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CONCERNING THE MATLAB GUI TO SET THE PREVENTIVE MAINTENANCE PROGRAM OF THE MACHINERY FOR A GIVEN PRODUCTION SYSTEM

BY

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Abstract. This paper deals with a Matlab GUI, based on the computation algorithm which allows sizing of a given production system taking into account the ordered production and the technical information from manufacturing documentation of the product. In the same time, the GUI allows to establish a scheduled preventive maintenance program, having information concerning the machinery condition during the manufacturing program. The developed GUI is applied for a lathe as the selected machinery and the maintenance program is established for the electrical motor which is the key component of this. The output data can be saved in the data files or can be displayed on the interface window.

Key words: GUI Matlab; preventive maintenance program; electrical motor.

1. Introduction

In the references from the specialized field are widely presented and compared two important maintenance techniques (Romaini & Shahrul, 2012): TBM- time-based maintenance and CBM condition-based maintenance. TBM is the maintenance performed on machinery/equipment based on a calendar schedule. Accordingly, the time is the maintenance trigger for TBM. This

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means that it can be used with both a predictive maintenance and preventative maintenance program (<https://www.fiixsoftware.com/...>). The predictive maintenance predicts when equipment failure might occur, and prevents the occurrence of the failure by achievement a maintenance procedures. The predictive maintenance allows to diminish the maintenance frequency to prevent unplanned maintenance, without increasing the costs associated with preventive maintenance: a) minimizing the time the equipment is being maintained, b) minimizing the production hours lost to maintenance, c) minimizing the cost of spare parts and supplies (<https://www.fiixsoftware.com/...>).

Preventive maintenance is the maintenance which is usually performed on a equipment component so that the probability of failure is decreased. The flexibility of preventive maintenance is given by: working on a fixed date, or on a variable time period, which means the maintenance procedure is based on a operation parameters measurements. The preventive maintenance schedules should be automatically adjusted depending on the works which were earlier done or depending on the date they were made. Condition-based maintenance is a maintenance program which monitors the machinery condition to decide what maintenance procedure needs to be made. Compared to preventive maintenance, CBM is performed only if it was noticed a decreasing of the parameters level of the condition equipment.

In the same time, CBM increases the time between maintenance repairs, because maintenance is done on an as-needed basis (<https://www.fiixsoftware.com/...>). Preventive maintenance is based on the active or time-based verification of some functionalities of the machinery/equipment during the production process or the verification of the level of some working parameters. This includes *e.g.*: the measurement of the vibration level and temperature, checking the pressure level or the work loads, checking of wear or disruption of components, controlling of corrosion or erosion, chemical analysis (*e.g.* lubricating agents) etc.

All these measurements and control methods are the purpose to perform maintenance program and thus prevent defects and dismantle of equipment. Therefore, it has the effect the increasing of the equipment lifetime, while maintaining the required level of the economic indicators. Otherwise, the effective operating time of the equipment will be reduced and consequently the production will be reduced.

Regarding to a maintenance program of a lathe, analyzing the electric diagram from (<https://www.google.com/...>) it can be noticed that the most important component is the electrical motor. The conventional lathes are driven by the electrical motors with constant speed; a pulley system is used to select one of several operation speeds. In the paper (<https://sawmillcreek.org/...>) are presented the disadvantages of this kind of lathes, such as: compatibility problems in the lathe interface corresponding to the customer requirements. But the progress in the power semiconductors electronics and microelectronics have

made possible to use AC motors. The last new type of motors, switched reluctance motor, represents an opportunity for the all industrial applications. The using of switched reluctance motor will improve the quality and lathe marketability. Any industrial factory must have in view the main purpose to maximize the maintenance effectiveness. One of the ways to do that is to determine the optimum preventive maintenance schedules by electronically creating and assuming work orders and performing condition monitoring.

An appropriate maintenance program of an electrical motor involves the correct understanding of testing methods or techniques which must be done by the qualified operators. Typical actions should be done with the motor installed and coupled to the driven load: a) with the motor installed and in functioning, b) with the motor installed and off line. The maintenance activities can be, according to (<http://www.apta.com/...>, 2017; Barnish Timothy & Muller, 2009): visual inspection, measuring of temperature in bearings and windings, vibration measurements, with a period of time of 6 months. For the electric motor with which is equipped the lathe, the maintenance procedures must be done at a 6 months period of time, which means 1,050 operation hours. In the national normative in force are recommended 1,100 operation hours between two maintenance procedures (technical revision, current repairs or overhaul).

