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Short Communication

OPTIMIZATION OF FAILURE IN MACHINE PARTS BY HYBRID METHOD

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Abstract

During the operation of these machine tools, different kinds of failures are faced by the industry. CNC machines into groups helps maintenance department to focus their attention to the machine that has high tendency to produce defect. A field failure analysis of computerized numerical control (CNC) lathes is described. Field failure data was collected over a period of one year on approximately ten CNC lathes. A coding system to code failure data was devised and a failure analysis data bank of CNC machine was established. The failure position and subsystem, failure mode and cause were analyzed to indicate the weak subsystem of a CNC lathe. If the machine producing the defect is inspected late, the damage caused might be large. Moreover, to remove this problem Hybrid method is use to identify machine failure.

Key Words:- CNC machine, Hybrid method, Failure.

Introduction

During the last decade, computerized numerical control (CNC) lathes have increasingly been introduced into mechanical machining process. As a result of their considerable inherent flexibility, stable machining accuracy and high productivity, CNC lathes are of immense interest to the users. However, as the breakdown of a single CNC lathe may result in the production of an entire workshop being halted and repairs are more difficult and expensive when a breakdown occurs [1].A CNC lathe is a complex system, with high-level automation and complicated structure, which employs mechanics, electronics, hydraulics and so on. It is mainly composed of the mechanical system; CNC system and hydraulic or/and air feed system [2 & 3]. Fig. 1 is the system block diagram of a typical CNC lathe. The mechanical system includes spindle and its transmission (fixed in a headstock), two slide axes (named *X*, *Z* or *U*, *W* in turns), carriage apron, turret or tool-holder, tailstock, bed and pedestal and so on. The spindle, with continuous or stepped continuous speed change, is driven by AC or DC spindle motor directly or through main transmission, and there is a photoelectric

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encoder on the spindle for thread turning. Both of *X* and *Z*-axes are driven by AC or DC servomotors through ball lead screws, and controlled simultaneously. The turret or tool-holder may exchange tools automatically. All of these are controlled by CNC system [2]. 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 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). The CNC system and some electronic components, such as contactor switches, relays, regulators, buttons and so on, are fixed in a cabinet. Other electronic components, such as limit switches, proximity switches, encoders and so on, are located on the machine [3].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 and the related research institutions within and beyond the warranty period. It was difficult to collect reliable field failure data of CNC lathes should contain following information:

1. Failure phenomenon.
2. Cause analysis.
3. Repair process.
4. Repair time.
5. Downtime.
6. Failure judgment

The case study company is a manufacturer of such frames and the main machine used to fabricate these parts is a computer numerical control (CNC) machine.The vast majority (92-98%) of these disturbances are voltage sags that occur due to lightning strikes, accidents, squirrels or equipment failure on the transmission and distribution grid feeding the production. It is important to understand the impact of such power disturbances on a CNC machine equipment and processes.

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 [4]. 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 [5].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 [6]. 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 [7].Guddat *et al.* investigated the effect of wiper PCBN inserts 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 [8].

Objective

An important component of failure cause analysis is a thorough understanding of "what happened". It begins by reviewing an "initial understanding" of the event and identifying unanswered questions and information gaps. The information-gathering process includes interviews with staffs and workers who were directly and indirectly involved with the physical environment where the event and other relevant processes took place, along with observation of usual work processes. This information is synthesized into a "final understanding", which is further used by the team to begin the "why" portion of the analysis in a logical sequence to find the problem. It is one of the many brainstorming methodology of asking "how much" five times repeatedly to help in identifying the failure cause of a problem. If a problem is repeatedly questioned, each time an alternative solution comes out which is linked to the failure cause of CNC machine.

Method and Material

Combination of Multi-criteria decision making (MCDM) is the decision-making technique and SAW method make hybrid method for considering some alternatives options. The Multiple Attribute Decision Making (MADM) again combined with WPM method which comes to mathematical analysis of hybrid method. This type of Hybrid can be used for the election in which there is only a small number of alternative courses. The MADM is used to solve problems in discrete spaces, typically used to solve problems in the assessment and selection of limited number of alternatives. The MADM approaches are done through two stages, namely:

- Perform aggregation of the decisions that responds to the decisions corresponding to all destinations on each alternative
- Perform alternatives ranking based on the aggregation of the decision makers.

Multi-Criteria Decision Analysis (MCDA) or Multi-Criteria Decision Making (MCDM) 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:

$$X_{ij} = \begin{matrix} & 1 & 2 & \cdots & m \\ 1 & b_{11} & b_{12} & \cdots & b_{1n} \\ 2 & b_{21} & b_{22} & \cdots & b_{2n} \\ 3 & b_{31} & b_{32} & \cdots & b_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ n & b_{m1} & b_{m2} & \cdots & b_{mn} \end{matrix}$$

Where b_{ij} is an alternative performance rating in relation to the j^{th} attributes. Weight value indicates the relative importance of each attribute, given as W:

$$W_j = \{ w_1 , w_2, w_3, \ldots, w_m \}$$

Performance rating (X) and weight value (W) represent the core values corresponding to the absolute preference of the decision makers.Based on the failure data the severity judgment values are assigned to these failures causes by using a severity conversion table 1.

Table 1 Severity Conversion.

Qualitative measure of failure event	**Analyzed value of severity event**
Low	0
Extremely Low	1
Very Low	2
Below Average	3
Average	4
Above Average	5
High	6
Very High	7
Most High	8
Extremely High	9

Simple Additive Weighting (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.

It was argued that SAW should be used only when the decision attributes can be expressed in identical units of measure (e.g., only dollars, only pounds, only seconds, etc.). However, if all the elements of the decision table are normalized, then SAW can be used for any type and any number of attributes. In that case, Equation1will take the following form:

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

Where (mij) normal represents the normalized value of mij, and Pi is the overall or composite score of the alternative Ai. The alternative with the highest value of Pi is considered as the best alternative.

Weighted Product Method (Wpm)

This method is similar to SAW. The main difference is that, instead of addition in the model. There is multiplication. The overall or composite performance score of an alternative is given by Equation 3.

$$P_i = \prod_{j=1}^{m} [(m_{ij})_{normal}]^{W_j} \dots \dots \dots \dots \dots \dots \dots (5)$$

The normalized values are calculated as explained under the SAW method. Each normalized value of an alternative with respect to an attribute, i.e., (mij) normal, is raised to the power of the relative weight of the corresponding attribute. The alternative with the highest Pi value is considered the best alternative [11].

Result and Discussion

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. MCDA aims at highlighting these conflicts and deriving a way to come to a compromise in a transparent process. Multiple criterion decision making (MCDM) refers to making decisions in the presence of multiple usually conflicting criteria.As explain in SAW methods theory, value of these four attributes are normalized and weights (w_1,w_2....w_4) of attributes such as breakdown, Looseness, Circuit fault and fuse. Various steps of the methodology were carried out of these MADM was applied to the data obtained from industry. For CNC machine these are Control panel (CP), Encoder (EN), Headstock (HS), feed mechanism (FM), Electrical System (ES), Hydraulic system (HS) and Coolant system (CS) are the Failure mode which is optimize by hybrid method.

Conclusions

This thesis proposes a way to find failure causes of CNC machines which based on the quality inspection of data from maintenance department taken for a number of machines. The failure data have been collected and analyzed systematically for both commonly used CNC 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.

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