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CNC Machine Tool Evaluation under Mixed Information by FMF Approach

Shashank Tiwari[1], Raghavendra Singh Kashyap[2]

[1]M-Tech Scholar, Department of Mechanical Engineering, Dr. C.V. Raman University, Kota, Bilaspur, (C.G.), INDIA

[2]Assistant Professor, Department of Mechanical Engineering, Dr. C.V. Raman University, Kota, Bilaspur, (C.G.), INDIA

ABSTRACT

Lathe CNC machines are the workhorses of the precision machining industry. CNC machines 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). Recently, CNC machines evaluation-selection for advanced manufacturing system problem has rosen. In the present reporting, Lathe CNC machines (Computer Numerical Control) machine tool has been evaluated on by exploring the concept of fuzzy set with full multification form approach.

Keywords-- Multi-Criteria Decision Making (MCDM), CNC lathe machine tool, Benchmarking

I. INTRODUCTION

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 (Onut et al. 2008).

Computer Numerical Control (CNC) is one in which the functions and motions of a machine tools are controlled by means of a prepared program containing coded alphanumeric data.

CNC can control the motions of the work piece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off.

The selection of a CNC machine tool among the alternatives is a multi-criteria decision-making(MCDM) problem including both qualitative and quantitative criteria. In conventional approaches, the CNC machine tool selection problem tends to consider quantitative criteria that less effectively dealing with the impreciseness or vagueness nature of the linguistic assessment. Under many situations, the qualitative measures of the alternatives such productivity, working automation; precision, accuracy etc are considered which often imprecisely defined by experts panel judgment ‘linguistic assessments’. Fig. 1 showed the CNC machine tool.

The core *objective* of presented is to evaluate the best CNC machine tool amongst preferred under CNC machine tool multi indices appraisement module (tackle criterion undertook uncertainty).

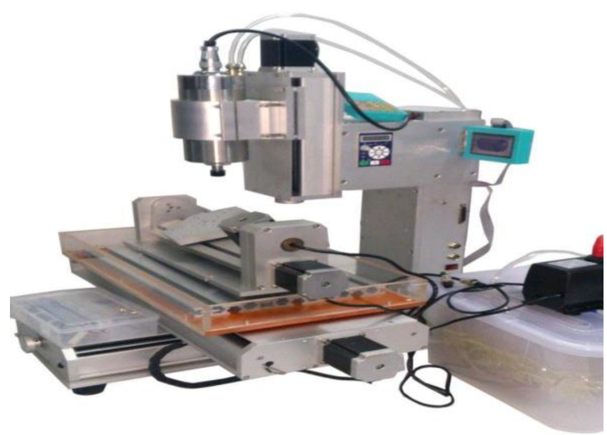

Fig: 1 CNC machine tool

An option that you make about what you think should be done or about which is the best of various alternatives. Decision making is regarded as the mental processes (cognitive process) resulting in the selection of a course of action among several alternative scenarios. Every decision making process produces a final choice. The output can be an action or an opinion of choice.

Prof. Zadeh proposed the concept of fuzzy logic in 1965. Fuzzy logic theory is a control tool and technique, which encompasses the data by allowing partial set membership rather than crisp set membership or non-membership.

II. FUZZY SET THEORY

Prof. Zadeh proposed the concept of fuzzy logic in 1965. Fuzzy logic theory is a control tool and technique, which encompasses the data by allowing partial set membership rather than crisp set membership or non-membership.

Fuzzy logic deals with the concept of partial truth, where the truth value may range between completely true and completely false. Fuzzy logic found their application where the valuable information is neither completely true nor completely false, or which are partly true and partly false.

Fuzzy logic deals with reasoning that is approximate rather than fixed and exact. Compared to traditional binary sets (where variables may take on true or false values) fuzzy logic variables may have a truth value that ranges in degree between 0 and 1 Brauers and Ginevicius (2010); Chakraborty (2011); Dadios and Jr (2002); Gadakh (2011);Kala (2010); Kalibatas and Turskis (2008); Karsak (2008); Kracka et al., (2010).