After a period of time of 26,400 operation hours an overhaul is recommended to be done. That means: stator/rotor inspection, shaft inspection, electrical resistance of windings, surge test which means checking the insulation conditions between two turns of motor windings, rotor balance, core losses, checking the rotor bars (if are broken). Additionally, cleaning works are carried out (water spray, low pressure steam or cryogenic cleaning).

Further information is presented in (Barnish Timothy & Muller, 2009). It is important to point out that all electrical procedures of preventive maintenance must be realized by meet the standards in force. If the lathe is equipped with the variable speed drive system, three main component must be subject to the maintenance procedures: rectifier circuit unit, DC circuit unit and inverter circuit unit. According to (<http://www.newark.com/...>), the troubleshooting a variable frequency drive is always a challenge. The variable frequency drive consists of a complicated combination of electric power components and sensitive electronic circuits. The four steps of testing are mentioned: a) checking the input rectifier, b) checking the variable speed drive output, c) checking the DC bus capacitors, d) checking the internal power supplies.

2. The Program Description

The developed Matlab GUI is based on a computation program whose design algorithm corresponds to the Flux Diagram, which is presented in Fig. 1.

The input data are: the value of the ordered production, specific to the manufacturing structure of the production system, number of working shifts,

machinery number and their specifications, D_{os} – the standardized operating hours between two types of maintenance procedures, data files concerning the machinery condition, previous maintenance reports.

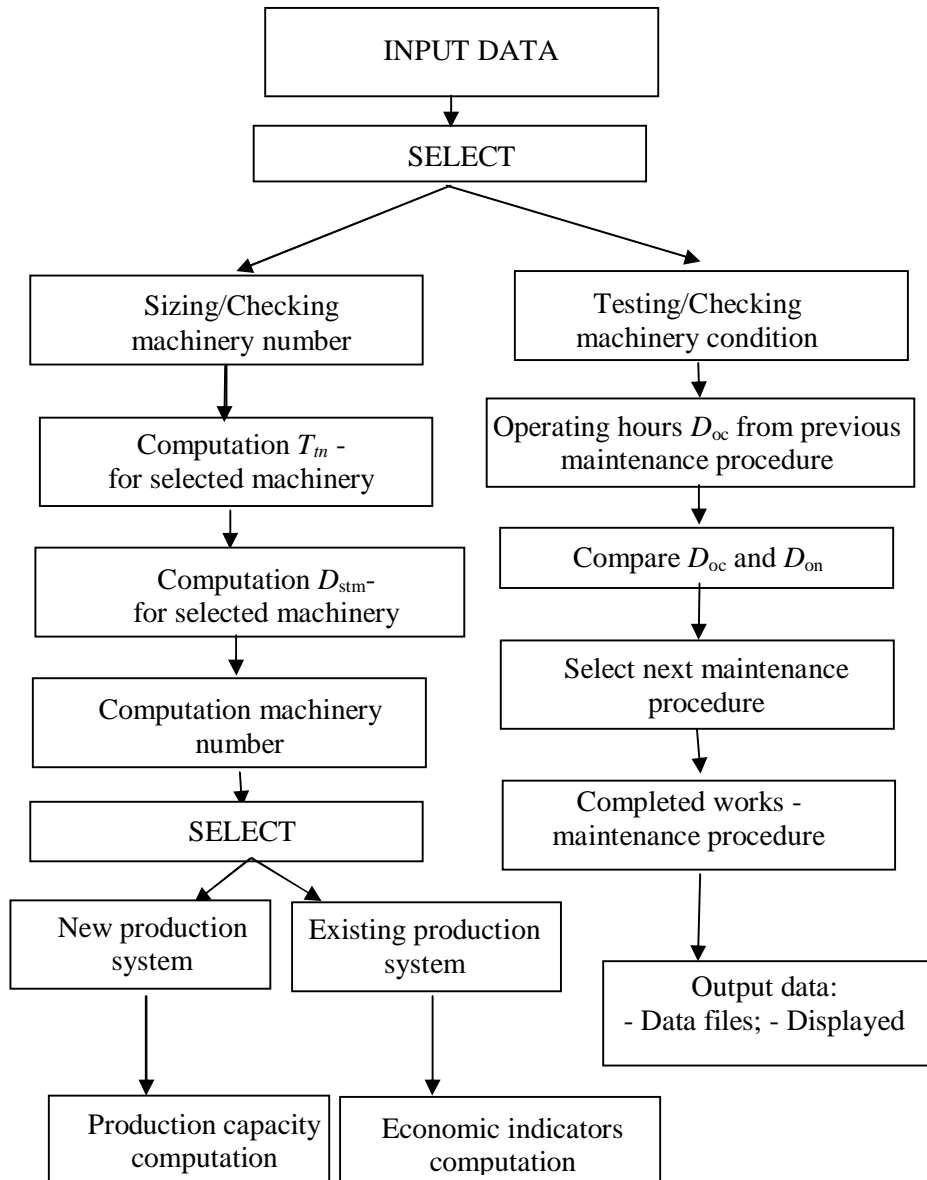


Fig. 1 – Flux Diagram - Computation algorithm.

