	SAMPLE	WEAR RATE
1	A	$2.190 \text{ X}10^{-8}$
2	B	$5.476 \text{ X}10^{-9}$
3	C	$2.108 \text{ X}10^{-8}$
4	D	$3.833\text{X}10^{-8}$
5	E	$5.476 \text{ X}10^{-10}$
6	F	$4.928\text{X}10^{-9}$
7	G	$1.040 \text{ X}10^{-8}$
8	H	$6.571 \text{ X}10^{-9}$
9	I	$1.068 \text{ X}10^{-8}$
10	J	$2.382 \text{ X}10^{-8}$
11	K	$1.287\text{X}10^{-8}$
12	L	$1.095 \text{ X}10^{-8}$
13	Control	$2.053\text{X}10^{-8}$

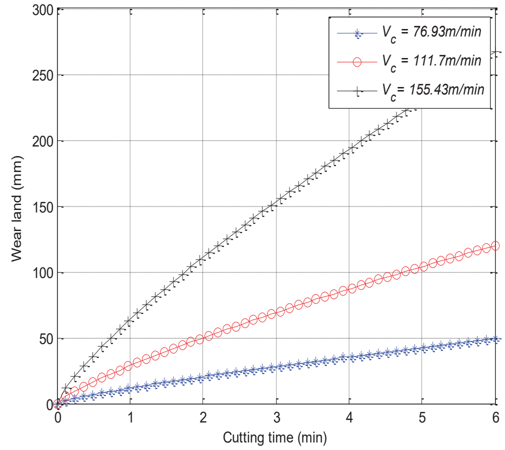

Figure 1: Effects of cutting time on wear land under elastic layer

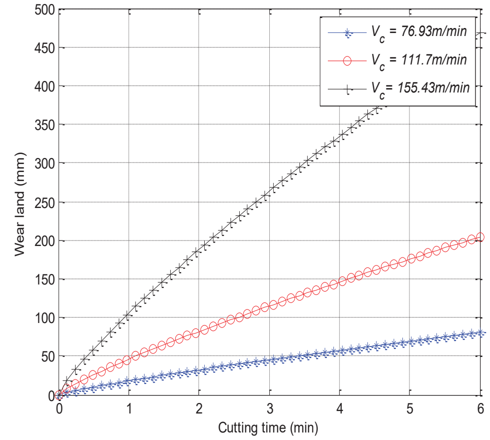

Figure 2: Effects of cutting time on wear land under elastic lump

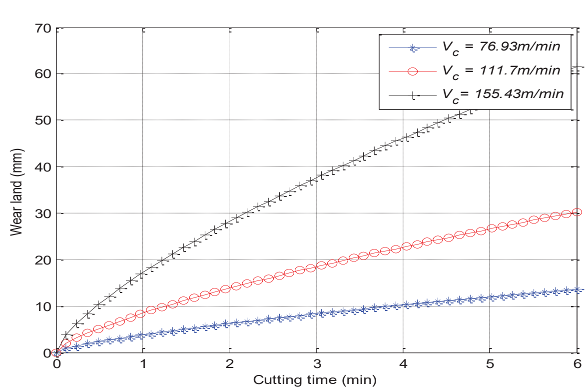

Figure 3: Effects of cutting time on wear land under plastic layer

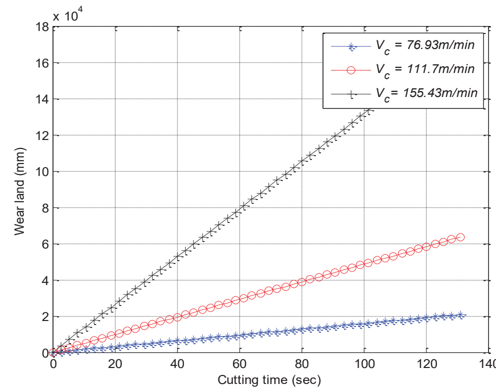

Figure 4: Effects of cutting time on wear land under plastic Lump.

Considering Figures 1 to 4, it was observed that the higher the cutting speed in relation with time the more its effects on wear land under different conditions of elastic layer elastic lump, plastic layer and plastic lump of the work piece materials [20].

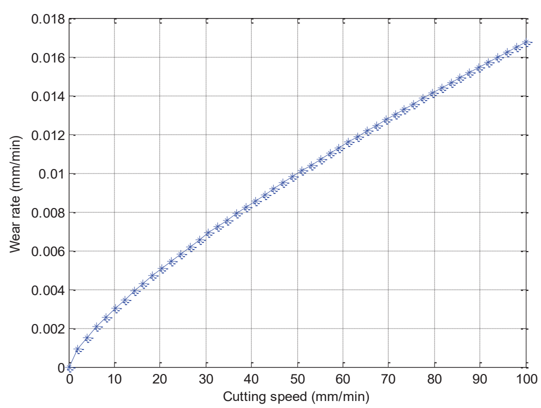

Figure 5: Effects of cutting speed on wear rate under predominant and purely adhesion during cutting operation.

