CNC MACHINE TOOL APPRAISEMENT USING MCDM HYDRID TECHNIQUE: AN EMPIRICAL RESEARCH

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Abstract
In today's emerged technology, CNC (Computer Numerical Control) machine tool evaluation has been determined as a sizzling issue. CNC leads a momentous role to accomplish the production task on scheduled time and even soughed as cost effective equipment that performs repetitious, thorny as well as precarious production tasks conjunctive with elevated accuracy. Productivity, precision and accuracy etc. are the most important issues behind adaptation/exploration of CNC machine tools. So, in such a cases, subjective attributes are considered beside the objective attributes and complexity of the CNC machine tool evaluation decision problems is solved by considering subjective assessments (judgment) of expert panel, also called the decision-making group. In this paper, Hybrid approach (technique for order preference by similarity to ideal solution) based Multi-Criteria Decision Making (MCDM) approach has been explored for decision making in fuzzy MCDM environment for evaluating the most preferable CNC machine tool from a group of preferred options/alternatives.

Keywords: Computer Numerical Control (CNC) machine tool; Generalized Trapezoidal Fuzzy Sets; TOPSIS; Multi-Criteria Decision Making (MCDM).

1. INTRODUCTION

CNC machines are the workhorses of the precision machining industry. CNC stands for Computer Numeric Control. CNC is an industry standard programming language designed specifically for controlling high-precision mills, lathes, cutting and grinding machines. It's the progeny of the marriage between Computer Aided Design (CAD) and Computer Aided Machining (CAM) In last decade, the appraisement against the CNC machine tool solicited attention tremendously by researchers in verdict making context. Due to that, CNC machine tool evaluation have tremendously been accommodated from miscellaneous verdict making tools, decision support techniques, approaches and software's to evaluate-select the feasible CNC machine tool. CNC machine tool is valuable for precision industry that uses programs to automatically execute a series of machining operations. CNC machines offer increased productivity and flexibility. The qualitative attribute of the alternatives such productive, working automation; precision, accuracy etc are considered with respect to each qualitative attribute often imprecisely defined by expert's panel judgment 'linguistic assessments'. In this paper, we used TOPSIS methodology (technique (technique for order preference by similarity to ideal solution) for the evaluation of turning CNC machine tool in multi-criteria decision making (MCDM) Trapezoidal Fuzzy environment.

In GDM, the brainstorming session is carried out, where the decision is not taken by single individual. It is taken by constituted committee. Each personnel, who are member of a constructed committee, deliver its own opinion for making the final decision against defined problem. The decisions, made by cluster of personnel's (group) are frequently unlike by others individual. Several questions are described amongst the individuals to conclude the results.

In GDM, decision built cooperatively by group of individuals tends to be more successful rather than decision built by a single individual. Social group behaviors influence the brainstorming session in GDM, for example groups high in cohesion, in combination with other antecedent conditions (e.g. ideological homogeneity and insulation from dissenting opinions) have been noted to have a negative effect for completing brainstorming session. The GDM brainstorming process is shown in fig. 2.

II. STATE OF ART AND PROBLEM FORMULATION

Hwang and Yoon (1981) pointed out that statistical decision methods do not measure the imprecision of human behavior; rather they are the means of modeling insufficient knowledge about the external environment. Fuzzy set theory approaches toward decision making consider human subjectivity, rather than merely applying objective probabilistic methods.. Ayag, Gurcan and Ozdemir (2012) proposed modified TOPSIS and the Analytical Network Process (ANP) and presented a performance analysis on machine tool evaluation problem. The ANP method is used to determine the relative weights of a set of three valuation criteria, as the modified TOPSIS method is utilized to rank competing machine tool alternatives in terms of their overall performance. Abdi, (2009) investigated reconfigurable machining system characteristics in order to identify the crucial factors influencing the machine evaluation and the machine reconfiguration. Duran and Aguilo (2008) proposed an analytic hierarchical process (AHP) based on fuzzy numbers multi-attribute method for the evaluation and justification of an advanced manufacturing system. Finally, a case study of machine tool evaluation is used to illustrate and validate the proposed approach. Chu (2009) developed a new fusion method of fuzzy information to managing information assessed in different linguistic scales (multi-granularity linguistic term sets) and numerical scales. The flexible manufacturing system adopted in the Taiwanese bicycle industry is employed in this study to demonstrate the computational process of the proposed method. Jiyang (2010) presented a comprehensive evaluation model for machine tool evaluation . Then Logarithmic least squares method based on fuzzy pair wise comparison matrix is applied for assessment of uncertain weights of evaluation criteria, the ways to determine performance value of the alternative with respect to qualitative and quantitative criteria has been discussed respectively. Korena and Shpitalni (2010) defined the core characteristics and design principles of reconfigurable manufacturing systems (RMS) and described the structure recommended for practical RMS with RMS core characteristics. After that, a rigorous mathematical method is introduced for designing RMS with this recommended structure.

