Insert Selection for Turning Operation on CNC Turning Centre using MADM Methods

Nikunj Patel

M. Tech. (AMT) Student, Department of Mechanical Engineering

U. V. Patel college of Engineering, Mehsana, Gujarat, India

Prof. R. K. Patel

Assistant Professor, Department of Mechanical Engineering

U. V. Patel College of Engineering, Ganpat University, Mehsana, Gujarat, India

Prof. U. J. Patel

Assistant Professor, Department of Mechanical Engineering

U. V. Patel College of Engineering, Ganpat University, Mehsana, Gujarat, India

Prof. B. P. Patel

Assistant Professor, Department of Mechanical Engineering

U. V. Patel College of Engineering, Ganpat University, Mehsana, Gujarat, India

Abstract - The effect of cutting tool insert geometry has significant role for surface finish in turning operation. There are many different types of tool inserts with different tool insert geometry are used in turning operation. This paper present a logical procedure to select best tool insert from alternative tool inserts for better surface finish in turning operation. The procedure based on three well known Multiple Attribute Decision Making (MADM) methods such as Analytical Hierarchy Process (AHP), Revised Analytical Hierarchy Process (RAHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). A tool insert selection index is proposed that evaluates and ranks of tool insert for good surface finish in turning operation.

Keywords – MADM, AHP, RAHP, TOPSIS, Turning, Surface finish

I. Introduction

Tool geometry parameters play an important role in determining the overall machining performance, including cutting forces, tool wear, surface finish, chip formation and chip breaking. The importance of selection of tool insert has been highlighted recently to be of enormous economic significance in maximizing tool life and surface roughness in machining. Over the past few decades, many investigations have been made to study the important effects of tool geometry on machining performance. Nearly all turning processes use single point cutting tools, which mean the tools that cut with only a single edge in contact with the work piece. Most turning process is done with coated indexable inserts, but the tool material can be high-speed steel, brazed carbide, ceramic, cubic boron nitride, or polycrystalline diamond. Generally, most of turning operations use just a few basic tool geometries. When turning with inserts, much of the geometry is built into the tool holder itself rather than the actual insert. The geometry of an insert includes the insert's basic shape, its tool geometry, the insert type, the insert's nose radius, and the insert's chip breaker design.

In turning, tool insert selection is based on the trade-off between strength and versatility. The larger point angles are stronger, such as round inserts for contouring and square inserts for roughing and finishing. The smaller angles (35° and 55°) are the most versatile for complex work. Turning inserts may be molded or ground to their working shape. The molded types are more economical and have wide application. Ground inserts are needed for maximum accuracy and to produce well defined or sharp contours. Several angles are important when introducing the cutting tool's edge into a rotating work piece. These angles include the angle of inclination, rake angle, clearance or relief angle, approach angle, and tool nose radius. Since a sharp edge is weak and fractures easily, an insert's cutting edge is prepared with particular shapes to strengthen it. Those shapes include a honed radius, a chamfer, a land, or a combination of the three

II. LITERATURE REVIEW

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 [1]. 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[2].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 [3]. 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 [4]. 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 [5]. Rao et al. have worked on the selection of material for wind turbine blade from the alternative material. They applied MADM (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 [6]. 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[7].Vijay Athawale and Shankar 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 [8]. 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 [9]. 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 [10].

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.

III. Multiple Attribute Decision Making (MADM) Methods

A. Analytic Hierarchy Process (AHP) Method –

One of the most popular analytical techniques for complex decision-making problems is the analytic hierarchy process (AHP), which decomposes a decision-making problem into a system of hierarchies of objectives, attributes (or criteria), and alternatives. An AHP hierarchy can have as many levels as needed to fully characterize a particular decision situation. A number of functional characteristics make AHP a useful methodology. These include the ability to handle decision situations involving subjective judgments, multiple decision makers, and the ability to provide measures of consistency of preference. Designed to reflect the way people actually think, AHP continues to be the most highly regarded and widely used decision-making method. AHP can efficiently deal with tangible (i.e., objective) as well as non-tangible (i.e., subjective) attributes, especially where the subjective judgments of different individuals constitute an important part of decision process. The main procedure of AHP using the radical root method (also called the geometric mean method) is as follows:

Step 1: Determine the objective and the evaluation attributes. Develop a hierarchical structure with a goal or objective at the top level, the attributes at the second level and the alternatives at the third level.