The computation program allows to select: a) the sizing/checking of the machinery number, according to the manufacturing documentation, which are required by the ordered production and b) testing/checking the machinery condition.

The first part of the program is important to properly decide on the increasing or decreasing of the ordered production required by the customer. The basic technological facilities can be designed based on the information from the technological documentation, such as type of machinery, normalized time per technological process, technological auxiliary time.

Accordingly to the manufacturing documentation of the ordered product or production task, the total normalized time per technological process T_m of the selected machinery is computed. To compute the machinery number (Brojboiu & Ivanov, 2015; Brojboiu & Ivanov, 2003), required by the manufacturing of the ordered production in a period of time *e.g.* one year, it is needed to determine the total time of maintenance procedures, taking into account the approach of the preventive maintenance program.

In case of technical sizing of new production system, the maximum ordered production or production capacity as well as the degree of utilization of production capacity, the capacity reserve and efficiency index of working time are calculated.

In case of selection one existing production system, the computed number of machinery or equipment N_{uc} is compared with the number of existing technology equipment. After that, the decision to increase the ordered production or the acquisition of new equipment can be taken. The second part of the computation algorithm allows to checking/testing the selected machinery condition.

That means information concerning the number of operating hours since the last maintenance procedure, the technique report of the operators who performed the last maintenance intervention, the results of the parameters measurements.

As a result of a comparison between the working time since the last maintenance intervention with the normalized operating time D_{on} it is automatically decided on the next maintenance procedure. The output data can be displayed on the graphical interface or can be saved as the file data using the Matlab procedure. The main window of the developed GUI is presented in Fig. 2. As it is noticed, the computation of the required machinery/equipment number is selected.

In the next GUI window, from Fig. 3, if the lathe is selected machinery for a ordered production $Q = 3,000$ pieces/year, are computed and displayed: the needed number of lathes, the number of the maintenance interventions, the estimated of production capacity, the efficiency index of lathe available time. The same parameters can be computed for any other selected machinery, which are requested by the manufacturing documentation of the ordered production.

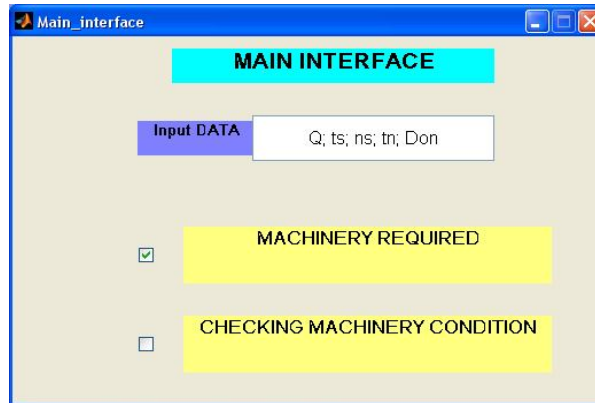


Fig. 2 – The GUI main window.

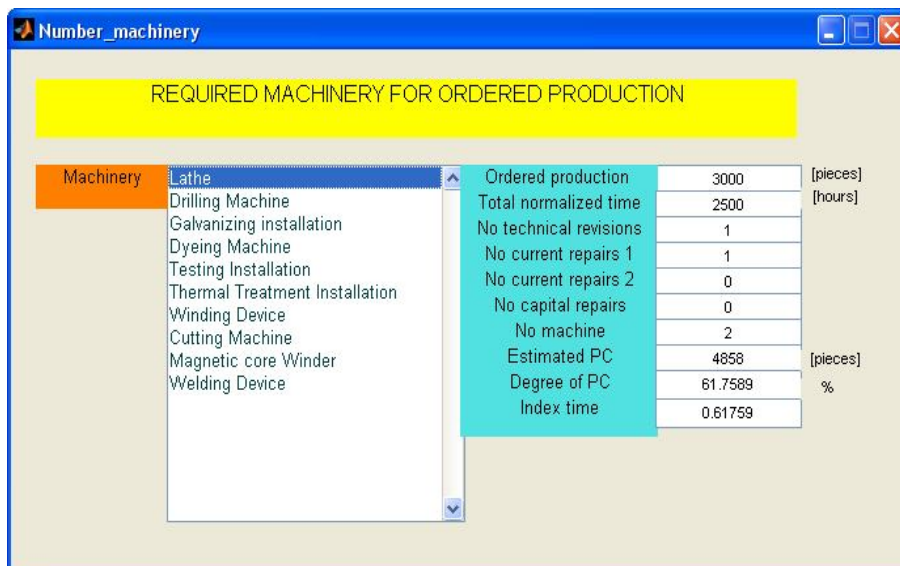


Fig. 3 – The interface window to compute the number of lathes.