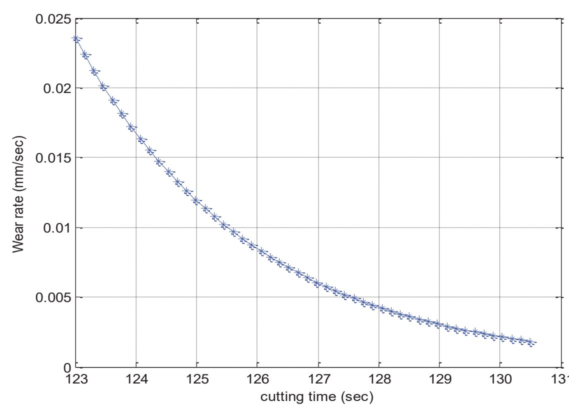

Figure 6: Effects of cutting time on wear rate under perfect layer

In Figures 5 to 6, the machining under predominant and purely adhesion cutting process showed higher effects of wear rate at high cutting speed while under perfect layer gave higher wear rate at lower cutting speed. It was noted that under a perfect layer condition, wear rate is proportional to wear land as indicated in Figure 7.
The simulation of the wear land and wear rate using MATLAB are as presented in Figures 7.

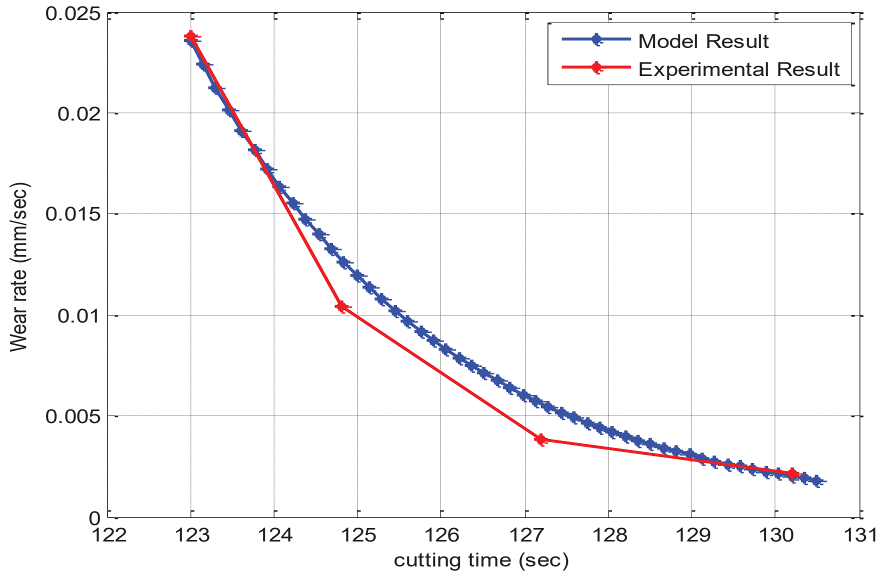

Figure 7: Validation of experimental and model on effects of cutting time on wear rate.

In Figures 5 to 6, the machining under predominant and purely adhesion cutting process showed higher effects of wear rate at high cutting speed while under perfect layer gave higher wear rate at lower cutting speed. And under perfect layer condition wear rate is proportional to wear land.

At different higher carburizing temperatures and holding time, the results showed better performance of the tool developed during machining at different length of cut, cutting speed and feed. Experimental and model validation results showed similar behavior in Figure 7 and this showed comparative results of tools developed and the control**.**

The simulation of the model gave the optimal cutting parameters which were applicable in the production of the cutting tool especially in the area of selection of materials, melt correction, casting, carburization and experimental analysis. The carburized mild steel showed higher value in hardness and tensile strength with better performance in wear resistance during experimental test. The wear rate and volume of the cutting tool reduce while the carbon content in solid solution increases in proportion to increase in carburizing temperature and holding time.

CONCLUSION

Designed control system through modeling of wear rate and wear land that can enhance performance evaluation of cutting tool has been established and can also be applicable for the manufacturers. Introduced a standard that have influence and reliability especially of high importance for cutting tool with less cutting wear, optimize speed and low cost in production for use. The results will also be of assistance to production of cutting tool using scraps as material with better wear resistance in every machine tool workshop. In summary, researchers and industrialists would benefits immensely from the findings of this work. The result confirmed better performance of palm kernel shell as a carburizer due to its consistent increase in the value of hardness and wear resistance. It was also confirmed that there was considerably improvement in wear resistance because the treatment has compensated for the combine effects of plastic deformation and wear of the cutting tools.

