Journal Of Harmonized Research (JOHR)

Journal Of Harmonized Research in Engineering
2(3), 2014, 324-328

ISSN 2347 – 7393

Original Research Article

SOME ASPECT ON FAILURE ANALYSIS OF CNC MACHINE USING ANALYTIC HIERARCHY PROCESS (AHP) AND MULTIPLE ATTRIBUTE DECISION MAKING (MADM)

Rachit Sandolkar, Sharda Pratap Shrivas

Department of Mechanical Engineering, Chouksey Engineering College Bilaspur, India

Abstract:
A systematic study of such failures is expected to help in identifying the critical elements/sub-system prone to failure.CNC machines into groups' helps maintenance department to focus their attention to the machine that has high tendency to produce defect. In this work failure analysis of computerized numerical control (CNC) lathes as well milling machine are collected, investigated and described. Failure data of CNC's lathes and CNC's milling over a period of six years was considered. The failure position and subsystem, failure mode and cause were analyzed to indicate the weak subsystem of a CNC Milling Multiple Attribute Decision Making (MADM) method, was used to identify each CNC machine failure. These failures were then used to create a quality inspection order, so that the machine with the lowest failure could be inspected before the machine with the highest failure The results suggest that the proposed method helps to detect failure causes of CNC machine earlier hence reducing the number of delay found in the production line.

Key Words:- CNC, Failure cause, MADM (SAW, WPM)

Introduction

Data on failures is a poorly researched area. It is only recently that failure data have been collected in any systematic way as an offshoot of organized maintenance planning. These data are of great interest to the machine tool manufacturer who will, end to design out the fault generating elements. A CNC Milling is a complex system, with high-level automation and complicated structure, which employs mechanics, electronics, and hydraulics and so on. It is mainly composed of the mechanical system; CNC system and hydraulic or/and air feed system [2&3]. A CNC system, as the heart of a lathe, is usually comprised of power supply, main printed circuit board(PCB) (usually a micro-computer), programmable logic controller (PLC) I/O PCB (which connects the control panel, limit switch, button, magnets, turret and

For Correspondence:
rsandolkar15ATgmail.com
Received on: June 2014
Accepted after revision: July 2014

so on),axis PCB (which controls the slide axes and the spindle through semi-closed or closed loop electronic control motor drive and photoelectric encoder), memory PCB(which connects additional encoder, CRT/MDI (manual data input), manual pulse generator (MPG), backup battery and RS-232 serial communication device). Fortunately, a state administrative institution in this country had made a mandatory rule that all CNC machine tools users had to trace the CNC machine tools performance and keep and feedback the complete maintenance reports to the manufacturers. CNC machines to improve both flexibility and productivity, the dimensional accuracy of the parts produced on these machines has become dependent upon accurate machines and good machining processes. With CNC machines, the primary goal is to automate the machining processes. Operators of these machines, if there are any, are usually responsible for loading parts and monitoring machine conditions but not for part-quality control.

Neseli et al.[4] 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 CNMG120404-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 within creases surface roughness. Dogra et al.[5] studied about that 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. Mannan et al. [6] 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. Guddat et al. [8] investigated the effect of wiper PCB Ninserts geometry 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. Rao et al. [9] 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. Abhang et al. [10] studied about selection of best lubricant in turning operation from alternative lubricants by using MADM methods.

To analyze the failure mode and cause, we count the number of failures for each failure mode according to the data bank by retrieving the failure mode code and then calculate the frequency of failures of each failure mode. Its aim is to find out whether a cause is repeatable in nature or not. If it is repeated, it has reoccurred at the certain intervals or not. The causes have re-occurred or not in a particular position. In fact the basic intent of this tool is to find out why this variation has taken place from the specified specifications. The main objective of a failure cause analysis is to reduce a large number of unknowns and unmanageable causes of variation to a much smaller family of related variables containing the dominant cause. In this paper proposed a network selection scheme based on utility function which takes more key factors for failure cause in CNC machine.

