Knowledge based Systems, a support to the Preventive Maintenance

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Abstract :- This paper mainly deals with the application of the Knowledge Based Systems, as a support to the preventive maintenance in any of the industries. The main purpose is to study the expert system where in the human intelligence is considered. The process of preventive maintenance in any industry can be maintained using the software packages like MAT LAB (Matrix Laboratory), DAS (Data Acquisition Software), and LABVIEW (Laboratory Virtual Instrument Engineering Workbench). The main purpose is to study the implementation of the Knowledge Based Systems for industries.

Keywords: Knowledge Based Systems, Expert system, Failure Mode & Effect Analysis, Simulink Modeling, Preventive Maintenance

I. INTRODUCTION

In order to run a successful manufacturing company, continuous improvement must be considered and implemented in the areas of safety, quality and reliability. To achieve this, one of the most important processes which must be subject of improvement is maintenance process. Improvement of safety, quality, reliability and dependability in a plant is directly associated to the maintenance system in a company. Moreover, it has been proved that the maintenance cost is one of the main parts of life cycle cost of a product or asset.

Knowledge Based System:

Knowledge based systems are sophisticated, interactive computer programs which use high quality, specialized knowledge in some narrow problem domain to solve complex problems in that domain. KBS have been referred to with a variety of names such as expert systems, intelligent assistants, epistemological systems and design and analysis systems. The two terms most popular in common usage, often used synonymously, are KBS and expert systems.

EXPERT SYSTEM:

Expert system is one of the areas of artificial intelligence. An expert system also known as knowledge based system is a computer program that contains the knowledge and analytical skills of one or more human experts in a specific problem domain. The goal of the design of the expert system is to capture the knowledge of a human expert relative to some specific domain and code this in a computer in such a way that the knowledge of the expert is available to a less experienced user

II. METHODOLOGY

2.1 MATLAB:

MATLAB is a powerful language for technical computing. The name MATLAB stands for MATrixLABoratory, because its basic data element is a matrix (array). MATLAB can be used for math computations, modeling & simulations, data analysis & processing, visualization & graphics, & algorithm development.

MATLAB is widely used in universities & colleges in introductory & advanced courses in mathematics, science, & especially in engineering. In industry the software is used in research, development & design. The standard MATLAB program has tools (functions) that can be used to solve common problems. In addition, MATLAB has optional toolboxes that are a collection of specialized programs designed to solve specific types of problems. Examples include toolboxes for signal processing, symbolic calculations, & control systems.

Until recently, most people who had previous knowledge of programming languages such as FORTRAN or C, & switched to MATLAB as the software became popular. Consequently, the majority of the literature that has been written about MATLAB assumes that the reader has knowledge of computer programming. Books about MATLAB often address last few years, however, MATLAB is being introduced to college students as the first (and sometimes the only) computer program they learn. For these students there is a need.

2.2 Survey of industry
Orione hydraulics pvt. Ltd., Belgaum:
As there are many hydraulic industrial plants in our country at both large & medium scales and there is a good economic effect to the nation. But in these, there are some problems that may cause loss to the process of manufacturing. This loss can be prevented by proper maintenance procedures.

Our focus is on the problems of the CNC Turning center. As mentioned earlier of the failure mode & effect analysis (FMEA) method, is considered as a tool for maintenance & to imply this in the industry we are using the MATLAB software. As considered of the

