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DEVELOPING AN INTEGRATED MAINTENANCE METHOD

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Lucrarea propune integrarea mentenanței în sistemul de fabricație cu cel puțin două mari avantaje: acordarea parametrilor modelului permanent în funcție de evoluția sistemului şi simularea în timp real, ceea ce face ca deciziile să fie cât mai corecte. În acest context am conceput şi am elaborat o metodologie de urmărire a comportării în funcționarea echipamentelor de producție cu mai multe axe comandate numeric, care asigură culegerea datelor prin testări efectuate la intervale de timp determinate, prelucrarea primară a acestor date, modelarea statistică a legilor de evoluție a comportării în funcționare şi identificarea strategiei optime de mentenanță pentru eficientizarea sistemelor de fabricație.

The paper proposes the integration of maintenance system in manufacturing with at least two major advantages: the adjustment of manufacturing parameters based on the evolution in real time and simulation of the system and support decisions making them as fair as possible. In this context, we designed and developed a methodology for service performance monitoring of multiple axis CNC production equipment. This methodology is based on collecting data from tests carried out at time intervals, processing the data, statistical modeling of in operation laws, identification of the evolution of behavior and optimal maintenance strategy for efficient manufacturing systems.

Keywords: maintenance, production, software

1. Introduction

The increasing complexity of production systems has a major impact on the maintenance function. In recent years, there has been a continuous development of methods and tools to improve availability, reliability and maintainability of production equipment [3].

Measurement of displacement errors in CNC machine tools by standard circular test provides information on actual measured values and approximation errors of a generic form such as circle or ellipse. The standard does not contain references to the resources used to obtain measurements, only on the experimental data acquisition and processing methods. Different tools have been developed to measure interpolation errors like: Fixed Magnetic Ball Bar (FMBB), Telescoping

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Magnetic Ball Bar (TMBB), Double Ball Bar (DBB), Laser Ball Bar (LBB), 3D Laser Ball Bar (3DBB), encoder Grid, Vector Bar, Laser Tracer. Typical models used for interpreting the source indicating the motion error. The results of these measurement tests provides us with data on the corrections needed to increase accuracy in numerical control processing.

The paper proposes a method for measuring and monitoring the performance of maintenance functions implemented directly on the numerical control system technology. The approach is based on a functional analysis of the maintenance function by controlling the displacement errors in tool path generation (linear and circular) [3]. This will lead to improvement of machining accuracy by setting the correction functions and a database that will allow us to develop a methodology for diagnosis of system health and maintenance strategy. Methodology for in-service performance monitoring of manufacturing systems is materialized in a way that integrates the maintenance of CNC equipment.

2. Presentation of the theoretical support

The maintenance of technological systems has two areas that partially overlap (Fig. 1): an area of design and development, which determines the intrinsic availability, determined by the manufacturer and a service area, which determines the operational availability, influenced by the user [1]. If the product (machine - tool, technological system) is not designed with increased durability, the operating costs greatly increase whatever policy the user adopts and however they organize maintenance activities.

Therefore we have focused our research on areas which need to be visible to the user. Thus, by attaching an integrated maintenance method of a numerical control machine tool, either used or new, the operator must use a compliant maintenance strategy by assessing the reaction of the mechanisms from the kinematic chains. This requires an analysis of the kinematic features of machine tools to collect the necessary information without installing additional sensors.

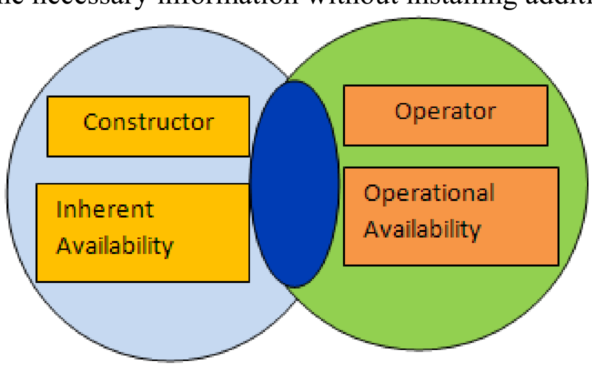

Fig. 1 Constructor and operator availability

The concept of preventive and predictive maintenance, according to which the equipment is functioning safely until it reaches a certain level of wear or a failure occurs, is most recommended from several angles: availability, cost, production planning, provision of spare parts for interventions [3]. Operating within this system, the equipment will be stopped at an early date before it breaks down and repairs will be made where necessary [1]. Preventive and predictive maintenance system allows early detection, fault and ware location and identification, and calculation of the remaining useful life of the equipment. In this way it is possible to plan and prepare of the intervention, intervention personnel, order the necessary parts to minimize repair duration, so clearly minimizing the maintenance costs.