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REFERENCES

1. P.G Mordovskoi, S.P Yakovleva and S.N Maharova. Influence of Equal Channel Angular Pressing on Tribological Properties of Low Carbon Steel. *Journal of Surface Engineered Materials and Advanced Technology* 5*(2015)* 24-27.
2. I.I Kunz and W. Konibg.Cutting Tool Materials Classification and Standardization.*CIRP Annals –Manufacturing Technology*36 (2) (1987) 531-535.
3. F. Klocke, S. Rizzuti, P. Frank, K. Gerschwiler, D. Lung and L. Settineri. Experimental and Numerical Investigation on the Delamination Behaviour of PVD-Coated Tools in Turning of Austenitic Steel. *International Journal Materials, Germany* 5 (2010) 1-70.
4. S. Jacobson, S. Wallen and P. Hogmark. International Conference on the Behavior of Materials in Machine Tools and Manufacture. *International Journal of Machine Tools* 28(4)(1998) 551-567.
5. H.C Child. Surface Hardening of Steels.Oxford University Press. London pp (1980) 60-169.
6. B.M Vikas and R.N Vinayak. Tool Wear Monitoring when Turning EN 8 Steel with HSS-M2 Tool. *International Journal of Innovative Research in Science, Engineering and Technology* 2(2013) 100-180.
7. M. Boujelbene., A. Moisan, W. Bouzidand Torbarty, S. Variation Cutting Speed on the Five Axis Milling. *Journal of Achievements in Materials and Manufacturing Engineering* 21(2)(2007) 2-14.
8. S.A. Afolalu, S.B Adejuyigbe and O.R Adetunji and O.I Olusola. Production of cutting tool from recycled steel and palm kernel shell as carbon additives;, International Journal of Innovation and Applied Studies, Vol.12 (1) July,2015, pp 110-122 http: www.ijoar.org. (2015).
9. S.A Afolalu, S.B Adejuyigbe and O.R Adetunji Impacts of Carburizing Temperature and Holding Time on Wear of High Speed Steel Cutting Tools, International Journal of Scientific and Engineering Research, Vol. 6 (5), pp 905-909, http: www.ijser.org. (2015).
10. S.A**.** Afolalu, S.B Adejuyigbe and O.R Adetunji and O.I Olusola Effects of Carburization on Mechanical Properties of recycled steel with palm kernel shell as carbon additives;, International Journal of Advance Research, Vol. 3 (5), pp 1-7, http: www.ijoar.org. (2015).
11. S.A Afolalu, O.O Ajayi, O.M Ikumapayi and S.A Adejuyigbe. (2015). Modeling and Simulation of Wave load on Periodic Support for Isolation System of Offshore Platform, International Journal of Scientific & Engineering Research, Vol. 6 (5), May-2015, pp 441-447
12. S.A Afolalu, E. Y. Salawu, I. P. Okokpujie, A. A. Abioye, O. P. Abioye, M .O Udo, O. R. Adetunji and O M. Ikumapayi Experimental Analysis of the Wear Properties of Carburized HSS (ASTM A600) Cutting Tool.International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 19 pp. 8995-9003 © Research India Publications. (2017).
13. P.G Mikell. Theory of Metal Machining. Fundamentals of Modern Manufacturing, 3rdEdition, John Wiley & Sons, Incorporation. New York. ISBN 0471744859 (2007) 67-111.
14. B.O. Orisanmi, S.A. Afolalu, O.R. Adetunji, E.Y. Salawu, and I.P. Okokpujie. Cost of Corrosion of Metallic Products in Federal University of Agriculture, Abeokuta. *International Journal of Applied Engineering Research*, *12*(24), 14141-14147. (2017).
15 A.A. Abioye, P.O. Atanda, O.P. Abioye, S.A. Afolalu and J.O Dirisu. Microstructural Characterization and Some Mechanical Behaviour of Low Manganese Austempered Ferritic Ductile Iron. *International Journal of Applied Engineering Research*, *12*(23), 14435-14441. (2017).
16. O.O. Ajayi, O.F. Omowa, O.P. Abioye, O.A. Omotosho, E.T. Akinlabi, S.A Akinlabi, and S.A. Afolalu. Finite Element Modelling of Electrokinetic Deposition of Zinc on Mild Steel with ZnO-Citrus sinensis as Nano-Additive. In *TMS Annual Meeting & Exhibition* (pp. 199-211). Springer, Cham. (2018)
17. O.R. Adetunji, A.A. Musa, and S.A. Afolalu. Computational Modelling of Chromium Steel in High Temperature Applications. *International Journal of Innovation and Applied Studies*, *12*(4), 1015. (2015).
18 O.R. Adetunji, A.A. Musa, and S.A. Afolalu. Computational Modelling of Chromium Steel in High Temperature Applications. *International Journal of Innovation and Applied Studies*, *12*(4), 1015. (2015).
19 O.R. Adetunji, O.O. Ude, S.I. Kuye, E.O. Dare, K.O. Alamu and S.A. Afolalu. Potentiodynamic Polarization of Brass, Stainless and Coated Mild Steel in 1M Sodium Chloride Solution. In *International Journal of Engineering Research in Africa* (Vol. 23, pp. 1-6). Trans Tech Publications.(2016).