Figure 2.1: Spring before failure	Figure 2.2: Spring with misalignment

The below graphs are plotted on the basis of data obtained from the company. It is maintained on daily basis. The machine breakdown problems are noted and the method of replacement and the cost spent for the machine repairs, components repairs and replacements are obtained.
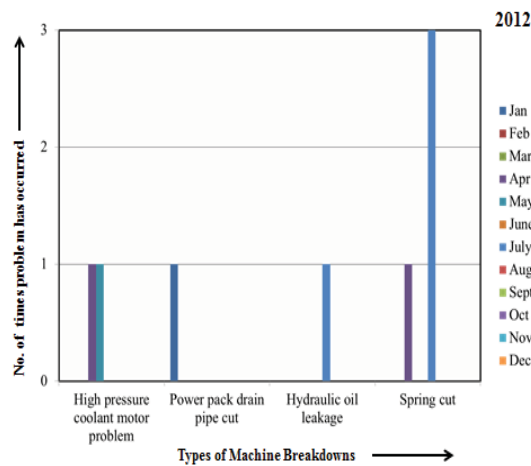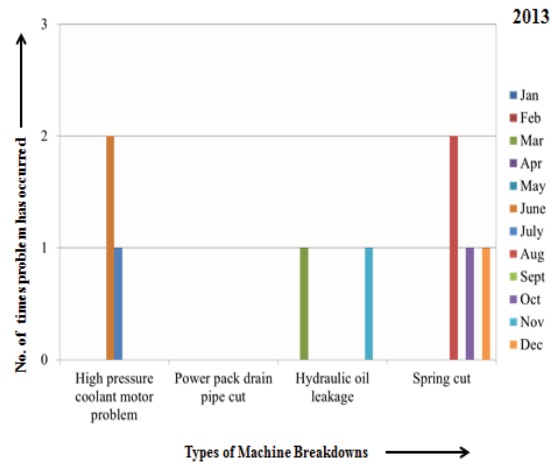
Figure 2.3: Graph showing the number of times the problems have occurred in 2012

Figure 2.4: Graph showing the number of times the problems have occurred in 2013

No. of times the problem has occurred

	High Pressure Coolant Motor Problem	Power Pack Drain Pipe Cut	Hydraulic Oil Leakage	Spring Cut
2012	2	1	1	4
2013	2	0	2	4
Total	4	1	3	8

Total Cost (Rs.)

	High Pressure Coolant Motor Problem	Power Pack Drain Pipe Cut	Hydraulic Oil Leakage	Spring Cut
2012	1750	450	700	16500
2013	13650	350	3850	4200
Total cost	15400	800	4550	20700

Table 2.1: Table showing the number of times the problems have occurred in 2012 & 2013, the total cost spent for maintenance

From the above tables we get to know that the most times occurred problem is the spring cut problem and the cost overall considering of the two years, most is spent for the spring cut problem itself, hence, we have considered the spring cut problem itself.
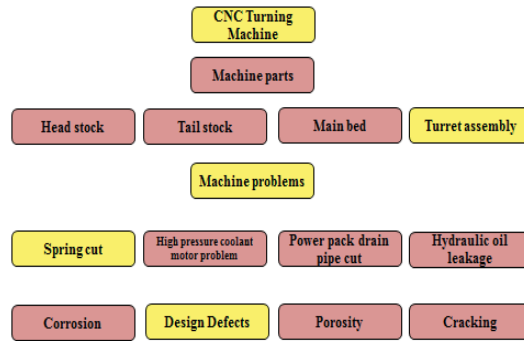
Framework

Figure 2.5: Framework of the project

III. FAILURE MODE & EFFECT ANALYSIS (FMEA)

[10]FMEA is an analytical technique (a paper test) that combines the technology & experience of people in identifying foreseeable failure modes of a product or process & planning for its elimination.

"It is a before-the-event action requiring a team effort to easily & inexpensively alleviate changes in design & production".

Functions of FMEA are:

•   Recognize & evaluate the potential failure of a product or process & its effect

•   Identify actions that could eliminate or reduce the chance of potential failures

•   Document the process

There are several types of FMEA: design FMEA, process FMEA, equipment FMEA, concept FMEA, service FMEA, system FMEA, environment FMEA and others. However, for all intents and purposes, all of the types can be broadly categorized under either design FMEA or process FMEA. For instance, equipment, service and environmental FMEA are just slightly modified versions of process FMEA and system FMEA is a combination of design and process FMEA.