To be in this convenient situation, we should keep in mind that the technical condition of operation of a machine can be assessed on the basis of "symptoms" that are exhibited during use: vibrations, noise, high temperatures in bearings, temperature variation and pressure in the cooling circuit, etc. (Fig. 2) [2]. This information can be collected by sensors and transducers via an interface for data acquisition, processed and interpreted with special software.

Making a tree analysis of problem-cause-solution (Fig. 3) we reach an innovative perspective on the concept of maintenance for machine tools as an integrated maintenance mode by controlling the precision of movement of the mobile elements [5].

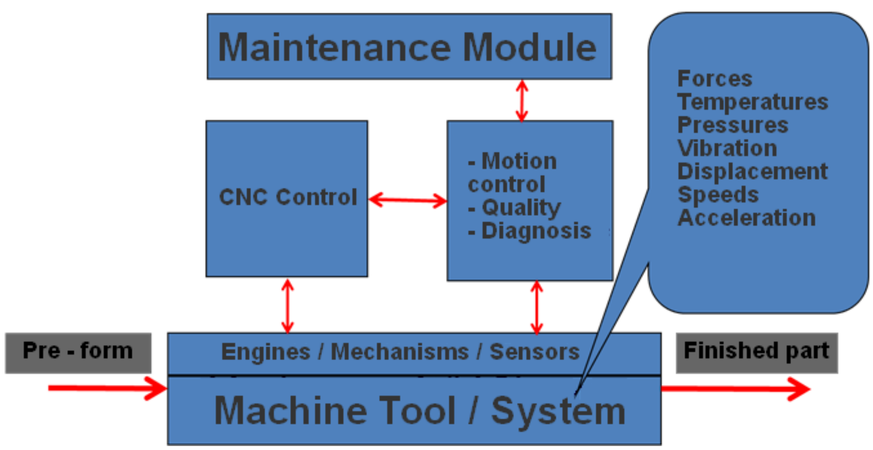

Fig. 2 General overview of machine tool and maintenance

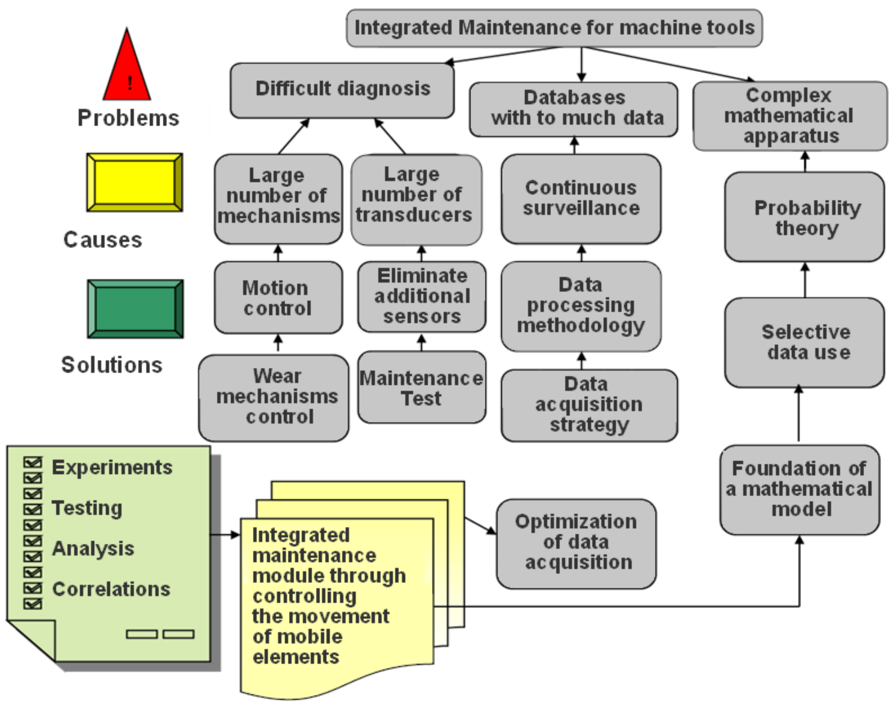

Fig. 3 Problem – Cause – Solution tree

1. Design of the integrated maintenance module – TestMen

This module was specifically designed to integrate a part of the maintenance functions in the machine tool behavior in software form.

