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Selection of Cutting Tool Insert in Turning of EN 8 Steel using Multiple Attribute Decision Making (MADM) Methods

K.G.Nikam*, S.S.Kadam

* P.G.Student, Production Engineering Department, K.I.T.'s College of Engineering, Kolhapur, Maharashtra, India.

Assistant Professor, Mechanical Engineering Department, K.I.T.'s College of Engineering, Kolhapur, Maharashtra, India.

Abstract

A surface finish is very important in turning process. The main objective of this paper is to select a right cutting tool insert from amongst a number of cutting tool inserts during turning of EN 8 steel work piece with good surface finish.In present study number of inserts are five.So it is difficult to select the one best insert amongst five cutting tool inserts. Multiple Attribute Decision Making (MADM) methods provide a ranking of the available alternatives thereby, decision of critical thinking become easier. Hence in this paper a logical procedure used to select best tool insert from alternative tool inserts for better surface finish in turning operation. The procedure based on two well known Multiple Attribute Decision Making (MADM) methods such as Simple Additive Weighting (SAW) and Weighted Product Method (WPM). A tool insert selection index is proposed that evaluates and ranks of tool insert for good surface finish in turning operation.Finally from ranking select the best tool insert for better surface quality

Keywords: Surface finish,MADM,SAW,WPM,Turning

Introduction

Now a days for any machining operation number of cutting tools available with different grades for particular material.It is very hard to select the proper cutting tool in any machining operation.Metal cutting processes are industrial processes in which metal parts are shaped or removal of unwanted material. Turning is one such machining process which is most commonly used in industry because of its ability to have faster material removal at the same time produces reasonably good surface finish quality. It is one of the most important and widely used manufacturing processes in engineering industries. In the study of metal cutting, the output quality is rather important. A significant improvement in output quality may be obtained by proper tool and work piece combination, optimizing the cutting parameters. Tool insert is not only improves output quality, but also ensures low cost manufacturing. Tool insert include tool insert geometry such as nose radius, approach angle, rake angle, angle of inclination, clearance angle etc. Cutting parameters include feed rate, cutting speed, depth of cut, cutting fluids and so on. In the CNC turning operation many alternative tools say inserts are available. The selection of the proper tool insert is most critical step to obtain the desire surface finish. Among the number of available and applicable tool insert, one can be selected based on the MADM (multiple attribute and decision making method) methods. The final selection of tool insert and work material combination can provide the required surface finish for turning operation using CNC turning machine.

Literature review

Patel et al. have studied about novel approach for selection of tool insert in CNC turning of alloy steel using MADM methods. There were five tool inserts available such as CCMT 09 T3 02 PF, VBMT 16 04 02 PF, DNMG 15 04 12 PF, TNMG 22 04 08 PF, SCMT 09 T3 04 PF. They used two MADM methods such as Simple Additive Weighting (SAW) and Weighted Product Method (WPM).From their results they provide rank and decided DNMG 15 04 12 PF is the best tool insert for better surface roughness in turning of alloy steel[1]. Rao et al. have worked on the selection of material for wind turbine blade from the alternative material. They applied MADM