CNC TURNING CENTRE								
Element	Function	Failure mode	Internal cause	External cause	Effects on M/c	External indicator	Observable effect	Internal indicator
Spring	Retracting the turret	Spring cut	Corrosion	no	Sudden breakdown	Sound indication	Defects in machining	Sensors
Spring	Retracting the turret	Spring cut	Porosity	Heavy load	Damage to the turret and process Breakdown	Stopping of machine	Effect on the process	Sensors
			Cracking			Clashing of the cut spring with other parts	Damage of other parts	Sensors
			Design defect			Slow down of the turret	Cycle time reduced	Sensors

Table 3.1: Failure Mode and Effect Analysis table for the problem identified.

IV.   SIMULINK MODELING

Simulink is a software package for modeling, simulating, and analyzing dynamical systems. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two. Systems can

also be multi rate, i.e., have different parts that are sampled or updated at different rates. For modeling, Simulink provides a graphical user interface (GUI) for building models as block diagrams, using click-and-drag mouse operations. With this interface, we can draw the models just as we would with pencil and paper. This is a far cry from previous simulation packages that require us to formulate differential equations and difference equations in a language or program.

By Newton's II law;

The relationship between an object's mass m, its acceleration a, and the applied force F is F = ma. Acceleration and force are vectors in this law the direction of the force. Vector is the same as the direction of the acceleration vector.

We have,

$F = m*a$ ------ (4.1)

$M. (d^2x/dt^2) = F_t – K(x-x_0) –C. (dx/dt)$ ------------ (4.2)

$d^2x/dt^2 = 1/M (F_t – K(x-x_0) –C. (dx/dt))$ ------------ (4.3)

Where,

F: Force acting on the spring (N), it is 100N for all three cases

M: Mass (kg), it is 14717.5N ≈ 1.5*10^3kg for all three cases

C: Coefficient of viscosity (), it is 0.01N-s/m for all three cases

x_0 : Initial deflection of spring (m), it is 12*10^-3m for all three cases

[11]Integrating the above equation twice; we get the values of x (displacement of turret)
And the same is obtained by using the Simulink modeling;

Case I:

In this case, the stiffness of the spring is in the initial condition and its value is K=650000N/m. with the normal stiffness the spring is capable of handling the workload in a correct position and accordingly the turret movement is occurring and hence the movement of the turret assembly is normal and thus there is proper move towards the chuck with the toolholder. The normal movement of the turret is represented graphically as shown below. The graph is obtained from the Simulink modeling.

Case II:

In this case, the stiffness of the spring is in the reduced condition and its value is K=35000N/m with the reduced stiffness the spring is not capable of handling the workload in a normal position, so the speed of the movement is reduced and accordingly the turret movement is occurring and hence the movement of the turret assembly is slow down and thus there is some delay in the move towards the chuck with the toolholder. The movement of the turret is represented graphically as shown below. The graph is obtained from the Simulink modeling.

Case III:

