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CNC machine tool evaluation under mixed information by RSA approach

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

M-Tech Scholar[1], Assistant Professor[2],
Department of Mechanical Engg,
Dr. C.V. Raman University, Kota, Bilaspur, (C.G.), India

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 searched as cost effective equipment that performs repetitious, thorny as well as precarious production tasks conjunctive with elevated accuracy. Recently, CNC machine tool evaluation-selection for advanced manufacturing system based firms; found critical task; as appropriate machine tool does not lays individual escalation in production, but also assist the firm to hike goods characteristic index as well as enhance overall productivity. In the present reporting, CNC (Computer Numerical Control) machine tool has been evaluated on by exploring the concept of generalized trapezoidal fuzzy set accompanied with ratio system analysis.

Key Words: **Benchmarking, L-R (Leanness-Resilient) Supply Chain, Performance Measurement (PM), Fuzzy Performance Index (FPI).**

1. INTRODUCTION

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. An option that you make about what you think should be done or about which is the best of various alternatives. Over the last few decades, engineering and science are the major impulse for the augmented utilization of CNC machine tool in industries in variety of application. Lathe CNC has found its major utility to perform threading operations.

In today's markets, high competition, rapid technological advancements, and continuous change have forced the organizations to search for the competitive advantages as the markets become comprehensive. Last four decade, the continuous development of automation in technology, has contributed to the exponential growth of lathe CNC machine tool in industry. Fig. 1 showed 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

2. 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 Brauers and Ginevicius (2010); Chakraborty (2011); Dadios and Jr (2002); Gadakh (2011); Kala (2010); Kalibatas and Turskis (2008); Karsak (2008); Kracka et al., (2010).

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.

3. RESEARCH OBJECTIVES:

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).

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4. CRISP VALUE CONVERTER:

$$defuzz(\hat{A}) = \frac{\int x \cdot \mu(x)dx}{\int \mu(x)dx} \quad \text{...(1)}$$

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

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

5. 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

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

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

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

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.

6. 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). 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

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	RSA	Ranks	Final solution by dominance approach
Lathe CNC-1	-0.06652	8	**Lathe CNC-3**
Lathe CNC-2	-0.05451	6	
Lathe CNC-3	-0.02483	**1**	
Lathe CNC-4	-0.04866	5	
Lathe CNC-5	-0.03704	3	
Lathe CNC-6	-0.07655	10	
Lathe CNC-7	-0.03188	2	
Lathe CNC-8	-0.04109	4	
Lathe CNC-9	-0.0555	7	
Lathe CNC-10	-0.07338	9	

CONCLUSIONS:

After applying the *Ratio System Analysis*, 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.

- The significant factors against drivers have been computed as per subjective information assigned by team of DMs.

- The module can be made applicable with same approach to diagnostic real life problems i.e. selection of cars, scooters, bikes, buses, aero plans, helicopters etc with respect to multiple designs attributes.

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BIOGRAPHY

Shashank Tiwari is an M-Tech scholar of Department of Mechanical Engg, Dr. C.V. Raman University, Kota, Bilaspur, (C.G.), India, and his current research area is CNC machine tool selection under fuzzy set.