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III. METHODS

$$defuzz(\hat{A}) = \frac{\int x \cdot \mu(x)dx}{\int \mu(x)dx}$$

$$= \frac{\int_{a_1}^{a_2} \left(\frac{x-a_1}{a_2-a_1} \right) \cdot xdx + \int_{a_2}^{a_3} xdx + \int_{a_3}^{a_4} \left(\frac{a_4-x}{a_4-a_3} \right) \cdot xdx}{\int_{a_1}^{a_2} \left(\frac{x-a_1}{a_2-a_1} \right) dx + \int_{a_2}^{a_3} dx + \int_{a_3}^{a_4} \left(\frac{a_4-x}{a_4-a_3} \right) dx}$$

$$= \frac{-a_1a_2 + a_3a_4 + \frac{1}{3}(a_4-a_3)^2 - \frac{1}{3}(a_2-a_1)^2}{-a_1-a_2+a_3+a_4}.$$

……………………………….……....(1)

. The Ratio system:

Ratio System defines data normalization by comparing alternative of an objective to all values of the objective:

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad \text{……….………………………...…....(2)}$$

$$U_i' = \frac{A_i}{B_i} \quad \text{…………………………………..………...(3)}$$

Here

$$A_i = \prod_{j=1}^{g} x_{ij}; i = 1,2,...,m$$

denotes the product of objectives of the i_{th} alternative to be maximized with $g = 1,2,...,n$ being the number of objectives to be maximized and where

$$B_i = \prod_{j=g+1}^{n} x_{ij}; i = 1,2,...,m$$

denotes the product of objectives of the i_{th} alternative to be minimized with $n-g$ being the number of objectives (indicators) to be minimized. Thus MULT-IMOORA summarizes ratio system analysis and full multiplicative form.

IV. EMPIRICAL RESEARCH: EVALUATION OF CNC MACHINE TOOL

A lathe CNC machine tool evaluation appraisement module against OI and SI has been constructed via literature survey (Sun, 2002; Duran and Aguilo, 2008; Qi, 2010; Sahu et al., 2014; Sahu et al., 2015, Sahu et al., 2016). CNC lathe machine tool evaluation appraisement module is shown in Table 1. Objective data is shown in Table 2.

Trapezoidal fuzzy number operator are used by (Duran and Aguilo, 2008; Qi, 2010), is explored to aggregate the fuzzy numbers, then Equation 1 is used to covert rating and weight against criterion into crisp value shown in Table 3-9. Finally normalization is carried out by Equation 2 and ranking is obtained by Equation 3, shown in Table 10.

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Table.1: CNC lathe machine tool appraisement module

	Information	Objectives	Sources
Evaluation of CNC machine tool	***OI***	Cost, INR, (C_1)	(Sun,2002)
		Tool Capacity, No., (C_2)	(Sun,2002)
		Requirement of Space , Inch, (C_3)	(Duran and Aguilo,2008)
		Maintenance Cost, INR/Year, (C_4)	(Qi,2010)
		Depreciations, Year, (C_5)	(Sahu et al., 2014)

		Power Consumption, Unit/hrs, (C_6)	(Sahu eta l., 2015)
	SI	Effectiveness, (C_7)	(Duran and Aguilo,2008)
		Operator intention, (C_8)	(Sun,2002)
		Flexibility against production system, (C_9)	(Duran and Aguilo,2008)
		Chances of part's failure, (C_{10})	(Sahu et al., 2016)
		Simplicity, (C_{11})	(Qi,2010)
		Programming flexibility, M/S, (C_{12})	(Sahu et al., 2016)

Table. 2: Technical and Cost (objective) information against CNC lathe machine tool measures

Evaluation of CNC lathe machine tools	(C_1)	(C_2)	(C_3)	(C_4)	(C_5)	(C_6)
Lathe CNC-1	16000000	6	49	51000	16	2
Lathe CNC-2	15000000	5	50	52000	14	3
Lathe CNC-3	17000000	6	50	50000	17	2
Lathe CNC-4	18000000	8	47	53000	18	3
Lathe CNC-5	19000000	7	50	50000	19	2
Lathe CNC-6	19000000	7	50	50000	19	4
Lathe CNC-7	12000000	8	52	54000	10	2
Lathe CNC-8	10000000	8	50	50000	11	3
Lathe CNC-9	18000000	8	52	50000	17	3
Lathe CNC-10	18000000	7	50	42000	16	3

Table 3: Weights against CNC lathe machine tool measures as assigned by DMs and corresponding aggregated fuzzy weights (AFW)