III. HYBRID TECHNIQUE:

Let $E = \{e_1, e_2, ..., e_q\}$ be the set of decision-makers in the group decision making process. $A = \{A_1, A_2, ..., A_m\}$ be the set of alternatives, and $C = \{C_1, C_2, ..., C_n\}$ be the set of criteria-attributes. Suppose that $\tilde{\tilde{a}}_{ijk} = (a_{ijk1}, a_{ijk2}, a_{ijk3})$ is the attribute value given by decision maker e_k, where $\tilde{\tilde{a}}_{ijk}$ is a trapezoidal fuzzy number for the alternative A_i with respect to the attribute C_j.

Normalize the decision matrix $X = (x_{ij})_{mn}$ using the following equation:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x^2_{ij}}}, \quad i = 1, 2, 3, ...m,, \quad j = 1, 2, 3, ...n$$

……………..………..(1)

Here r_{ij} is the normalized criterion rating. The normalization method mentioned above is to preserve the property that the range of a normalized trapezoidal fuzzy number $\tilde{r}_{ij}$ belongs to the closed interval $[0,1]$.

Let $W = (w_{1,} w_{2,.........}, w_n)$ be the relative weight vector about the criteria, evaluatedby fuzzy AHP satisfying $\sum_{j=1}^{n} w_j = 1$.

Calculate the weighted normalized decision matrix $v = (v_{ij})_{mn}$ ……………………....(2)

Applied C. L. Hwang and K. Yoon (1981) to make decision:

IV. CASE STUDY

A case study has been carried out by a well known advance manufacturing organization which produce the customize product situated at western part of India. To select the most feasible alternative, a committee of four expert panel decision makers, DM1, DM2, DM3, and DM4 has been formed from quality assurance manager, manager of production unit and their team. The decision making committee assesses the concerned alternatives based on a structured model (criteria hierarchy), (Table 1) for the evaluation of best CNC m/c tool alternative. Structured model involved the twenty criteria in which C9, C12, C17 are non-beneficial criteria and rest of the criteria are beneficial. Criteria importance weights and criteria ratings of each alternative have been expressed as linguistic terms which have been transformed further in scale numbers, as given in Table 2. appropriateness ratings (assigned by DMs) for various alternatives have been shown in Tables 3. ranking order of various alternatives has been showed in Table 4. Hence, Alternative sorting is as following proceeding.

$$A_3 > A_2 > A_1 > A_4 > A_5$$

Proposed fuzzy based CNC machine tool evaluation module: Procedural steps

Procedural steps of CNC machine tool evaluation module have been highlighted below-

Step 1: Form a committee of decision-makers, and then identify the evaluation criteria of CNC turning m/c tool.

Step 2: Choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic ratings for CNC m/c tool evaluation.

Step 3: Aggregate the rating the decision makers' ratings to get the aggregated fuzzy rating $\tilde{x}_{ij}$ of best CNC m/c tool evaluation A_j under criterion C_j .

Step 4: Construct the fuzzy- decision matrix and the normalized decision matrix.

Step 5: Construct weighted normalized fuzzy decision matrix.

Step 6: Determine PIS and NIS.

Step 7: Calculate the distance of each CNC FPIS and FNIS, respectively.

Step 8: Calculate the closeness coefficient of each CNC alternatives.

Step 9: According to the closeness coefficient, the best CNC machine tool among available alternatives ranking order.

V. CONCLUSION

In present era, CNC machine tool leads a prominent role to inclusive the production task into desirable extent. The CNC machine tool evaluation-selection dilemma has received attention in the brain of managers and to be seemed the best chosen in extent of the subjective indices e.g. economics, quality, less maintenance, and higher schedule utilization conjunctive with several objectives indices. In this paper, the multiple attribute decision-making TOPSIS (technique for order positive solution to ideal solution) analytical methodology has been explored an effectively in subjective attributes (fuzzy) environment. The proposed methodology enables the committee to incorporate and aggregate multiple fuzzy information given by decision-makers with multiple information attributes. In this paper, the best CNC turning machine tool has been selected from all other preferred choices. The research resulted that alternative A3 is the best choice from all the preferred choice ***Fig: 1*** shown the ranking