Methodology

MADM is an approach employed to solve problems involving selection from among a finite number of alternatives. An MADM method specifies how attribute information is to be processed in order to arrive at a choice. MADM methods have decision variable values that are determined in a continuous or integer domain with either an infinitive or a large number of choices, the best of which should satisfy the decision maker constraints and preference priorities. Multi-Criteria Decision

Analysis is a discipline aimed at supporting decision makers faced with making numerous and sometimes conflicting evaluations. MADM is evaluated against the alternative m_i (i = 1,2 ,...., m) against a set of attributes or criteria m_j (j = 1,2 ,..., n) where each attribute are not Mutually dependent with each other. Decision matrix of each alternative on each attribute, X is given as:

$$X_{ij} = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & \dots & m \end{array} \\ \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ b_{31} & b_{32} & \dots & b_{3n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{m1} & b_{m2} & \dots & b_{mn} \end{bmatrix} \end{array}$$

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

Step 2: Determine the relative importance of different attributes with respect to the goal or objective. Find the relative normalized weight (W_j) of each attribute by calculating the geometric mean of the i^{th} row, and normalizing the geometric means of rows in the comparison matrix by:

$$GM_j = \left[\prod_{j=1}^{m} b_{ij}\right]^{\frac{1}{m}} \dots\dots\dots\dots\dots\dots\dots (1)$$

Step 3: 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.

$$W_j = GM_j / \sum_{j=1}^{m} GM_j \dots\dots\dots\dots\dots\dots (2)$$

Where b_{ij}(i= 1,2 3, …… n and j= 1,2,3, …….m)

Step 4: The overall or composite performance score of an alternative is given by equation 3.

$$P_i = \sum_{j=1}^{m} W_j(m_{ij}) \dots\dots\dots\dots\dots\dots\dots (3)$$

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

Failure data collection and analysis

The present work required CNC milling machine failure data from industries. Also this data were required in specific format. It was difficult to collect field failure data on machine several years ago, because users hardly kept adequate and complete maintenance records beyond the warranty period. In this computerized maintenance environment, users feel encouraged to keep the systematic maintenance records of their machineries. Failure data were collected for a period of five years on several conventional machine tools of milling machines. This kind of information was not easily available with the local industries. Therefore initially literature was referred to check availability of data. Failure data were collected from Simplex industries Raipur & Bhilai Engineering Corporation a period of three years on two CNC machines such as lathe and machines. It contained the following information

- Machine number
- Date of repair.
- Failure effect.
- Repair time.
- Down time.
- Date of hand-over.
- Causes of failure.

Result and Discussion

Milling is the process of machining flat, curved or irregular surface by feeding the work piece against a rotating cutter containing a number of cutting edges. Milling process consists of a motor driven spindle, which mounts and revolves the milling cutter and a reciprocating adjustable worktable, which mounts and feeds the work-piece. The milling machine has been classified into various subsystems as shown in Fig.1. The frequency of failures for each subsystem and failure modes have been considered for finding out the weakest sub-system. The Milling machine has been classified the various sub-systems and failure modes shown in table 1. In the present analysis failure frequency and downtime have been taken into consideration for deciding critical sub-systems of machine tools. It can be seen from the Fig. 2. that the maximum failures took place in electrical system, coolant and chuck sub-systems.

Table 1 Milling machine sub system and failure mode

S. NO.	SUB SYSTEM	FALIURE MODES
1	Control Panel	Breakdown
2	Encoder	Looseness
3	Spindle	Circuit fault
4	Feed Mechanism	Fuse burnt
5	Electrical System	
6	Hydraulic System	
7	Coolant System	

