

Optimization of Controlling Factors on Tool Wear When Coolant Mixed with Additives on Turning of Mg-Y Alloy

K. Ramadoss, R. Elansezhian, S. Jayabal

Abstract: The output parameters like surface roughness, the tool job interface temperature, metal removal rate, and tool wear during turning operation are depending upon the input factors of the turning operation. In this paper a magnesium alloy was subjected into turning operation on a medium speed lathe to observe the tool wear. The chance of fire hazard and sticking of tool with magnesium alloy is reduced by introducing Minimum quantity lubrication technique. The lubricoolents are mixed with nano sized additives of Silicon carbide, Copper oxide and Titanium oxide. Since input factors are in more numbers, the initial optimization of feed rate, quantity of supplied coolant, mixed nano additive with optimized quantity, the optimized nano Copper Oxide was further mixed with surfactants such as Sodium Dodecylsulfat (SDS). Cetyl Trimethyl Ammonium Bromide (CTAB) and Zwitterionic at a concentration of 1g/lit and 2g/lit. A new magnesium alloy yttrium and calcium composition was subjected to turning operation with different machining parameters and with different cutting tips for analysis of surface roughness, Temperature developed, Rate of metal removal and tool wear. Optimization was carried out by using Taguchi method. The optimized values of Speed, Feed rate, Type of nanoparticle with concentration, and Type of surfactant were obtained. The mixing of surfactant contributed considerably in reduction of nano particle usage. The model based predicted value and Experimental values are very close to each other.

Keywords: Surface Roughness, Metal Removal Rate, Magnesium Alloy, Nano Additives, Surfactants, Minimum Quantity Lubrication. Tool Wear.

I. INTRODUCTION

Turning operation is the common method for metal removal with good surface finish. The turning operation is normally influenced by types of lathe, cutting tools, operation parameters and the lubricoolent used which can reduce the tool- job interface temperature [1]. Now a days the usage of lubricoolents are minimised for better economy, least green gas evaporation and to safeguard operators health.[2].. The

optimum parameter selection also depends upon with operator's experience. The hand book data also with insufficient information when these machines are equipped with new coolant mixtures and new cutting tools[3]. In early years of 20th century the practitioners were unable to use the statistical design because the knowledge on these area were concealed and expertise by statisticians. The cutting parameters are selected based on the experience or by referring to the hand books. But the selected parameters are may not be optimal in most cases. Selection of wrong or non-optimal parameters leads to the wastage of raw material, man power, electricity, cutting fluid, cutting tools etc., and then these affect the cost of the product (9). Many researchers have developed numerous mathematical models, which requires in depth knowledge and experience (10). Taguchi proposed that the engineering optimization with three step approach such as system design, parameter design and tolerance design. The objective of this parameter design is to optimize the settings of the process parameters values(11).

II. EXPERIMENTAL PROCEDURE

A new magnesium alloy was stir casted with the composition of commercial Magnesium alloy Mg AZ 91 D of 9% wt Al, 1% wt Zn, and in addition 2% wt Y and 0.5% Ca, balance with magnesium wt. The homogenous mixture was casted in to 30 mm diameter and 300 mm long rod(12) A newly fabricated minimum quantity lubricants set up was installed and trial run carried out with the materials like mild steel, brass, aluminum and magnesium alloys by turning operation. The turning operation was conducted under dry, flood lubricoolant and MQL environment conditions on medium speed Lathe.

Manuscript published on 30 August 2018.

* Correspondence Author (s)

K. Ramadoss, Research Scholar, Department of Mechanical Engineering, Pondicherry Engineering College, Puducherry, India. E-mail: E-mail: ramadoss_krishna@yahoo.co.in

R. Elansezhian, Associate Professor, Department of Mechanical Engineering, Pondicherry Engineering College, Puducherry, India.