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(Multiple attribute decision making method) such as TOPSIS and fuzzy set theory and from the analysis they observed that if the wind turbine blades are made out of composite materials using carbon fibers, then they possess the high stiffness, low density and long fatigue life [2]. Abhang et al. studied about selection of best lubricant in turning operation from alternative lubricants by using MADM methods. They applied TOPSIS and AHP model and conclude that lubricant index evaluate and ranks best lubricant during steel turning operation and combined TOPSIS and AHP method provides a convenient approach for solving complex MADM problems in manufacturing domains [3]. Athawale and chakraborty have applied the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method for selection of best CNC machine from alternative machine in terms of specification and cost of machine [4]. Manshadi et al. proposed a numerical method for solving problem of material selection for cryogenic storage tank for transportation of liquid nitrogen from seven alternative materials.They used different MADM methods and from their results they provide rank and decided material number 3 ss 301-FH is the best and right choice for the tank [5]. B.Savant et al. have solved the problem of the selection of automated guided vehicle by using MADM methods. They applied Preference selection index (PSI) and TOPSIS MADM methods. From PSI and TOPSIS ranking results, they compared methods and average of the methods selects best AGV for the industrial application [6]. In case of Neseli et al. have find out the influence of tool geometry (nose radius, approach angle and rake angle) on the surface finish obtained in turning of AISI 1040 steel on lathe machine by using AL2O3 coated tool inserts CNMG 120404-BF, CNMG 120408-BF, CNMG 120412-BF for finishing operation. They conclude that rake angle has the highest effect in reducing surface roughness and the effect of tool nose radius and approach angle increases with increases surface roughness [7]. Dogra et al. studied about the effect of tool geometry i.e. tool nose radius, rake angle,variable edge geometry and their effect on tool wear, surface roughness and surface integrity of the machined surface during turning. They conclude that, the large edge hone produce higher force and higher surface roughness than small edge hone. The large tool nose radius gives good surface finish than small tool nose radius. The greater negative rake angle gives higher compressive stress which deeper affected zone below machined surface [8].
Mannan et al. have studied the effect of inserts shapes (round and square), cutting edges, inserts rake types and nose radius on surface roughness and residual stresses. . The cutting speed, feed and depth of cut were maintained constant. They conclude that, round inserts generate lower surface finish than square inserts. The positive rake produces lower values when coolant is used and high value in dry cutting. The surface roughness increasing with nose radius increases and use of coolant generate lower values of surface roughness [9]. Gokkeya and nalbant studied about the effect of tool geometry (insert radius: 1.2mm, 0.8mm, and 0.4mm) and process parameter such as depth of cut, feed rate on surface roughness of AISI 1030 steel on CNC lathe machine. They conclude that, a good combination among the insert radius, speed rate and depth of cut can provide better surface qualities [10]. Guddat et al. investigated the effect of wiper PCBN inserts geometry (nose radius, edge radius, chamfer angle) on surface integrity. Wiper inserts produce smoother surfaces within the range of the experiments conducted and are more stable when it comes to changes in feed and nose radius [11].
In the literature review, many researchers have worked on tool geometry effect on surface roughness in turning operation and also studied of MADM methods which are useful for solving selection problem in manufacturing environment. Here, MADM methods are apply for the selection of best tool insert from alternative tool insert for better surface roughness in CNC turning operation.

MADM (multiple attribute decision making) method

MADM can be defined as decision aids to help a decision maker identify the best alternative among a finite number of alternatives that maximize his satisfaction with respect to more than one attribute. Attributes are characteristics of objects in the world.Attribute should provide means of evaluating the levels of objectives.They can be measured in relative independence from decision makers needs or desires.Each attributes can be characterized by number of attributes (choosen by decision makers concept of criteria).
There are different methods of MADM such as Simple Additive Weighting (SAW),Weighted Product Method (WPM), ELECTRE, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP), Revised Analytic Hierarchy Process (RAHP) Method.
Out of these methods only two methods were used for tool selection such as SAW and WPM so only these two methods were seen in detail.

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Simple Additive Weighting (SAW) Method:
Churchman and Ackoff (1945) first utilized the SAW method to with a portfolio selection problem. The SAW method is probably the best known and widely used method for multiple attribute decision making MADM.Because of its simplicity, SAW is the most popular method in MADM problems.It consist of following steps ,

- Identifying the Suitable Weights:
  Among different methods of calculating weights, Geometric Mean Method is popular because of its simplicity and consistency. It consists of the following steps
- Find the relative importance of different attributes with respect to achieving the goal.
- Construct a pair-wise comparison matrix using a scale of relative importance. The judgments are entered using the fundamental scale of the analytic hierarchy process. An attribute compared with itself is always assigned the value 1, so the main diagonal entries of the pair-wise comparison matrix are all 1. The numbers 3, 5, 7, and 9 correspond to the verbal judgments 'weak importance','Essential or strong importance','demonstration importance', and 'absolute importance' (with 2, 4, 6, and 8 for compromise between these values) according to table 1. Assuming M attributes, the pair-wise comparison of attribute i with attribute j yields a square matrix BM x M where aij denotes the comparative importance of attribute I with respect to attribute j. In the matrix, bij = 1 when i = j and bji = 1/bij.