The graphical interface of the module TestMen includes the definition of subsidiary modules and calling functions related to maintenance (Fig. 4).

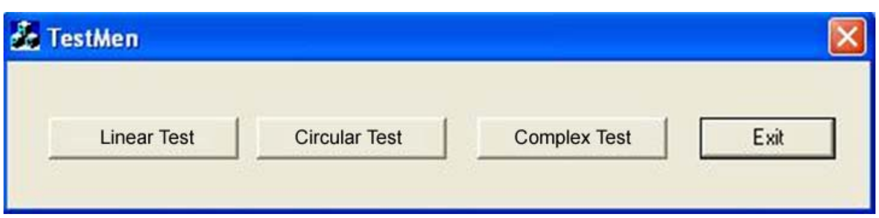

Fig. 4 General TestMen Interface

This module allows:

- editing and generating controller programs;
- testing the displacement of the machine tool's function according to types of tests;

- data acquisition;
- draw graphs;
- data processing and deciding maintenance strategy.

At the start of the module, depending on the type of test we want to do it on the machine-tool, visualize or data process, we can choose linear test, circular test or complex test. Freeform complex type test generates complex trajectories to refine the machine tool parameters. Fig. 5 shows the class diagram.

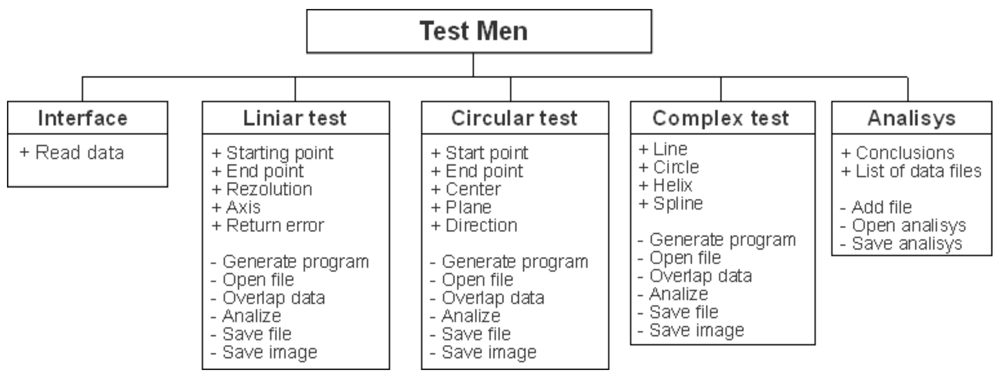

Fig. 5 Class diagram

The data acquisition interface can work in different ways depending on the instrumental used to measure. In the case of DBB, LBB, grid encoder, they come with their own interface or a board that has to be installed on your computer. Interface can be also directly made so you receive data on the serial port or USB port.

To define a linear test (Fig. 6) it is needed to select an axis, define the coordinates on the other two axes and then block them. We consider a test portion or the whole length of the axis and chose the type of return to be verified. After generating the CNC program we put it on machine-tool and run the test measuring the displacement. After we finish the test we can analyze the data, check and compare with other measurements or save the data to be used in the analysis.