REFERENCES

- C. L. Hwang and K. Yoon (1981), Multiple Attribute Decision Making –Methods and Applications: A State of the Art Survey, *Springer-Verlag*.
- G. S. Liang and M. J. J. Wang (1991), A fuzzy multi-criteria decision making method for facility site evaluation, *International Journal of Production Research*, **29**, pp. 2313–2330.
- S. J. Chen and C. L. Hwang (1992), Fuzzy Multiple Attribute Decision-making, *Springer-Verlag*.
- T. C. Chu, "Faculty location evaluation using fuzzy TOPSIS under group decisions", *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, to appear.
- C. T. Chen, C. T. Lin and S. F. Hwang (2006), A fuzzy approach for supplier evaluation and evaluation in supply chain management, *International Journal of Production Economics*, **102**, pp. 289–301.
- O. Duran, J. Aguilo (2008), Computer-aided machine-tool evaluation based on a

Fuzzy-AHP approach, *International Journal of Expert Systems with Applications*, **34**, pp. 1787–1794.

- S. J. Chuu (2009), Selecting the advanced manufacturing technology using fuzzy multiple attributes group decision making with multiple fuzzy information, *International Journal of Computers & Industrial Engineering*, **57**, pp. 1033–1042.
- M. R. Abdi (2009), Fuzzy multi-criteria decision model for evaluating reconfigurable machines, *International Journal of Production Economics*, **117**, pp. 1–15.
- J. Qi (2010), Machine Tool Evaluation Model Based on Fuzzy MCDM Approach, *International Conference on Intelligent Control and Information Processing*, August 13-15, Dalian, China.
- Y. Korena, M. Shpitalni (2010), Design of reconfigurable manufacturing systems, *International Journal of Manufacturing Systems*, **29**, pp. 130–141.
- Z. Ayag, R. Gurcan and Ozdemir (2012), Evaluating machine tool alternatives through modified TOPSIS and alpha-cut based fuzzy ANP, *International Journal of Production Economics*, **140**, pp. 630–636.
- Sahu, A.K., Sahu, N.K. and Sahu, A.K. (2016). Application of integrated TOPSIS in ASC index: partners benchmarking perspective, Benchmarking: An International Journal, Vol. 23, No. 3, pp. 540-563.
- Sahu, A.K., Sahu, N.K. and Sahu, A.K. (2015a). Benchmarking CNC Machine Tool Using Hybrid-Fuzzy Methodology: A Multi-Indices Decision Making (MCDM) Approach, International Journal of Fuzzy System Applications (IJFSA), Vol. 4, No. 2, pp. 28-46.
- Sahu, A.K., Sahu, S.K., Datta, S. and Mahapatra, S.S. (2015b). Supply chain flexibility assessment and decision-making: A fuzzy intelligent approach, International Journal of Business Excellence, Vol. 8, No. 6, pp. 675-699.
- Sahu, A.K., Sahu, N.K. and Sahu, A.K. (2015c). Appraisement and benchmarking of third-party logistics service provider by exploration of risk-based approach, Cogent Business & Management Vol. 2, No. 1, pp. 112-1637.
- Sahu, A.K., Sahu, N.K. and Sahu, A.K. (2017).Performance Estimation of firms by GLA supply chain under imperfect data, Theoretical and Practical Advancements for Fuzzy System Integration, pp. 245-277.

Table 1. *CNC machine tool module*

Attributes/Criteria
Productivity (C_1)
Flexibility (C_2)
Utilization (C_3)
Adaptability (C_4)
Precision (C_5)
Reliability(C_6)
Safety and Environment(C_7)
Maintenance &Service(C_8)
Capability (C_9)
Functionality (C_{10})
Customization (C_{11})
Cost (C_{12})
Convenient (C_{13})
Accuracy (C_{14})
Effectiveness (C_{15})
Risk (C_{16})
Power consumptions (C_{17})
Environment Impact (C_{18})
Product Quality (C_{19})
Working Automation (C_{20})

Table 2. *The scale for assigning attributes ratings* $\otimes U$ *and weights* $\otimes w$

(Attribute/criteria ratings)	
Absolutely Poor (AP)	10%
Very Poor (VP)	20%
Poor (P)	30%
Medium Poor (MP)	40%
Fair (F)	50%
Medium Good (MG)	60%
Good (G)	70%
Very Good (VG)	80%
Absolutely Good (AG)	90%
Good (GGG)	100%