Step 2: Determine the relative importance of different attributes with respect to the goal or objective.

- 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 ‘moderate importance’, ‘strong importance’, ‘very strong importance’, and ‘absolute importance’ (with 2, 4, 6, and 8 for compromise between these values). Assuming M attributes, the pair-wise comparison of attribute i with attribute j yields a square matrix $B_{M \times M}$ where a_{ij} denotes the comparative importance of attribute I with respect to attribute j. In the matrix, $b_{ij} = 1$ when i = j and $b_{ji} = 1/b_{ij}$.

$$B_{M \times N} = \begin{matrix} B_1 \\ B_2 \\ B_3 \\ - \\ - \\ B_M \end{matrix} \begin{bmatrix} 1 & b_{12} & b_{13} & - & - & b_{1M} \\ b_{21} & 1 & b_{23} & - & - & b_{2M} \\ b_{31} & b_{32} & 1 & - & - & b_{3M} \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ b_{M1} & b_{M2} & b_{M3} & - & - & 1 \end{bmatrix} \quad (1.1)$$

- Find the relative normalized weight (w_j) of each attribute by (i) calculating the geometric mean of the i-th row, and (ii) normalizing the geometric means of rows in the comparison matrix. This can be represented as:

$$GM_j = \left[\prod_{j=1}^{M} b_{ij}\right]^{\frac{1}{M}} \quad (1.2)$$

$$W_j = GM_j / \sum_{j-1}^{M} GM_j \quad (1.3)$$

The geometric mean method of AHP is commonly used to determine the relative normalized weights of the attributes, because of its simplicity, easy determination of the maximum Eigen value, and reduction in inconsistency of judgments.

- Calculate matrices A_3 and A_4 such that $A_3 = A_1 * A_2$ and $A_4 = A_3 / A_2$, where $A_2 = [w_1, w_2, \ldots , w_j]^T$.
- Determine the maximum Eigen value λmax that is the average of matrix A4.
- Calculate the consistency index $CI = (\lambda_{max} - M) / (M - 1)$. The smaller then value of CI, the smaller is the deviation from the consistency.

- Obtain the random index (RI) for the number of attributes used in decision making. Refer to Table 1.1 for details.
- Calculate the consistency ratio CR = CI/RI. Usually, a CR of 0.1 or less is considered as acceptable, and it reflects an informed judgment attributable to the knowledge of the analyst regarding the problem under study.

Step 3: The next step is to compare the alternatives pair-wise with respect to how much better (i.e., more dominant) they are in satisfying each of the attributes, i.e., to ascertain how well each alternative serves each attribute. If there is N number of alternatives, then there will be M number of N x N matrices of judgments, since there are M attributes. Construct pair-wise comparison matrices using a scale of relative importance. The judgments are entered using the fundamental scale of the AHP method. The steps are the same as those suggested under main step 2.

Table 1.1 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**

In the AHP model, both the relative and absolute modes of comparison can be performed. The relative mode can be used when decision makers have prior knowledge of the attributes for different alternatives to be used, or when objective data of the attributes for different alternatives to be evaluated are not available. The absolute mode is used when data of the attributes for different alternatives to be evaluated are readily available. In the absolute mode, CI is always equal to 0, and complete consistency in judgments exists, since the exact values are used in the comparison matrices.

Step 4: The next step is to obtain the overall or composite performance scores for the alternatives by multiplying the relative normalized weight (w_j) 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. This step is similar to the SAW method. This is also called the weighted sum method and is the simplest and still the widest used MADM method. Here, each attribute is given a weight, and the sum of all weights must be 1. Each alternative is assessed with regard to every attribute. The overall or composite performance score of an alternative is given by Equation 1.4.

$$P_i = \sum_{j=1}^{M} w_j \left(m_{ij}\right)_{normal} \quad (1.4)$$

Where (m_{ij}) normal represents the normalized value of m_{ij}, and P_i is the overall or composite score of the alternative A_i. The alternative with the highest value of Pi is considered as the best alternative [11].