S. Jayabal, Associate Professor, Department of Mechanical Engineering, Alagappa Chettiar Government College of Engineering and Technology, Karaikudi (Tamil Nadu), India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](https://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

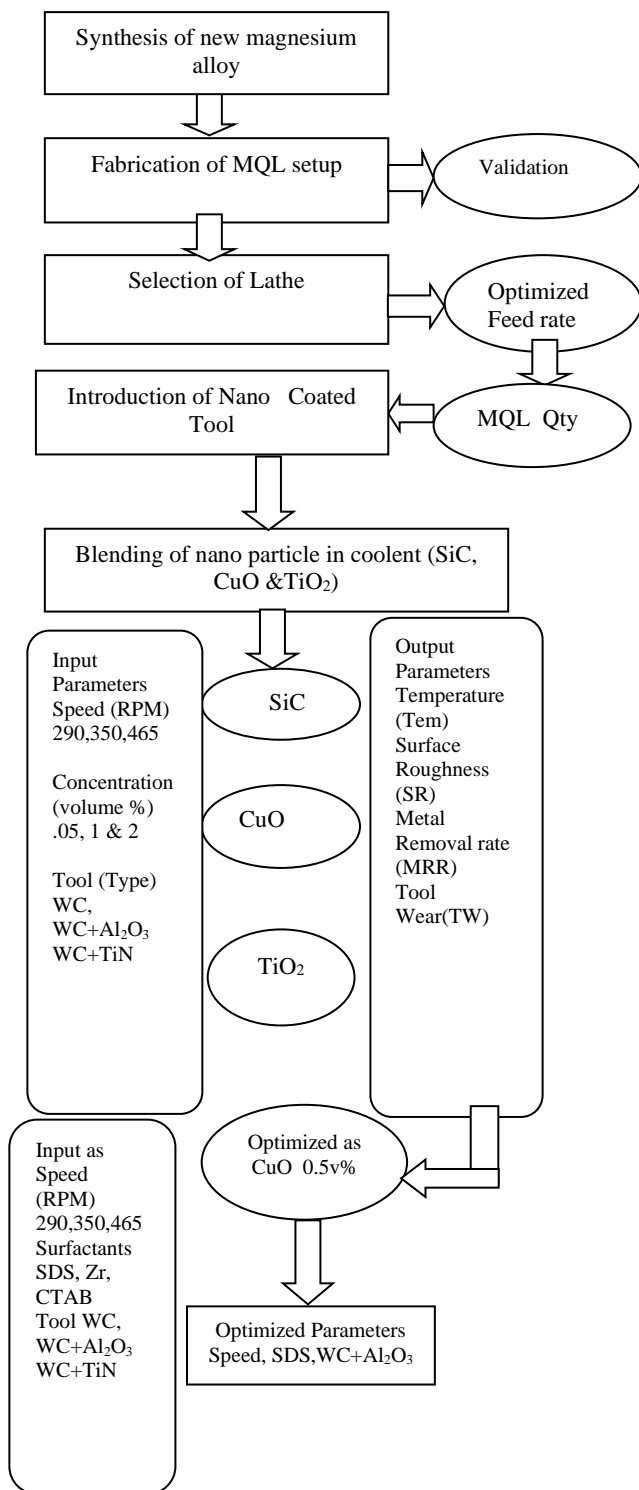


Figure 1. Flow Chart of Machining Programmed

The nozzle of the MQL setup designed such that it would supply a constant coolant flow of 10 ml/s at the pressure of 7 kg/cm². A medium speed semi automatic Lathe (make-1987, Type-170G2, Size-1960 mm, cross slide 260 mm and RPM range 65-1000) was selected to carry out the turning operation, since these type of lathes are in common usage with flood lubricoolant where the operator health is a major concern and wastage of coolant oil and unwanted emissions CO_x, SO_x and NO_x are maximum. During the preliminary investigations following conclusions were arrived.

- (i) A comparison study concluded that MQL will be effective other than dry and wet (conventional) flood lubricoolant machining with constant flow rate 10ml/s.
 - (ii) The depth of cut is taken as constant 0.5 mm.
- The flow chart for complete machining programme is given in Figure 1. The photographic images of work piece and tool inserts are shown in Figures 2 and 3 respectively.



Figure 2. Photographic Image of Magnesium Alloy



Figure 3. Photographic images of (i) Tungsten carbide Uncoated Tool (ii) Tungsten carbide Tool coated with Titanium Nitrate (iii) Tungsten carbide Tool coated with Aluminum Oxide

The specifications of tool inserts are as below.