In this case, the stiffness of the spring is totally lost and its value is K=0N/m with the no stiffness, the spring is unable of handling the workload in a normal position, so the turret movement is stopped and accordingly there is break between the machining process and thus there is some delay in the work and the machining process. The movement of the turret is represented graphically as shown below. The graph is obtained from the Simulink modeling.
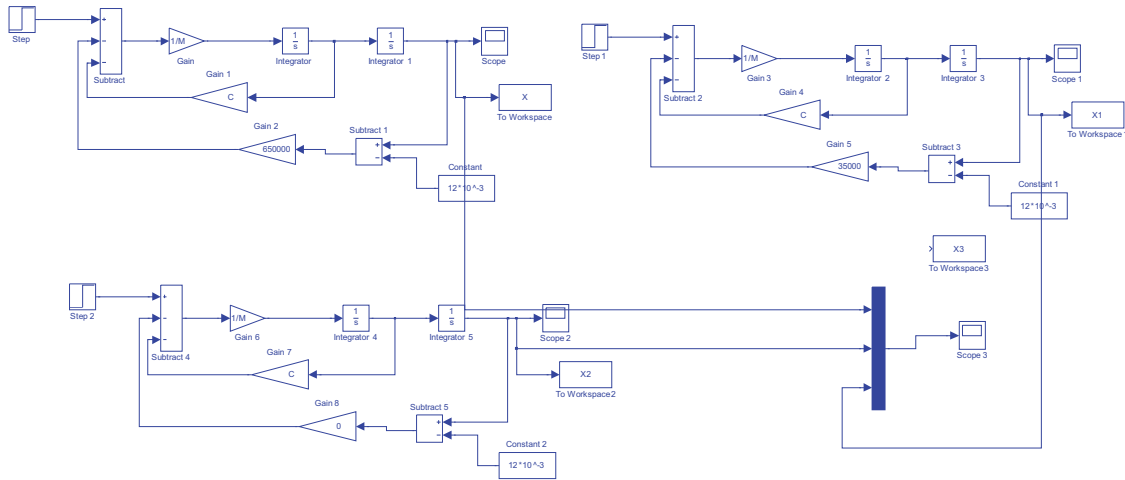
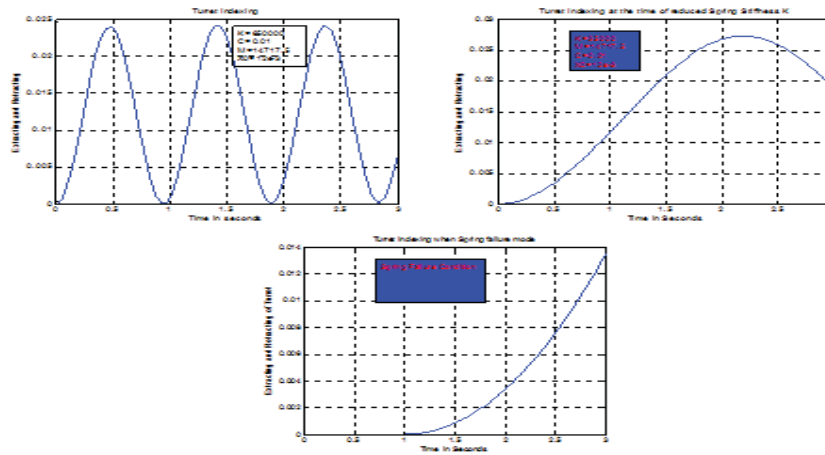Figure 4.1: Simulink Modeling for the spring cut problem

Figure 4.2: The position of the turret based on the three cases considered above(display is in Simulink modeling)
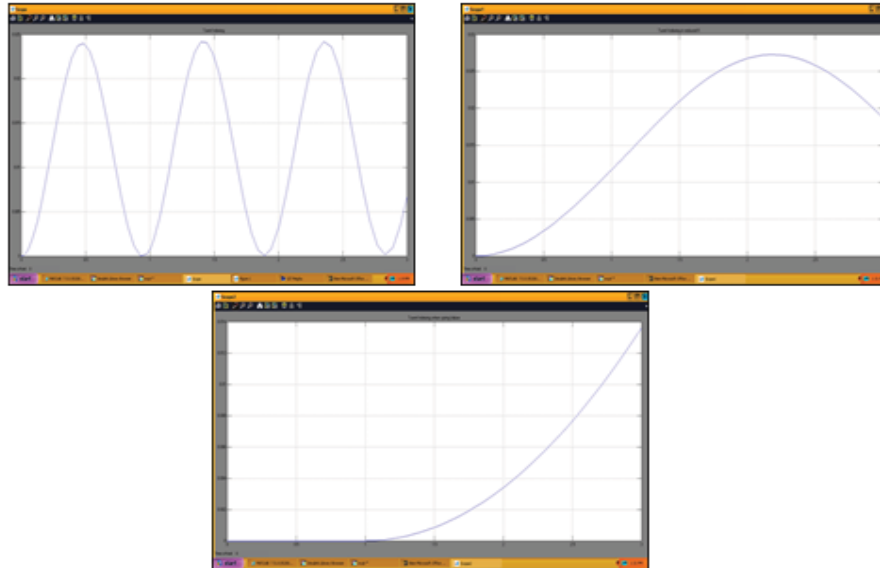
Figure 4.3: The position of the turret based on the three cases considered above(display is in Matlab Workspace plotting)
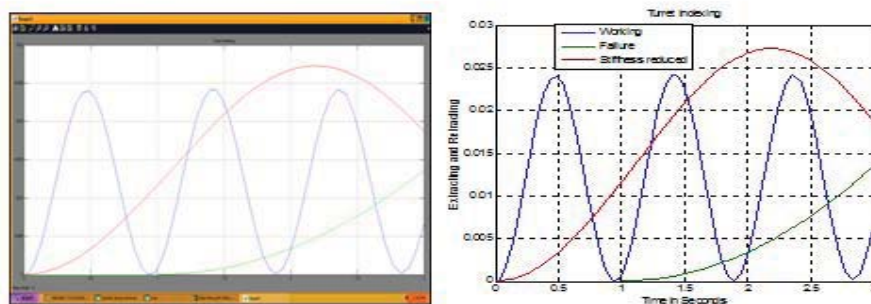