B. Revised Analytic Hierarchy Process (RAHP) Method-

Step 1: The problem is that if a new alternative, identical to a non-optimal alternative, is introduced, then the ranking of the existing alternatives changes. The reason for this ranking inconsistency was that the relative performance measures of all alternatives in terms of each attribute (obtained in step 2 of AHP method) summed to one. Instead of having the relative performance values sum up to one, dividing each relative performance value by the maximum value in the corresponding vector of relative values was suggested. This avoids the rank reversals when a new non-optimal alternative is introduced. This method is also called 'ideal mode AHP' or revised version.

Step 2: The overall or composite performance scores for the alternatives are obtained by multiplying the relative normalized weight (w_j) of each attribute with its corresponding normalized weight value (relative weight or ideal weight) for each alternative, and summing over all the attributes for each alternative. This step is similar to step 4 of AHP method. The alternative materials are arranged in the descending order of the selection index [11].

C. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method -

This method is based on the concept that the chosen alternative should have the shortest Euclidean distance from the ideal solution, and the farthest from the negative ideal solution. The ideal solution is a hypothetical solution for which all attribute values correspond to the maximum attribute values in the database comprising the satisfying solutions; the negative ideal solution is the hypothetical solution for which all attribute values correspond to the minimum attribute values in the database. TOPSIS thus gives a solution that is not only closest to the hypothetically best, that is also the farthest from the hypothetically worst. The main procedure of the TOPSIS method for the selection of the best alternative from among those available is described below:

Step 1: The first step is to determine the objective, and to identify the pertinent evaluation attributes.

Step 2: This step represents a matrix based on all the information available on attributes. This matrix is nothing but the decision table shown in Table 3.1. Each row of this matrix is allocated to one alternative, and each column to one attribute. Therefore, an element m_{ij} of the decision table 'D' gives the value of the j^{-th} attribute in original real values, that is, non-normalized form and units, for the i^{-th} alternative. In the case of a subjective attribute (*i.e.*, objective value is not available), a ranked value judgment on a scale is adopted. Once a subjective attribute is represented on a scale, then the normalized values of the attribute assigned for different alternatives are calculated in the same manner as that for objective attributes.

Step 3: Obtain the normalized decision matrix, R_{ij}. This can be represented as

$$R_{ij} = m_{ij} / [\sum_{j=1}^{M} m_{ij}^2]^{1/2} \qquad (1.5)$$

Step 4: Decide on the relative importance (*i.e.,* weights) of different attributes with respect to the objective. A set of weights w_j (for j=1, 2… M), such that $\sum w_j=1$ may be decided upon. The weights of different attributes with respect to the objective, w_j (for j=1, 2… M), are decided by the decision maker rather arbitrarily, only few systematic methods can be used. The systematic method of deciding the weights of attributes Entropy Method is explained below.

The entropy concept for deciding the objective weights of attributes. Entropy is a measure of uncertainty in the information formulated using probability theory. It indicates that a broad distribution represents more uncertainty than does a sharply peaked one. To determine weights by the entropy measure, the normalized decision matrix R_{ij}, given by Equation 3.8, is considered. The amount of decision information contained in Equation 3.8 and associated with each attribute can be measured by the entropy value e_j as:

$$e_j = -k \sum_{i=1}^{N} R_{ij} \ln R_{ij} \qquad (1.6)$$

Where, k = 1/ln N is a constant that guarantees $0 \leq e_j \leq 1$. The degree of divergence (d_j) of the average information contained by each attribute can be calculated as:

$$d_j = 1 - e_j \qquad (1.7)$$

The more divergent the performance ratings R_{ij} (for i = 1, 2…N) for the attribute B_j, the higher its corresponding d_j, and the more important the attribute B_j for the decision-making problem under consideration.

The objective weight for each attributes W_j (for j = 1, 2… M) is thus given by:

$$w_j = d_j \Big/ \sum_{k=1}^{M} d_j \quad (1.8)$$

Step 5: Obtain the weighted normalized matrix V_{ij}. This is done by the multiplication of each element of the column of the matrix R_{ij} with its associated weight w_j. Hence, the elements of the weighted normalized matrix V_{ij} are expressed as:

$$V_{ij} = W_j R_{ij} \quad (1.9)$$

Step 6: Obtain the ideal (best) and negative ideal (worst) solutions in this step.