(i) Tungsten carbide Uncoated Tool

Molecular Formula: WC

Appearance : Grey-Black, Lustrous solid

Melting point : 2870°C

(ii) Tungsten carbide Tool coated with Titanium Nitrate

Molecular formula: WC + TiN

Appearance : gold lustrous solid

Melting point : 3250°C

(iii) Tungsten carbide Tool coated with Aluminum Oxide

Molecular Formula : WC + Al₂O₃

Appearance : Black lustrous solid

Melting point : 2960°C

III. OBSERVED OUTPUT PARAMETERS

Trials were performed preliminary to optimize a) Feed rate of the lathe, b) The Nano Particle which was mixed with coolant fluid, and its optimized concentration. The Taguchi method design of experiments (DOE) tool was used for optimization, L9 orthogonal array and the concept of S/N ratio was selected for the improvement of quality through variable reduction. The characteristics of S/N ratio $-10\log_{10} \frac{1}{n} \sum \frac{1}{y^2}$ was taken to analyze the tool Wear. The tool wear was measured using Rapid I Machine Vision System as shown in Figure 4.





Figure 4. Measurement of Tool wear using Rapid I

A.Preparation of Nano Additives and Surfactant Mixture

Nano additives such as silicon carbide (SiC), copper oxide (CuO) and titanium oxide(TiO₂) were procured from M/S Alfa Aesar-USA with nano particle size 40-50 nm and mixed with coolant lubrication oil in 0.5% v,1%v and 2%v concentration. The surfactants SDS (1g/lit), Zwitterionics (1g/lit) and CTAB (2g/lit) were mixed with nanoCuO coolant mixture which was optimized nano additive [8] in previous studies. These mixtures were prepared in magnetic stirrer for 8 hrs. Sediment test were conducted and confirmed those additives not settled even after 3days [9].

The photographic images of Nano additives and its blending and Sample of prepared Nano additive Mixture are shown in Figures 5 and 6 respectively.



Figure 5. Nano Additives and Its Blending



Figure 6. Sample of Prepared Nano Additive Mixture

IV. RESULTS AND DICUSSION

The experimental results of tool wear for varying speed, tool type and surfactants are given in Table 1.

Table 1. Experimental Results

Speed (rpm)	Tool	Surfactant	Tool wear (mm)
1	1	1	0.11
1	2	2	0.12
1	3	3	0.15
2	1	2	0.14
2	2	3	0.17
2	3	1	0.18
3	1	3	0.15
3	2	1	0.18
3	3	2	0.2

All the values are given in terms of coded factors .The three levels of speed are 290 rpm and 350 rpm and 465 rpm and the surfactants are SDC, ZR and CTAB. The statistical package MINITAB was used to generate tool wear regression equation as given below.

$$\text{Tool wear} = 0.06667 + 0.06500 n - 0.008333 t - 0.01500 s - 0.01167 n^2 + 0.001667 t^2 + 0.008333 s^2 + 0.01000 nt - 0.006667 ns$$

The mathematical equations correlating input parameters and output characteristic (tool wear) for observed data are formed using regression modeling. The non linear regression models are generated based on high value of coefficient of correlation and selection of best fit. The quadratic model was obtained with the Coefficient of correlation of (R²) 0.999.The close prediction was obtained using codes factors. Statistical plots play an important role in statistics and data analysis. There are also many statistical tools generally referred to as graphical techniques. A contour plot is like a topographical map in which coordinate values are plotted to understand the feasible region for the optimization of output characteristics. The contour plots for tool wear for varying speed, tool and surfactants are shown in Figure 7. Tool wear was measured using Machine vision system (Rapid-I). Rapid-I Software comes with powerful graphical tools for enhanced measurements and inspections. Using the powerful graphical suite available in Rapid-I, the **drafting of tool profile was created by drawing on a CAD package**. After the turning operation, again the tool profile was drawn. Differences between the two profiles were estimated with the **on-screen digital micrometer tool to estimate tool wear**.

The tool wear in range of 0.11 to 0.20 was obtained. The experimental values of tool wear are shown in Figure 9.The tool wear increases as the levels are increases. By the self analysis optimization , the intermediate levels of input parameters for minimum tool wear satisfying other output characteristics were also obtained. The better value of output characteristics were obtained for the speed of 350 rpm using Tungsten carbide Tool coated with Aluminum Oxide using SDC surfactant.