Evaluation of CNC lathe machine tools	Importance weight expressed in linguistic terms					AFW
	DM1	DM2	DM3	DM4	DM5	
C_1	H	H	M	H	H	(0.640,0.740,0.740,0.840)
C_2	VH	VH	VH	H	H	(0.760,0.860,0.920,0.960)
C_3	H	H	MH	H	MH	(0.620,0.720,0.760,0.860)
C_4	M	VH	H	H	H	(0.660,0.760,0.780,0.860)
C_5	VH	H	VH	H	H	(0.740,0.840,0.880,0.940)
C_6	VH	VH	VH	H	H	(0.760,0.860,0.920,0.960)
C_7	H	H	MH	H	MH	(0.620,0.720,0.760,0.860)
C_8	M	VH	H	H	H	(0.660,0.760,0.780,0.860)
C_9	VH	H	VH	H	H	(0.740,0.840,0.880,0.940)
C_{10}	VH	VH	VH	H	H	(0.760,0.860,0.920,0.960)
C_{11}	VH	VH	VH	H	H	(0.760,0.860,0.920,0.960)
C_{12}	H	H	MH	H	MH	(0.620,0.720,0.760,0.860)

Table.4 Appropriateness rating against subjective CNC lathe machine tool measure, (C_7)

Evaluation of CNC lathe machine tools	Appropriateness rating against individual 1st level evaluation measures					AFR
	DM1	DM2	DM3	DM4	DM5	
Lathe CNC-1	G	MP	F	F	MP	(3.800,4.800,5.400,6.400)
Lathe CNC-2	G	G	VG	G	VG	(7.800,8.800,9.400,10.00)
Lathe CNC-3	VG	VG	VG	G	G	(8.200,9.200,9.600,10.00)
Lathe CNC-4	VG	G	VG	VG	VG	(8.600,9.600,9.800,10.00)
Lathe CNC-5	VG	MG	G	G	G	(7.000,8.000,8.800,9.600)

Lathe CNC-6	MG	F	G	MG	VG	(6.000,7.000,7.600,8.400)
Lathe CNC-7	F	G	MG	F	G	(5.400,6.400,7.000,8.000)
Lathe CNC-8	F	G	G	G	F	(5.800,6.800,7.400,8.400)
Lathe CNC-9	F	G	G	G	G	(6.400,7.400,8.200,9.200)
Lathe CNC-10	G	MG	F	VG	MG	(6.000,7.000,7.600,8.400)

Table.5 Appropriateness rating against subjective CNC lathe machine tool measure, (C_8)

Evaluation of CNC lathe machine tools	Appropriateness rating against individual 1st level measures					AFR
	DM1	DM2	DM3	DM4	DM5	
Lathe CNC-1	MG	F	G	MG	VG	(6.000,7.000,7.600,8.400)
Lathe CNC-2	F	G	MG	F	G	(5.400,6.400,7.000,8.000)
Lathe CNC-3	F	G	G	G	F	(5.800,6.800,7.400,8.400)
Lathe CNC-4	F	G	G	G	G	(6.400,7.400,8.200,9.200)
Lathe CNC-5	G	MG	F	VG	MG	(6.000,7.000,7.600,8.400)
Lathe CNC-6	VG	VG	G	G	G	(7.800,8.800,9.400,10.00)
Lathe CNC-7	MG	VG	G	F	G	(6.400,7.400,8.000,8.800)
Lathe CNC-8	G	VG	MG	VG	VG	(7.800,8.800,9.200,9.600)
Lathe CNC-9	MG	G	MG	G	VG	(6.600,7.600,8.400,9.200)
Lathe CNC-10	F	VG	F	MP	VG	(5.600,6.600,6.800,7.400)

Table.6 Appropriateness rating against subjective CNC lathe machine tool measure, (C_9)

Evaluation of CNC lathe machine tools	Appropriateness rating against individual 1st level evaluation measures					AFR
	DM1	DM2	DM3	DM4	DM5	
Lathe CNC-1	VG	VG	G	G	G	(7.800,8.800,9.400,10.00)
Lathe CNC-2	MG	VG	G	F	G	(6.400,7.400,8.000,8.800)
Lathe CNC-3	G	VG	MG	VG	VG	(7.800,8.800,9.200,9.600)
Lathe CNC-4	MG	G	MG	G	VG	(6.600,7.600,8.400,9.200)
Lathe CNC-5	F	VG	F	MP	VG	(5.600,6.600,6.800,7.400)
Lathe CNC-6	MG	F	G	MG	VG	(6.000,7.000,7.600,8.400)
Lathe CNC-7	F	G	MG	F	G	(5.400,6.400,7.000,8.000)
Lathe CNC-8	F	G	G	G	F	(5.800,6.800,7.400,8.400)
Lathe CNC-9	F	G	G	G	G	(6.400,7.400,8.200,9.200)
Lathe CNC-10	G	MG	F	VG	MG	(6.000,7.000,7.600,8.400)

Table.7 Appropriateness rating against subjective CNC lathe machine tool measure, (C_{10})