The ideal (best) and negative ideal (worst) solutions can be expressed as:

$$V^{+} = \{(\sum_{i}^{max} V_{ij} \Big/ j \in J), (\sum_{i}^{min} V_{ij} \Big/ j \in J')/i = 1,2,\ldots\ldots,N\}$$
$$= \{ V_1^+, V_2^+, V_3^+, \ldots\ldots\ldots, V_M^+ \} \quad (1.10)$$
$$V^{-} = \{(\sum_{i}^{min} V_{ij} \Big/ j \in J), (\sum_{i}^{max} V_{ij} \Big/ j \in J')/i = 1,2,\ldots\ldots,N\}$$
$$= \{ V_1^-, V_2^-, V_3^-, \ldots\ldots\ldots, V_M^- \} \quad (1.11)$$

Where, J = (j = 1, 2… M) /j is associated with beneficial attributes, and J' = (j = 1, 2… M) /j is associated with non-beneficial attributes.

V_j^+ indicates the ideal (best) value of the considered attribute among the values of the attribute for different alternatives. In the case of beneficial attributes (*i.e.*, those of which higher values are desirable for the given application), V_j^+ indicates the higher value of the attribute. In the case of non-beneficial attributes (*i.e.*, those of which lower values are desired for the given application), V_j^+ indicates the lower value of the attribute. V_j^- indicates the negative ideal (worst) value of the considered attribute among the values of the attribute for different alternatives. In the case of beneficial attributes (*i.e.*, those of which higher values are desirable for the given application), V_j^- indicates the lower value of the attribute. In the case of non beneficial attributes (*i.e.*, those of which lower values are desired for the given application), V_j^- indicates the higher value of the attribute.

Step 7: Obtain the separation measures. The separation of each alternative from the ideal one is given by the Euclidean distance in the following equations.

$$S_i^+ = \{\sum_{j=1}^{M} (V_{ij} - V_j^+)^2\}^{0.5}, \quad i = 1,2,\ldots\ldots,N \quad (1.12)$$
$$S_i^- = \{\sum_{j=1}^{M} (V_{ij} - V_j^-)^2\}^{0.5}, \quad i = 1,2,\ldots\ldots,N \quad (1.13)$$

Step 8: The relative closeness of a particular alternative to the ideal solution, P_i, can be expressed in this step as follows.

$$P_i = S_i^- / (S_i^+ + S_i^-) \quad (1.14)$$

Step 9: A set of alternatives is generated in the descending order in this step, according to the value of Pi indicating the most preferred and least preferred feasible solutions. P_i may also be called the overall or composite performance score of alternative A_i [11].

IV. STRATEGY CASE STUDY

Here, the strategically case study is explained in the form of example. This example problem is related with selection of a suitable Tool insert for work tool combination of machining operation. The Tool insert selection problem considers five alternative material and five attributes and the data are given in table 1.2.

Table 1.2: Attributes for CNC turning tool insert

Tool insert No.	Nose radius (mm)	Approach angle (Degree)	Rake angle (Deg.)	Clearance angle (Degree)	Angle of inclination (Deg.)
1	**0.2**	**95**	**0**	**7**	**0**
2	**0.2**	**93**	**0**	**5**	**0**
3	**1.2**	**107.5**	**-6**	**0**	**-7**
4	**0.8**	**91**	**-6**	**0**	**-6**
5	**0.4**	**45**	**0**	**7**	**0**

Tool insert 1: CCMT 09 T3 02 PF, Tool insert 2: VBMT 16 04 02 PF, Tool insert 3: DNMG 15 04 12 PF, Tool insert 4: TNMG 22 04 08 PF, Tool insert 5: SCMT 09 T3 04 PF.

A. Calculation of AHP Method-

Step 1: Determine the objective and the evaluation attributes. Develop a hierarchical structure with a goal or objective at the top level and the alternatives at the third level.