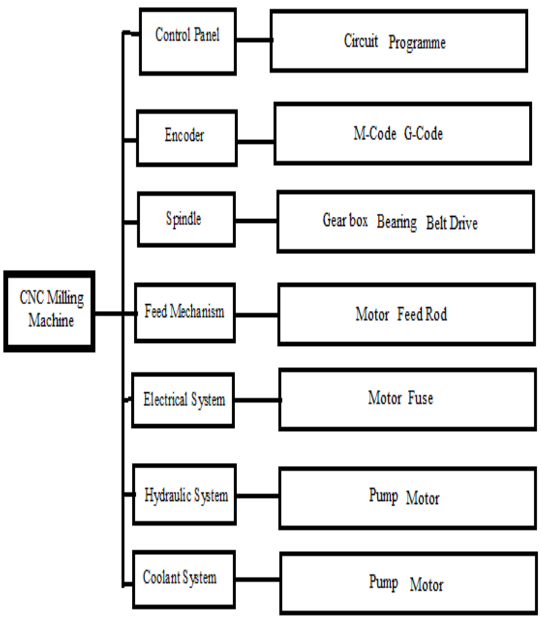

Fig 1. System blog diagram of CNC Milling Machine

Fig 2. CNC Milling Machine

The seven failure causes are taken as sub-system of each milling machine and make a Matrix by servetery component from 0 to 9 digits. As per SAW method the AHP process using to find weight W_i of CNC Milling Machine. The relative importance geometric mean (GM_j) is obtained by using AHP method. Obtain the weighted normalized matrix $(m_{ij})_{normal}$. This is obtained by the division of each element of the column of the matrix X_{ij} with its associated higher weight $(X_j)_{max}$. Hence, the elements of the weighted normalized matrix $(m_{ij})_{normal}$ are expressed as:

$$(m_{ij})_{normal} = \begin{bmatrix} .14 & 0 & .22 & .13 \\ 0 & 0 & .44 & .13 \\ .71 & .5 & .44 & .38 \\ .28 & .75 & .55 & .75 \\ 1 & 1 & 1 & 1 \\ 1 & .63 & .44 & .75 \\ .43 & .75 & .44 & .38 \end{bmatrix}$$

The relative closeness of a particular alternative to the ideal solution, P_i, can be obtain that suggests among the failure causes of CNC milling machine the Electrical system are most critical system. The result obtained from SAW and WPM for these CNC milling machines indices are compiled and compares in Table 2.

Table 2. Result Comparisons of CNC Milling Machine

FAILURE	COMPARISION TABLE

CAUSES	SAW INDEX (P_i)	RANK	WPM INDEX (P_i)	RANK
Control Panel	0.1239	7	1.875	6
Encoder	0.1459	6	1.352	7
Spindle	0.4946	4	3.342	4
Feed Mechanism	0.5986	3	3.473	3
Electrical System	1.0000	1	4.000	1
Hydraulic System	0.7030	2	3.630	2
Coolant System	0.4905	5	3.320	5

Conclusion

The failure data have been collected and analyzed systematically for commonly used CNC milling machine. A two Step matrix algorithm was used, and this algorithm was able to automatically select the best number of failure cause, with the appropriate number of failure mode. After this, a SAW and WPM was implemented for each failure cause, producing a rank for each failure cause of CNC machine. The machines with the highest rank were those that failed first. The critical sub-system has been identified by MADM method.

Milling Machine Rank

- SAW - Electrical System, Hydraulic System, Feed Mechanism, Spindle, Coolant System, Encoder and Control Panel.
- WPM - Electrical System, Hydraulic System, Feed Mechanism, Spindle, Coolant System, Control Panel and Encoder.

References

[1]. Keller AZ, Kamth ARR, Perea UD. *Reliability analysis of CNC machine tools.* Reliability Engineering (1982) Vol. 3: 449–473.

[2]. Walker John R. Machining fundamentals. Goodheart-Willcox Company, Inc, (1977).

[3]. FANUC CNC system manuals. Beijing FANUC Mechatronics Ltd., (1989) (in Chinese).

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

[5]. 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.

[6]. 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.

[7]. 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.

[8]. 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.

[9]. 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.

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

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

[12]. Sunil Kumar Gupta, Sharda Pratap Shrivas, Chitrakant Tiger, *Failure Cause Analysis Of CNC Machine By AHP & MCDM Approach*, Journal of Harmonized Research in Engineering, 2(1), 187-193 (2014).