Table 1.Saaty's scale for pair wise comparisons

Scale	Definition	Explaination
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance	The judgment is to favor of one activity over another, but it is not conclusive
5	Essential or Strong Importance	The judgment is strongly in the favor of one activity over another
7	Demonstration Importance	The conclusive judgment as to the important of one activity over another
9	Absolute	The judgment in to favor of one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

Table 2. Random index (RI) Values

Attributes	3	4	5	6	7	8	9	10
RI	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

$$B_{M\times M} = \begin{array}{c} B_1 \\ B_2 \\ B_3 \\ - \\ - \\ B_M \end{array} \begin{bmatrix} 1 & b_{12} & b_{13} & - & - & b_{1M} \\ b_{21} & 1 & b_{23} & - & - & b_{2M} \\ b_{31} & b_{32} & 1 & - & - & b_{3M} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ b_{M1} & b_{M2} & b_{M3} & - & - & 1 \end{bmatrix}$$

- Calculate the Geometric mean and weights
  $GMj = [\ \Pi^{M}{}_{j=1}\ bij\ ]^{1/M}$
  $Wj = GM / \Sigma GM$
- Calculate A3 and A4 matrices such that

A3 = A1 X A2
A4 = A3/A2

Where A1 is the Relative Importance matrix and A2 is weight matrix [w1 , w2 , ….wj upto j attributes]

- Calculate the maximum eigen value λmax , by taking the average of A4 matrix.
- Determine Consistency index
  CI = λmax – M / M-1.

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- Obtain the Random index value from Table 5, for the required attributes.
- Calculate Consistency ratio
  CR = CI / RI
  In general CR value <0.1 is acceptable, if CR value is greater 0.1 then we have to re think the relative importance.
- Now implement methodology SAW method is Simple Additive Weighing Method. As the name it suggests this method is simple and basic of all MADM methods. The score to each alternative can be calculated by the formula. Based on the score, select the alternate.
  $Pi = \Sigma^{m}_{j=1} w_j (M_{ij})_{normal}$
  Where wj is weight matrix
  Mij Normal is a normalized matrix of basic table.

Weighted Product Method (WPM) :
Weighted Product Method (WPM) is similar to Simple Additive Weighting **(**SAW) Method but whereas instead of addition there is multiplication in the model. The normalized values are calculated and each normalized value is raised to the power of relative weight. The alternative with highest Pi is the better alternative among others.
$Pi = \Pi^{M}_{j=1} [(M_{ij})_{normal}]^{Wj}$
Where wj is weight matrix
Mij Normal is a normalized matrix of basic table.

Actual work

The problem was related with selection of a suitable Tool insert for work tool combination of machining operation. The workpiece material was EN 8 steel. The Tool insert selection problem considers five alternative material and five attributes and the data are given in table 3.
The five alternative tool inserts were suggested by tool dealer such as TNMG 160408 FG,CCMT 09T304 FG,CNMG 120412 FC,SCMT 09T308 FG and CPMT 09T304 FG. All the five inserts were CVD coated carbide inserts manufactured by TaeguTec. Five attributes are selected as nose radius,approach angle,rake angle,clearance angle and angle of inclination.Surface roughness has affected by these attributes.For attributes are selected from past research papers. From that research papers it is seen that surface roughness is affected by these five attributes.Two methods were used such as SAW and WPM.Score of each alternative was first calculated by SAW and then WPM.

Table 3.*Attributes for CNC turning tool insert*

Tool insert No.	Nose radius (mm)	Approach angle (Degree)	Rake angle (Degree)	Clearence angle (Degree)	Angle of inclination (Degree)
1.	0.8	93	-7	0	-6
2.	0.4	95	0	7	0
3.	1.2	95	-6.5	0	-6
4.	0.8	93	0	7	0
5.	0.4	95	0	11	0

Tool insert1:TNMG 160408 FG , Tool insert 2:CCMT 09T304 FG, Tool insert 3:CNMG 120412 FC, Tool insert 4:SCMT 09T308 FG, Tool insert 5:CPMT 09T304 FG

SIMPLE ADDITIVE WEIGHTING (SAW) METHOD

$$A_L = \begin{vmatrix} 1 & 3 & 5 & 7 & 9 \\ 1/3 & 1 & 3 & 5 & 7 \\ 1/5 & 1/3 & 1 & 3 & 5 \\ 1/7 & 1/5 & 1/3 & 1 & 3 \\ 1/9 & 1/7 & 1/5 & 1/3 & 1 \end{vmatrix}$$