Step 2: Construct a pair-wise comparison matrix using a scale of relative importance.

$$A_1 = \begin{bmatrix} 1 & 3 & 5 & 7 & 9 \\ 1/3 & 1 & 3 & 5 & 7 \\ 1/5 & 1/3 & 1 & 3 & 5 \\ 1/7 & 1/5 & 1/3 & 1 & 3 \\ 1/9 & 1/7 & 1/5 & 1/3 & 1 \end{bmatrix}$$

- Find the geometric mean (GM_j) of each attribute, $GM_j = [\prod_{j=1}^{M} b_{ij}]^{\frac{1}{M}}$

$$GM_j = \begin{bmatrix} 3.9362 \\ 2.0361 \\ 1 \\ 0.4908 \\ 0.2511 \end{bmatrix}$$

- Find the relative normalized weight (W_j) of each attribute , $A_2 = W_j = GM_j / \sum_{j=1}^{M} GM_j$

$$A_2 = W_j = \begin{bmatrix} 0.5102 \\ 0.2639 \\ 0.1296 \\ 0.0636 \\ 0.0325 \end{bmatrix}$$

- Calculate matrix A_3 and A_4 , $A_3=A_1\times A_2$

$$A3=\begin{bmatrix} 2.68834 \\ 1.36710 \\ 0.67236 \\ 0.32956 \\ 0.17310 \end{bmatrix}$$

Here, calculate $A_4 = A_3 \div A_2$

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

- Determine the maximum Eigen value $\boldsymbol{\lambda}_{max}$ that is average of matrix A_4

$$\lambda_{max} = \frac{26.1341}{5}$$

$$\boldsymbol{\lambda}_{max} = 5.2268$$

- Calculate 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 1.1 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

Step 3: Convert the given data in to normalized data.

Table 1.3 Normalized data

Tool inserts	Nose radius(mm)	Approach angle(deg)	Rake angle(deg)	Clearance angle(deg)	Angle of inclination (deg)
1	**0.166**	**0.883**	**0**	**1**	**0**
2	**0.166**	**0.865**	**0**	**0.7142**	**0**
3	**1**	**1**	**1**	**0**	**1**
4	**0.666**	**0.846**	**1**	**0**	**0.8571**
5	**0.333**	**0.418**	**0**	**1**	**0**

Step 4: 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. This step is similar to the SAW method. So, for tool insert 1 calculation given below:

$$P_1 = w_1m_{11} + w_2m_{12} + w_3m_{13} + w_4m_{14} + w_5m_{15}$$
$$= (0.5102\times0.166) + (0.2639\times0.883) + (0.1296\times0) + (0.0636\times1) + (0.03255\times0)$$
$$= 0.3812$$

Similarly for all Tool insert results are, P_2=0.3582, P_3=0.9362, P_4=0.72047, P_5=0.3438

By arranging in descending order, The Tool insert selection index is 3-4-1-2-5. The AHP method also suggests the Tool insert designated as 3, i.e. DNMG 15 04 12 PF 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 of tool insert is 4, i.e. TNMG 22 04 08 PF and the last choice is the material designated as 5, i.e. SCMT 09 T3 04 PF.

B. Revised AHP Method-

Step 1: This method is similar to AHP method but, Here Instead of having the relative performance values sum up to one, dividing each relative performance value by the maximum value in the corresponding vector of relative values was suggested in AHP method. So, relative performance value is calculated below:

$$W_1 = 1,\ W_2 = 0.5172, W_3 = 0.2540,\ W_4 = 0.1249,\ W_5 = 0.0637$$

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

$$P_1 = w_1m_{11} + w_2m_{12} + w_3m_{13} + w_4m_{14} + w_5m_{15}$$
$$= (1\times0.166) + (0.5172\times0.883) + (0.2540\times0) + (0.1249\times1) + (0.0637\times0)$$
$$= 0.7476$$

Similarly, for all Tool insert results are, P_2=0.7026, P_3=1.8317, P_4=1.4123, P_5=0.6741

By arranging in descending order, The Tool insert selection index is 3-4-1-2-5. The revised AHP method also suggests the Tool insert designated as 3, i.e. DNMG 15 04 12 PF 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. TiAI6V4 and the last choice is the material designated as 5, i.e. SCMT 09 T3 04 PF which is same ranking as AHP method.

C. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method-

Step 1: The objective is to evaluate the five alternative tool inserts, and the five attributes are: nose radius, approach angle, rake angle, clearance angle and angle of inclination.

Step 2: The next step is represent all the information available for the attributes in the form of decision matrix. The data given in table 1.1 are represented as matrix $R_{7\times7}$.

Step 3: The quantitative values of the tool insert selection attributes, which are given in table 1.1, are normalized as explained in equation 3.1 and the normalized matrix $R_{7\times7}$ is shown below:

$$\begin{bmatrix} 0.1313 & 0.4777 & 0 & 0.6311 & 0 \\ 0.1313 & 0.4677 & 0 & 0.4508 & 0 \\ 0.7878 & 0.5406 & 0.7071 & 0 & 0.7592 \\ 0.5252 & 0.4576 & 0.7071 & 0 & 0.6507 \\ 0.2626 & 0.2263 & 0 & 0.6311 & 0 \end{bmatrix}$$

Step 4: Relative importance of attributes can be assigned the values as explained in step 4 of TOPSIS method theory.

e_1 = 0.7659 similarly, e_2=0.4605, e_3=0, e_4=0.1493, e_5=0.0821

$d_1 = 1-e_1$

d_1 = 0.2341 similarly, d_2=0.5395, d_3=1, d_4=0.8507, d_5=0.9179

Here the objective weight for each attributes W_j is given by:

W_1=0.0660, similarly, weight of attribute is W_2=0.1523, W_3=0.2823, W_4=0.2401, W_5=0.2591

Step 5: The weighted normalized matrix, $V_{7\times7}$ is calculated.

$$\begin{bmatrix} 0.0109 & 0.1344 & 0 & 0.2401 & 0 \\ 0.0109 & 0.1317 & 0 & 0.1714 & 0 \\ 0.0660 & 0.1523 & 0.2823 & 0 & 0.2591 \\ 0.0439 & 0.1288 & 0.2823 & 0 & 0.2220 \\ 0.0219 & 0.0636 & 0 & 0.2401 & 0 \end{bmatrix}$$

Step 6: The next step is to obtain the ideal (best) and negative ideal (worst) solution. These are calculated as:

$V_1^+ = 0.0660$, $V_2^+ = 0.1523$, $V_3^+ = 0.2823$, $V_4^+ = 0.2401$, $V_5^+ = 0.2591$

$V_1^- = 0.0109$, $V_2^- = 0.0636$, $V_3^- = 0$, $V_4^- = 0$, $V_5^- = 0$

Step 7: The next step is obtain the separation measures, and these are calculated as:

$S_1^+ = 0.3873$, $S_2^+ = 0.3935$, $S_3^+ = 0.2401$, $S_4^+ = 0.2451$, $S_5^+ = 0.3957$

$S_1^- = 0.2502$, $S_2^- = 0.1844$, $S_3^- = 0.3956$, $S_4^- = 0.3663$, $S_5^- = 0.24049$

Step 8: The relative closeness of a particular alternative to ideal solution calculated and these are:

$P_1 = 0.3925$, $P_2 = 0.3190$, $P_3 = 0.6223$, $P_4 = 0.5991$, $P_5 = 0.3779$

The relative closeness to ideal solution can be considered as the 'tool insert selection index'.

Step 9: The alternative Tool inserts are arranged in descending order of their tool insert selection index. This can be arranged as: 3-4-1-5-2. The TOPSIS method also suggests the Tool insert designated as 3, i.e. DNMG 15 04 12 PF 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 tool insert no 4, i.e. TNMG 22 04 08 PF and the last choice is the material designated as 5, i.e. SCMT 09 T3 04 PF which is same ranking as AHP method.

V. CONCLUSION

The proposed MADM method, the AHP, RAHP and TOPSIS 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 three methods is 3-4-1-5-2 which is same all three methods. So, from the ranking of three MADM methods we found that tool insert 3 i.e. DNMG 15 04 12 PF is the best tool insert for better surface roughness in turning of alloy steel.

VI. REFERENCE

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

[2] 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.

[3] 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.

[4] 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.

[5] 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.

[6] 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.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] R. Venkata Rao, "Decision Making in Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods", Springer, Verlag- Londan, 2007.