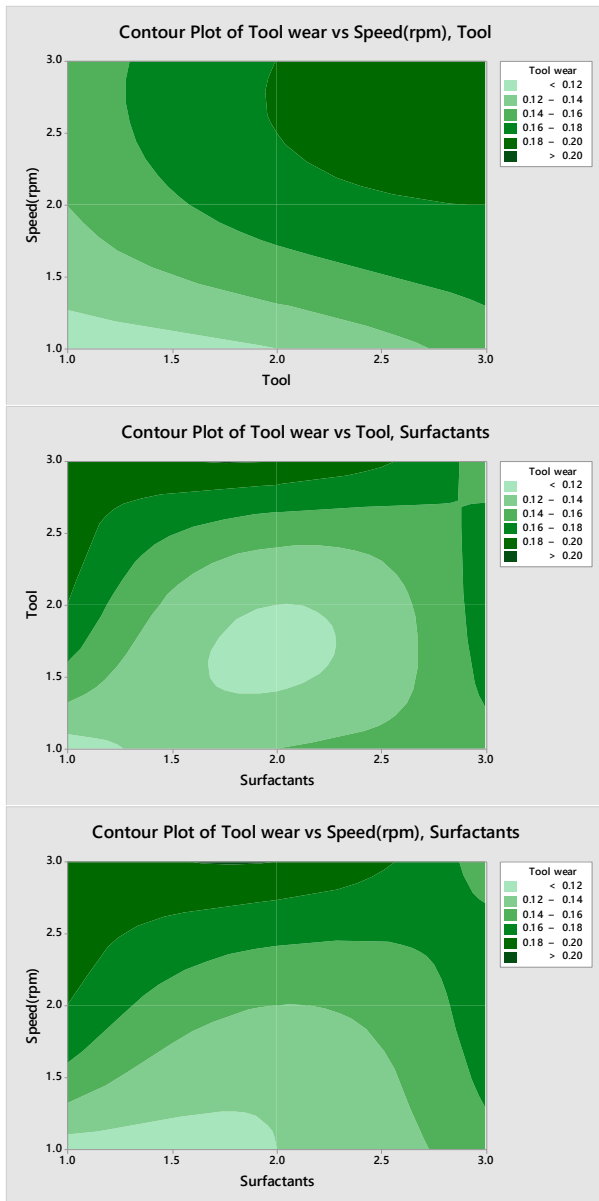


Figure 7. Contour Plots of Tool Wear

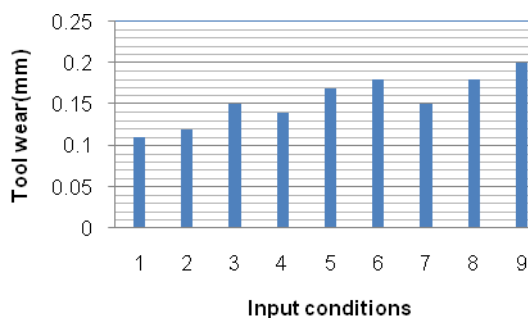


Figure 9. Experimental Values of Tool Wear

V. CONCLUSION

The Optimization of controlling factors on tool wear, when coolant mixed with Nano aditives and surfactants during turning operation of Magnesium alloy was carried out in the present investigation. The other output characteristics such as surface roughness, temperature and metal removal rate were also taken in to account for minimizing tool wear in this present investigation. The depth of cut and feed rate were

initially optimized and kept as 0.5 mm and 0.193 mm/rev. respectively. The Feed rate was optimized by analyzing the surface roughness of the turned bar. The tool wear is increased for increasing speed, hardness of tool and type of surfactants used. The better value of output characteristics were obtained for the speed of 350 rpm using Tungsten carbide Tool coated with Aluminum Oxide using SDC surfactant by self analysis.