Geometric mean (GMj) of each attribute,

$$GMj = [\ \Pi^{M}_{j=1} bij\ ]^{1/M}$$

$$GMj = \begin{vmatrix} 3.9362 \\ 2.0361 \\ 1 \\ 0.4908 \\ 0.2511 \end{vmatrix}$$

The relative normalized weight (Wj) of each attribute ,

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$A_2 = Wj = GMj / \Sigma^{M}_{j=1} GMj$

$$A2 = Wj = \begin{vmatrix} 0.5102 \\ 0.2639 \\ 0.1296 \\ 0.0636 \\ 0.325 \end{vmatrix}$$

The matrix A_3 and A_4 , $A_3 = A_1 \times A_2$

$$A_3 = \begin{vmatrix} 2.68834 \\ 1.36710 \\ 0.67236 \\ 0.32956 \\ 0.17310 \end{vmatrix}$$

Here, calculate $A_4 = A_3 \div A_2$

$$A_4 = \begin{vmatrix} 5.2691 \\ 5.1803 \\ 5.1867 \\ 5.1801 \\ 5.3179 \end{vmatrix}$$

The maximum Eigen value λ_{max} that is average of matrix A4

$\lambda_{max} = 26.1341/5$

$\lambda_{max} = 5.2268$

The consistency index $CI = (\lambda_{max} - M) / (M - 1)$

CI= 0.0567

Calculate consistency ratio CR=CI/RI, here no of attributes are five so, from table 2. RI value taken as 1.11. so, CR=0.0567/1.11

CR=0.05108, here, CR value is less than 0.1 so it is accepted.

Table 4. Normalize data for tool insert selection attributes

Tool insert No.	Nose radius (mm)	Approach angle (Degree)	Rake angle (Deg.)	Clearence angle (Deg.)	Angle of inclination (Deg.)
1.	0.666	0.9789	1	0	1
2.	0.333	1	0	0.6363	0
3.	1	1	0.9285	0	1
4.	0.666	0.9789	0	0.6363	0
5.	0.333	1	0	1	0

The next step is to obtain the overall or composite performance scores for the alternatives by multiplying the relative normalized weight (wj) of each attribute (obtained in step 2) with its corresponding normalized weight value for each alternative (obtained in step 3), and summing over the attributes for each alternative. So, for tool insert 1 calculation given below:

$P_1 = W_1 M_{11} + W_2 M_{12} + W_3 M_{13} + W_4 M_{14} + W_5 M_{15}$
$= (0.5102\times0.666) + (0.2639\times0.9789) + (0.1296\times1) + (0.0636\times0) + (0.0325\times1)$
$= 0.7602$

Tool insert-2, P2 = 0.4727

Tool insert-3, P3 = 0.9269

Tool insert-4, P4 = 0.6385

Tool insert-5, P5 = 0.4958

By arranging in descending order, the tool insert selection index is 3-1-4-5-2. It may be observed that the above ranking is for the given preferences of the decision maker. The ranking depends upon the judgment of relative importance of attributes made by the decision maker. The ranking of material based on Tool insert selection index given by SAW method is 3-1-5-2-4. The SAW method also suggests the Tool insert designated as 3, i.e. CNMG 120412 FC as the right choice for the given problem of selection of a suitable Tool insert for work tool combination of machinery operation. The second choice is the material 1, i.e. TNMG 160408 FG and the last choice is the material designated as 2, i.e. CCMT 09 T3 04 FG.

Weighted Product Method (WPM)

This method is similar to SAW. The main difference is that, instead of addition in the model, There is multiplication. The overall performance score (i.e. material selection index, in this problem) for each material is calculated using the normalized data of the attribute given in Table 4 for the given weights of the attributes.

For Tool insert 1:

$P_1 = M_{11}^{W1} + M_{12}^{W2} + M_{13}^{W3} + M_{14}^{W4} + M_{15}^{W5}$
$= (0.666)^{0.5102} + (0.9579)^{0.2639} + (1)^{0.1296} + (0)^{0.0636} + (1)^{0.0325}$
$= 3.8014$

Similarly for all Tool inserts, the results are,

Tool insert-2 P2 = 2.5422

Tool insert-3 P3 = 3.9934

Tool insert-4 P4 = 2.7730

Tool insert-5 P5 = 2.5705

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The values of Pi are arranged in the descending order as 3-1-4-5-2. Here WPM suggests the tool insert designated as 3. i.e. CNMG 12 04 18 FC as the right choice of the given tool insert selection problem, the second choice is TNMG 16 04 08 FG, and the last choice of tool insert is designated as 5, i.e. CCMT 09 T3 04 FG .