Figure 4.4: The positions of the turret based on the three cases considered above(display is in Simulink modeling, together)

V. KNOWLEDGE BASE

   In this project work, as focused on the spring problem, the reasons considered for the failure was may be due to: corrosion, porosity, cracking and design defect. The first three are the reasons which cannot be controlled so easily or it can be changed with their material properties, coolant supply or the total load applied hence only chance is of changing the design of the spring. So considering this we have suggested the knowledge base as the spring with C-clamp. Instead of replacing the whole spring part, only at its ends the clamp can be provided.

- Corrosion, as there is continuous supply of the coolant it is difficult to control

- Porosity, as it depends on the material property according to manufacturers

- Cracking, as the amount of load applied can't be reduced so not easy to control

- Design defects can be controlled & changed

- So spring with the c-clamp is provided

- Hence with this, further problem due to spring cut can be sort out easily using the knowledge based (expert advice) provided

• Time & cost are saved

Figure 5.1: Spring with C-clamp

REFERENCES

[1] S.Sadagopan, "Management Information System", 10th Edition, Pg. No:146-170
[2] R.V. Raman and K.V.K. Prasad 'Applications of Knowledge Based Systems in Mining Engineering' Proceedings of the Twentieth International Symposium on the Application of Computers and Mathematics in the Mineral Industries. Volume 1: Mining. Johannesburg, SAIMM. 1987. pp. 167 - 180.

[3] K P Tripathi, "A Review on Knowledge-based Expert System: Concept and Architecture" Bharati Vidyapeeth Deemed University Institute of Management Kolhapur, India, IJCA Special Issue on "Artificial Intelligence Techniques - Novel Approaches& Practical Applications" AIT, 2011
[4] Bruce E. Berzonsky 'Knowledge-Based Electrical Diagnostic System for Mining Machine Maintenance', IEEE transactions on industry applications, vol. 26, no. 2. March/April 1990
[5] Dieter Wach 'Experience with Knowledge–based systems for maintenance diagnosis', control systems, robotics and automation-Vol.XVI.
[6] P-H. Speel [1], A. Th. Schreiber [2], W. van Joolingen [2], G. van Heijst [3], G.J. Beijer [4] , "Conceptual Modeling for Knowledge-Based Systems", Unilever Research Vlaardingen, 2 University of Amsterdam, 3 CIBIT, 4 Bolesian
[7] John Mylopoulos[1], Vinay Chaudhri[2], Dimitris Plexousakis[3], Adel Shrufi[1], Thodoros Topaloglou[1], "Building knowledge base management systems", Edited by Gunter Schlageter and H.-J. Schek. Received May 19, 1994 / Revised May 26, 1995 / Accepted September 18, 1995
[8] Amos Gilat, "MATLAB, An introduction with applications", original edition, pg. no : 1-5
[9] R.C. Mishra, "Maintenance Engineering and Management", 3rd Edition, Pg. No.:1-14
[10] Bester field, "Total Quality Management", Pearson Education, 2011. ISBN,   Pg. No.: 134-140
[11] S.Ponnusamy, "Physics, Higher Secondary for I year", Volume I, Pg. No.: 14-16