Evaluation of CNC lathe machine tools	Appropriateness rating against individual 1st level evaluation measures					AFR
	DM1	DM2	DM3	DM4	DM5	
Lathe CNC-1	G	MG	MG	MG	G	(5.800,6.800,7.800,8.800)
Lathe CNC-2	VG	MG	MG	MG	MG	(5.800,6.800,7.600,8.400)
Lathe CNC-3	G	MP	MG	MP	G	(4.600,5.600,6.600,7.600)
Lathe CNC-4	VG	G	MG	VG	VG	(7.800,8.800,9.200,9.600)
Lathe CNC-5	F	G	G	MP	MP	(4.400,5.400,6.200,7.200)

Lathe CNC-6	MG	F	G	MG	VG	(6.000,7.000,7.600,8.400)
Lathe CNC-7	F	G	MG	F	G	(5.400,6.400,7.000,8.000)
Lathe CNC-8	F	G	G	G	F	(5.800,6.800,7.400,8.400)
Lathe CNC-9	F	G	G	G	G	(6.400,7.400,8.200,9.200)
Lathe CNC-10	G	MG	F	VG	MG	(6.000,7.000,7.600,8.400)

Table.8 Appropriateness rating against subjective CNC lathe machine tool measure, (C_{11})

Evaluation of CNC lathe machine tools	Appropriateness rating against individual 1st level evaluation indices					AFR
	DM1	DM2	DM3	DM4	DM5	
Lathe CNC-1	G	MP	F	F	MP	(3.800,4.800,5.400,6.400)
Lathe CNC-2	G	G	VG	G	VG	(7.800,8.800,9.400,10.00)
Lathe CNC-3	VG	VG	VG	G	G	(8.200,9.200,9.600,10.00)
Lathe CNC-4	VG	G	VG	VG	VG	(8.600,9.600,9.800,10.00)
Lathe CNC-5	VG	MG	G	G	G	(7.000,8.000,8.800,9.600)
Lathe CNC-6	MG	F	G	MG	VG	(6.000,7.000,7.600,8.400)
Lathe CNC-7	F	G	MG	F	G	(5.400,6.400,7.000,8.000)
Lathe CNC-8	F	G	G	G	F	(5.800,6.800,7.400,8.400)
Lathe CNC-9	F	G	G	G	G	(6.400,7.400,8.200,9.200)
Lathe CNC-10	G	MG	F	VG	MG	(6.000,7.000,7.600,8.400)

Table.9 Appropriateness rating against subjective CNC lathe machine tool measure, (C_{12})

Evaluation of CNC lathe machine tools	Appropriateness rating against individual 1st level evaluation measures					AFR
	DM1	DM2	DM3	DM4	DM5	
Lathe CNC-1	G	G	VG	VG	G	(7.800,8.800,9.400,10.00)
Lathe CNC-2	MG	VG	MG	VG	MG	(6.600,7.600,8.200,8.800)
Lathe CNC-3	MG	VG	MG	G	VG	(7.000,8.000,8.600,9.200)
Lathe CNC-4	G	G	F	MG	MG	(5.600,6.600,7.400,8.400)
Lathe CNC-5	G	G	MG	VG	MG	(6.600,7.600,8.400,9.200)
Lathe CNC-6	MG	F	G	MG	VG	(6.000,7.000,7.600,8.400)
Lathe CNC-7	F	G	MG	F	G	(5.400,6.400,7.000,8.000)
Lathe CNC-8	F	G	G	G	F	(5.800,6.800,7.400,8.400)
Lathe CNC-9	F	G	G	G	G	(6.400,7.400,8.200,9.200)
Lathe CNC-10	G	MG	F	VG	MG	(6.000,7.000,7.600,8.400)

Table.10 Evaluation of CNC lathe machine tool

Evaluation of CNC lathe machine tool	FMF	Ranks	Final solution by dominance approach
Lathe CNC-1	226.4672	9	**Lathe CNC-3**
Lathe CNC-2	1239.117	7	
Lathe CNC-3	4085.394	**1**	
Lathe CNC-4	1659.12	5	
Lathe CNC-5	2708.617	3	
Lathe CNC-6	673.391	8	
Lathe CNC-7	3602.351	2	

Lathe CNC-8	2648.918	4	
Lathe CNC-9	1300.8	6	
Lathe CNC-10	191.0318	10	

V. CONCLUSION

After applying the FMF approach, it is found that Lathe CNC-3 is the optimum alternative than others. The summarized preference orders against different CNC lathe machine tools have been depicted in Table. 10. Moreover, module for crisp or subjective objectives can be segregated with respect to their interrelated metrics / dimensions and can also be solved for benchmarking problems.

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