Conclusion

The proposed MADM method, the Simple additive Weighted (SAW) and Weighted Product Method (WPM) applied for selection of a suitable tool insert from number of alternatives. The ranking of tool insert based on its performance score (i.e. tool insert selection index) for all two methods is 3-1-4-5-2 which is same all two methods. So, from the ranking of three MADM methods it can be found that tool insert 3 i.e. CNMG 12 04 12 FC is the best tool insert for better surface roughness in turning of EN 8 steel. The Second choice is TNMG 16 04 08 FG.

References

[1] Nikunj V. Patel, R. K. Patel, U. J. Patel, B. P. Patel , A Novel Approach for Selection of Tool Insert in CNC Turning Process Using MADM Methods, International Journal of Engineering and Advanced Technology , ISSN: 2249 – 8958, Volume-1, Issue-5, June 2012.

[2] Dr. D. Nageswara Rao, K.Suresh Babu N.V.Subba Raju M.Srinivasa Reddy, The Material Selection For Typical Wind Turbine Blades Using A MADM Approach& Analysis of Blades, MCDM 2006, Chania, Greece, June 19-23, 2006.

[3] Abhang, L. B. & Hameedullah, M* Selection of Lubricate Using Combine Multiple Attribute Decision Making Method, Advance in Production Engineering & Management 7 (2012) 1, 39-50.

[4] Vijay Manikrao Athawale, Shankar Chakraborty, A TOPSIS Method-based Approach to Machine Tool Selection, Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh, January 9–10, 2010.

[5] Manshadi BD, Mahmudi H, Abedian A,Mahmudi R (2007) A novel method for materials selection in mechanical design: combination of non-linear normalization and a modified digital logic method. Materials & Design 28:8–15.

[6] Vishram B. Sawant, Suhas S. Mohite, Rajesh Patil A Decision-Making Framework using a Preference Selection Index Method for Automated Guided Vehicle Selection Problem. International Conference on Technology Systems and Management (ICTSM) 2011 Proceedings published by International Journal of Computer Applications® (IJCA), 12-16.

[7] Suleyman Neseli, Suleyman Yaldiz , Erol Turkes, Optimization of tool geometry parameters for turning operations based on the response surface methodology, Measurement 44 (2011) 580–587.

[8] M. Dogra,V. S. Sharma, J. Dureja , Effect of tool geometry variation on finish turning – A Review Journal of Engineering Science and Technology Review 4 (1) (2011) 1-13.

[9] M.A.Manan, R.M. Arunachalam, A.C. Spowage, Surface integrity when machining age hardened Inconel 718 with coated carbide cutting tools, International Journal of Machine Tools & Manufacture 44 (2004) 1481–1491.

[10] Hasan Go¨kkaya a, Muammer Nalbant, The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel, Materials and Design 28 (2007) 717–721.

[11] J. Guddat, R. M'Saoubia, P. Alma, D. Meyer Hard, Turning of AISI 52100 using PCBN wiper geometry inserts and the resulting surface integrity, Procedia Engineering 19 (2011) 118 – 124.

[12] Saaty T.L., How to make a decision , the analytic hierarchy process, European Journal of operation research, 48,1,9-26,1990

Author Biblography

	**Mr. K.G.Nikam** , He has completed his graduation from P.V.P.I.T. Budhgaon,Sangli district ,Maharashtra ,India in 2011.At present he is PG student in Department of Production Engg. ,Class:M.E.(Mechanical Production) Part-II ,KIT's college of engineering ,Kolhapur, Maharashtra, India,Email ID - ketannikam9@gmail.com

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	**Mr.S.S.Kadam,** He has completed his M.E. (Mech-Prod) in KIT's college of engg.,Kolhapur,Maharashtra,India. He is presently working as an Associate professor in Department of Mechanical Engineering, KIT's college of engineering ,Kolhapur, Maharashtra, India, Email ID - kadamshivraj@rediffmail.com