Table 3. *Rating for A1, A2,A3*

Attributes/Criteria	P1	P2	P3	P4	P5
Productivity (C_1)	10	10	10	10	10
Flexibility (C_2)	20	20	20	20	20
Schedule Utilization (C_3)	30	30	30	30	30
Adaptability (C_4)	40	40	40	40	40
Precision (C_5)	50	50	50	50	50
Reliability(C_6)	60	60	60	60	60
Safety& Environment(C_7)	70	70	70	70	70
Maintenance &Service(C_8)	80	80	80	80	80
Capacity (C_9)	90	90	90	90	90
Functionality (C_{10})	100	100	100	100	100
Customization (C_{11})	10	10	10	10	10
Capital Cost (C_{12})	20	20	20	20	20
Convenient For Use (C_{13})	30	30	30	30	30
Accuracy (C_{14})	40	40	40	40	40
Efficiency (C_{15})	50	50	50	50	50
Risk (C_{16})	60	60	60	60	60
Resource Consumption (C_{17})	70	70	70	70	70
Environment Impact (C_{18})	80	80	80	80	80
Product Quality (C_{19})	90	90	90	90	90
Working Automation (C_{20})	100	100	100	100	100
Productivity (C_1)	20	20	20	20	20
Flexibility (C_2)	30	30	30	30	30
Schedule Utilization (C_3)	40	40	40	40	40
Adaptability (C_4)	50	50	50	50	50
Precision (C_5)	60	60	60	60	60
Reliability(C_6)	70	70	70	70	70
Safety& Environment(C_7)	80	80	80	80	80
Maintenance &Service(C_8)	90	90	90	90	90
Capacity (C_9)	100	100	100	100	100
Functionality (C_{10})	10	10	10	10	10
Customization (C_{11})	20	20	20	20	20
Capital Cost (C_{12})	30	30	30	30	30
Convenient For Use (C_{13})	40	40	40	40	40
Accuracy (C_{14})	50	50	50	50	50
Efficiency (C_{15})	60	60	60	60	60
Risk (C_{16})	70	70	70	70	70
Resource Consumption (C_{17})	80	80	80	80	80
Environment Impact (C_{18})	90	90	90	90	90

Product Quality (C_{19})	**100**	**100**	**100**	**100**	**100**
Working Automation (C_{20})	**10**	**10**	**10**	**10**	**10**
Productivity (C_1)	**30**	**30**	**30**	**30**	**30**
Flexibility (C_2)	**40**	**40**	**40**	**40**	**40**
Schedule Utilization (C_3)	**50**	**50**	**50**	**50**	**50**
Adaptability (C_4)	**60**	**60**	**60**	**60**	**60**
Precision (C_5)	**70**	**70**	**70**	**70**	**70**
Reliability(C_6)	**80**	**80**	**80**	**80**	**80**
Safety& Environment(C_7)	**90**	**90**	**90**	**90**	**90**
Maintenance &Service(C_8)	**100**	**100**	**100**	**100**	**100**
Capacity (C_9)	**10**	**10**	**10**	**10**	**10**
Functionality (C_{10})	**20**	**20**	**20**	**20**	**20**
Customization (C_{11})	**30**	**30**	**30**	**30**	**30**
Capital Cost (C_{12})	**40**	**40**	**40**	**40**	**40**
Convenient For Use (C_{13})	**50**	**50**	**50**	**50**	**50**
Accuracy (C_{14})	**60**	**60**	**60**	**60**	**60**
Efficiency (C_{15})	**70**	**70**	**70**	**70**	**70**
Risk (C_{16})	**80**	**80**	**80**	**80**	**80**
Resource Consumption (C_{17})	**90**	**90**	**90**	**90**	**90**
Environment Impact (C_{18})	**100**	**100**	**100**	**100**	**100**
Product Quality (C_{19})	**10**	**10**	**10**	**10**	**10**
Working Automation (C_{20})	**20**	**20**	**20**	**20**	**20**
Productivity (C_1)	**30**	**30**	**30**	**30**	**30**
Flexibility (C_2)	**40**	**40**	**40**	**40**	**40**
Schedule Utilization (C_3)	**50**	**50**	**50**	**50**	**50**
Adaptability (C_4)	**60**	**60**	**60**	**60**	**60**
Precision (C_5)	**70**	**70**	**70**	**70**	**70**
Reliability(C_6)	**80**	**80**	**80**	**80**	**80**
Safety& Environment(C_7)	**90**	**90**	**90**	**90**	**90**
Maintenance &Service(C_8)	**100**	**100**	**100**	**100**	**100**
Capacity (C_9)	**10**	**10**	**10**	**10**	**10**
Functionality (C_{10})	**20**	**20**	**20**	**20**	**20**
Customization (C_{11})	**30**	**30**	**30**	**30**	**30**
Capital Cost (C_{12})	**40**	**40**	**40**	**40**	**40**
Convenient For Use (C_{13})	**50**	**50**	**50**	**50**	**50**
Accuracy (C_{14})	**60**	**60**	**60**	**60**	**60**
Efficiency (C_{15})	**70**	**70**	**70**	**70**	**70**
Risk (C_{16})	**80**	**80**	**80**	**80**	**80**
Resource Consumption (C_{17})	**90**	**90**	**90**	**90**	**90**
Environment Impact (C_{18})	**100**	**100**	**100**	**100**	**100**
Product Quality (C_{19})	**10**	**10**	**10**	**10**	**10**
Working Automation (C_{20})	**20**	**20**	**20**	**20**	**20**
Productivity (C_1)	**30**	**30**	**30**	**30**	**30**
Flexibility (C_2)	**40**	**40**	**40**	**40**	**40**
Schedule Utilization (C_3)	**50**	**50**	**50**	**50**	**50**
Adaptability (C_4)	**60**	**60**	**60**	**60**	**60**
Precision (C_5)	**70**	**70**	**70**	**70**	**70**
Reliability(C_6)	**80**	**80**	**80**	**80**	**80**
Safety& Environment(C_7)	**90**	**90**	**90**	**90**	**90**
Maintenance &Service(C_8)	**100**	**100**	**100**	**100**	**100**
Capacity (C_9)	**10**	**10**	**10**	**10**	**10**
Functionality (C_{10})	**20**	**20**	**20**	**20**	**20**
Customization (C_{11})	**30**	**30**	**30**	**30**	**30**
Capital Cost (C_{12})	**40**	**40**	**40**	**40**	**40**