REFERENCES

1. Wu An-ru, Xia chang-qing ‘Study of the microstructure and mechanical properties of Mg-rare earth alloys’ J of Material Dsign 28(2007)1963-1967.
2. J.F King: Development of practical High temperature magnesium casting alloys, magnesium alloys and their applications. Edited By B.L Mordike and KU kainu, WILEY – VCH Weinheim Gerany P.14-22.2000.
3. HE Friedrich and B.L Mordike: Magnesium technology, springer-verlog Berlin Heidelberg Germany-2006.
4. B.L Mordike and T.Ebert: Magnesium applications-potential, journal of material science engineering A 302- P.37-45. 2001.
5. E.Gariboldi: Drilling a magnesium alloy using PVD coated twist drills, journal of material processing technology 134.P 287-295.2003.
6. F.Tikal M chmier and C vollmer: High speed drilling in A291D without lubricants: WILEY – VCH verlog Gmbtt, weinheim, Germany 2000.
7. N.Tomac K.Tonneson and T.Mikkac: Study of influence of aluminium content on mechinability of magnesium alloys, stronjanstic 50(6) 363-367, 2008.
8. G.Hamko, C.Lochhichler, W.Riederer and G Macher: Techniques for recycling of magnesium proceedings of the 6th international conference magnesium alloys and their applications Wiley-VCH Germany 2004.
9. Tharaighmani S, Rosli S, Hassam “ A study of minimum quantity of lubricants on inconel 718 steel” journal of archives of material science and engineering, September-2009.
10. M. H.Ruzi , M.Norhamidi, S.Abu Bakar, R.J.Khairur, M.N.Nor Hafiez, A.Sufizar and I.I.Mohd Halim Murtadhahadi: A Review Of Workability Of Wrought Magnesium Alloys, Advanced Manufacturing Research Group’09 Seminar 3, Advanced Manufacturing Research Group, 2009.
11. optimization of high speed turning parameters of super alloy 718 material using Tagudhi technique: Dinesh Thakar , B.Ramamoorthy & L.Vijayaraghavan Indian Journal of engineering& material sciences vol.16 february 2009 PP 14-50
12. K Ramadoss, R Elanshezhan ’Synthesis and characterization of newly formulated Magnesium Alloy with rare earth metal and study of microstructure and mechanical properties ’proceedings IEEE-ICRDPET2013vol1 p103.
13. K Ramadoss, R Elanshezhan ’Performance Validation of Newly Developed Minimum Quantity Lubrication (MQL) setup on Capstan Lathe’ proceedings IEEE-ICRDPET2013vol1 p107
14. Ali Riza Motorcu ‘The optimization of machining parameters using the Taguchi method for surface Roughness of AISI8660 Hardened alloy steel’.Strojinski vestnik-Journalof Mechanical Engineering 56(2010)6 391-401.
15. Sijo M.T and Biju.N’Taguchi method for Optimization of Cutting Parameters in Turning oprations’ AMAE Int.J. on Manufacturing and material science.Vol01May2011p44.
16. Nasr, M. N. A., Ng, E.-G., and Elbestawi, M. A., 2007, “Modelling the Effects of Tool-Edge Radius on Residual Stresses When Orthogonal Cutting AISI 316 L,” Int. J. Mach. Tools Manuf., 47(2), pp. 401–411.
17. Ventura, C. H. H., K ohler, J., and Denkena, B., 2015, “Influence of CuttingEdge Geometry on Tool Wear Performance in Interrupted Hard Turning,” J. Manuf. Processes, 19, pp. 129–134.
18. Bassett, E., K ohler, J., and Denkena, B., 2012, “On the Honed Cutting Edge and Its Side Effects During Orthogonal Turning Operations of AISI1045With Coated WC-Co Inserts,” CIRP J. Manuf. Sci. Technol., 5(2), pp. 10 8–126



Authors Profile



K. Ramadoss received his Master Degree in (Rotodynamic Machines) 2005, from Punjab Engineering College, Chandigarh. He received his B.E degree from AMIE/summer in 1998, from Institution of Engineers. Worked as Assistant Professor in E.G.S.P. Engineering College Nagapattinam, At Present he is doing his PhD studies

in Pondicherry University.



Dr. R. Elansezhian, Associate Professor, is a young dynamic researcher and academician with 17 years of teaching experience in Mechanical Engineering Department, Pondicherry Engineering College, Pondicherry, INDIA. He obtained his Ph.D degree from Indian Institute of Technology (Madras). His research

areas include Nano and amorphous materials, Characterization of materials, Smart materials and structures, Mechanical and tribological studies on coatings, electroless and PVD nanocoatings, CAD modeling, Robotics and automation. He has published nearly 58 research papers in various reputed Journals. He has contributed nearly 50 papers in International conferences in India and abroad. He also presented himself as eminent resource person in lectures and conferences. He is a visiting Professor at Jilin University, China. He is a member of ISTE, ASME, SSPC and NACE.



Dr. S. Jayabal received his B.E degree in Mechanical Engineering from Madras University, India, M.E degree in Computer Aided Design and PhD degree in Mechanical Engineering from Anna University, Chennai, India. He is currently working as Assistant Professor (Senior Grade) and Head of the Department of Mechanical Engineering at

Alagappa Chettiar Government College of Engineering and Technology, Karaikudi, Tamilnadu. He has guided 6 PhD students and currently guiding seven research scholars. He has published 86 research articles in national and international journals and 82 research articles in conferences. His areas of interest include composite materials, indoor air quality, chatter vibration and soft computing techniques.