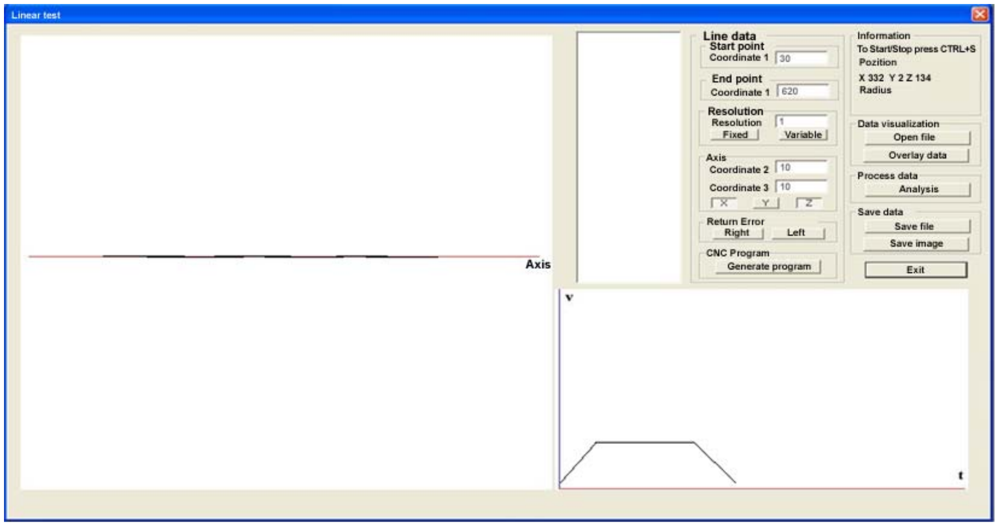

Fig. 6 Linear test interface

To define a circle test (Fig. 7) first we chose the working plane (XY, XZ or YZ), then the direction and three points in the plan (starting point, end point and center). After generating the CNC program we put on the machine tool and run the test measuring the displacement. After we finish the test we have the same possibilities as in linear test, analyze the data, check and compare with other measurements or save the data to be used in the analysis.

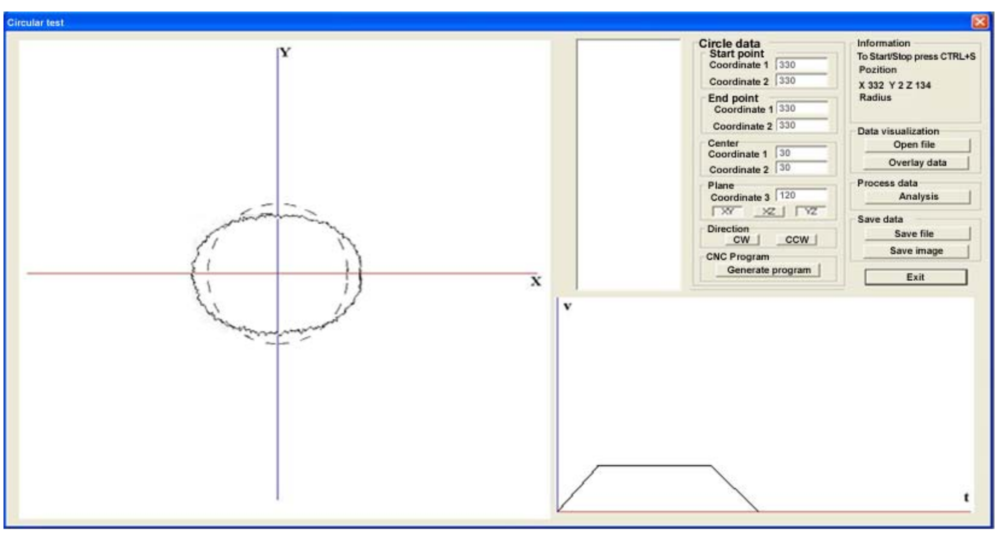

Fig. 7 Circular test interface

On the analysis interface (Fig. 8) first we add files containing data from measurement tests on the machine-tool, and then add notes from observations, conclusions and parameter values to be adjusted. We can also consult an earlier analysis or save it this analysis to be viewed in the future.

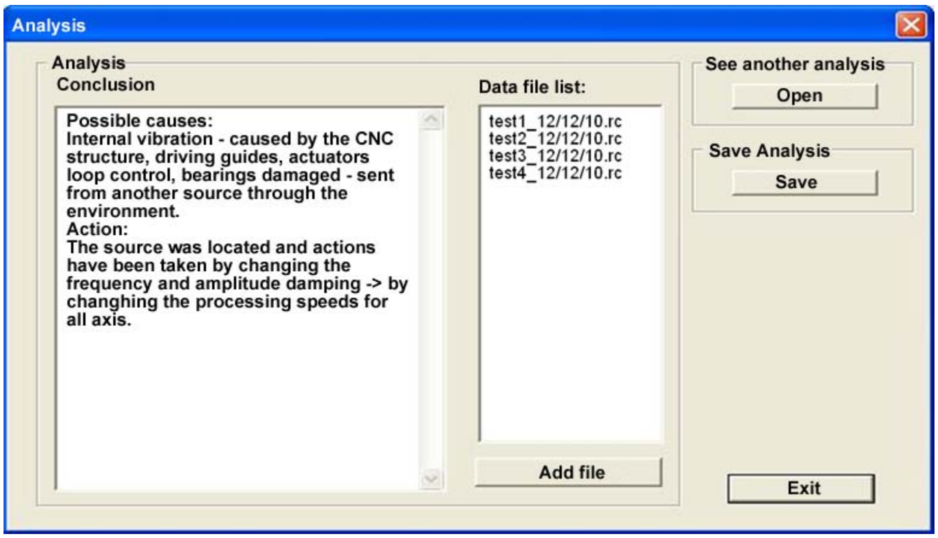

Fig. 8 Analysis Interface

2. Criteria for selecting the maintenance type

Fig. 9 shows the algorithm for selecting the type of maintenance for machine tools that have integrated maintenance module [4]. It is noted that for the establishment of maintenance strategy we are using the following criteria:

- the impact of wear on the processing capacity of the machine tool;
- adjusting the state of the machine-tool to the production needs [4];
- cost of intervention;
- the use of surveillance techniques based on the fact that failure does not occur instantaneously, but is progressive and can be detected;
- cost of equipment supervision techniques.

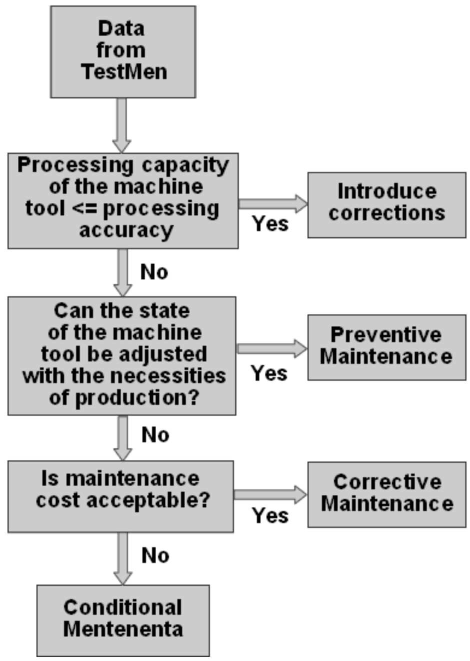

Fig. 9 Selection algorithm

Data acquisition through TestMen module allows the determination of the processing capacity (C_u) of each machine tool and also helps asses the possibility of manufacturing parts with a certain precision (P_r).

The efficiency of maintenance activities depends on the type of maintenance and of the strategy adopted to conduct interventions. Thus, after calculating the working capacity of the machine tool, taking in consideration the degree of wear we can determine the possibility to manufacture parts with a certain precision. We may be three cases:

a) C_u much greater than P_r, the cause may be that adjustments were made overstressing the mechanisms of cinematic chains leading in an increased wear. In this case we recommend changing the destination of the machine tool (for parts that require higher accuracy) or a maintenance intervention to adjust and relive the stress for easier travel.

b) C_u greater than P_r for ensuring the accuracy of processing. Ideal case when the machine tool fits its purpose.

c) C_u is less than P_r. To meet production requirements the machine tool must be initially calibrated and corrections must be adjusted from the calibration of kinematic chains, and if the result is not satisfactory maintenance strategy should be adopted.

If we consider the following types of maintenance (Fig. 9):

- preventive maintenance which includes replacement of critical component when the machine tool reaches a certain age *v* or when it fails before reaching the age *v*. It is recommended to plan interventions to reduce play (adjustments, tensioning, changing the lubricant, etc.) and the use of processing regime to allow completion of planned production [2].
- corrective maintenance, replacing the only critical component when they fail. It is the worst case with negative implication in production, with a high consumption of resources, material and time and it is done with extensive cost.

5. Conclusions

Using the kinematic behavior analysis method, that we propose and the module TestMen to test the equipment, the analysis results in:

- Identifying the degree of wear of the components of the feed cinematic chain almost entirely based on the accuracy of processing of the machine tools;
- Determination of the processing capacity of the machine tools;
- Implementing an optimal maintenance strategy adapted to the needs of production;
- Minimizing the access time to maintenance-specific information thus optimizing the use of human and material resources;
- Quick access to information and with minimal effort because the product TestMen provides timely information execution and data processing;
- Real-time management of interventions reducing the number of trips of the production and maintenance reducing costs;
- Knowledge and use of specialized personnel experience;
- Reducing maintenance costs through total control of the state of the machine tool. Through control two equally important objectives can be achieve: to compare the results with standard deviations and apply corrections, on the one hand and involvement - motivating employees to involve more;
- Documenting the breakdowns occurred in the operation of the machine (the location and nature of failure, information about the failure, symptoms, consequences, causes) determines the realization of maintenance activities with top quality, reduces costs and thus increases efficiency in production;

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