Convenient For Use (C_{13})	**50**	**50**	**50**	**50**	**50**
Accuracy (C_{14})	**60**	**60**	**60**	**60**	**60**
Efficiency (C_{15})	**70**	**70**	**70**	**70**	**70**
Risk (C_{16})	**80**	**80**	**80**	**80**	**80**
Resource Consumption (C_{17})	**90**	**90**	**90**	**90**	**90**
Environment Impact (C_{18})	**100**	**100**	**100**	**100**	**100**
Product Quality (C_{19})	**10**	**10**	**10**	**10**	**10**
Working Automation (C_{20})	**20**	**20**	**20**	**20**	**20**

Table 4. *Computations of* CC_i

Alternatives	CC_i	Ranking
A_1	0.547	3
A_2	0.558	2
A_3	0.561	1
A_4	0.527	4
A_5	0.519	5

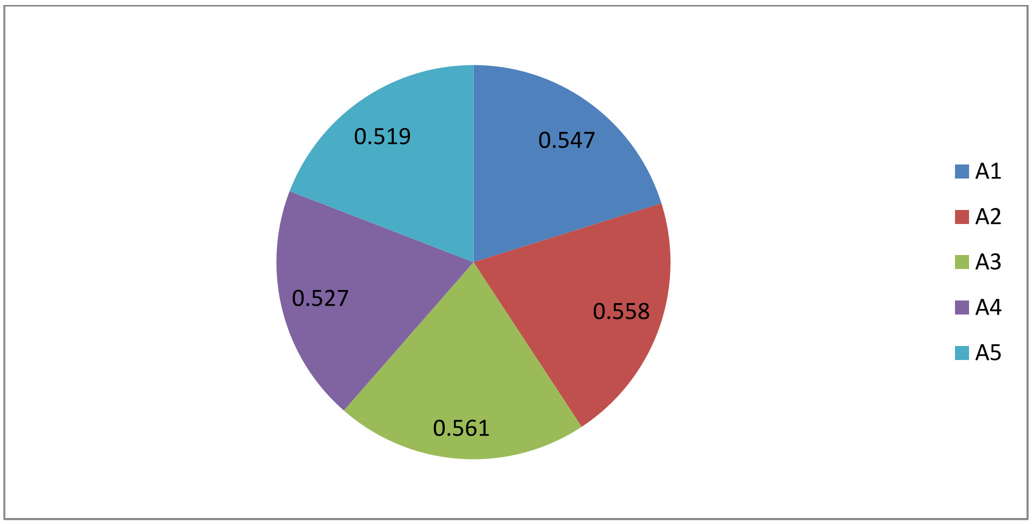

Fig:1 Ranking by pie chart