For the same case of lathe, if in the main GUI window, it is selected “Checking machinery condition”, the interface window is open as it is shown in the Fig. 4.

Taking into account that the drive electrical motors from electric diagram of lathe are most important component, it is displayed the maintenance program for checking the thermal condition of windings and bearings, motor vibrations, insulation of windings through measurement of insulation resistance and finding of possible failures of the insulation.

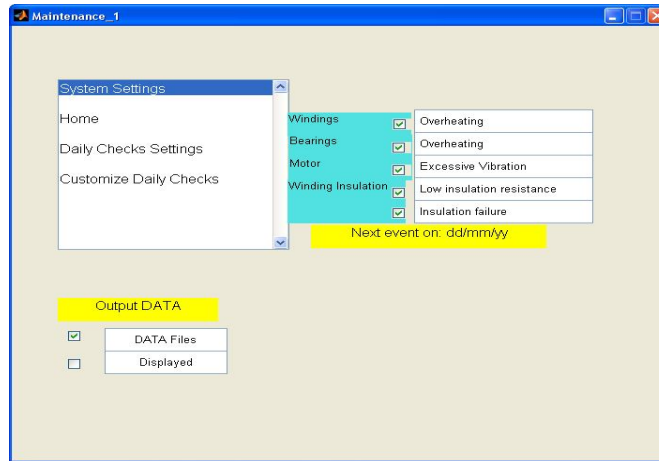


Fig. 4 – The interface window corresponding to the machinery condition checking.

By analyzing all made observations the data of the next maintenance procedure is displayed, The measured data and specifications regarding the motor which is subject to the maintenance procedure are saved in the data files using the Matlab application or are displayed on the interface window according to the made selection.

If it is chosen displayed output data, several output data can be noticed from the interface window, presented in Fig. 5.

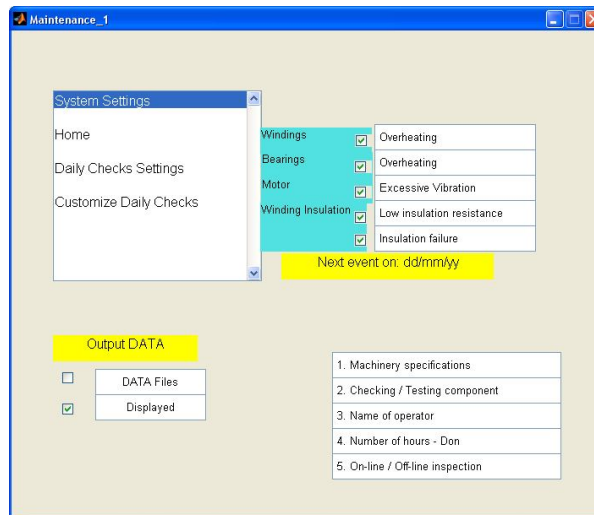


Fig. 5 – Interface window – displayed output data.

The Matlab GUI can be applied for any other machinery/equipment and the automatically maintenance program can be improved to be applied for any component of the selected equipment or for the other type of drive motor.

3. Conclusions

In this paper a GUI based on the Matlab application is presented. The computation algorithm allows selecting: the computation of the machinery number based on the manufacturing documentation of the product or to decide on the preventive maintenance scheduled program. In the last one case, based on the input data concerning the machinery condition during the ordered production manufacturing, the maintenance procedure can be established, as well as the data of next maintenance event. The GUI is applied to compute the number of lathes needed for manufacturing of a given Q ordered production; in the same time the GUI is applied to establish the next maintenance event of an drive electrical motor of the lathe. The several output data concerning the activities from the motor maintenance program are displayed on the GUI window. This GUI can be improved so that to be applied for many other components of the selected machinery and the number of useful output data can be extended.

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CU PRIVIRE LA O INTERFAȚĂ GRAFICĂ MATLAB PENTRU STABILIREA
UNUI PROGRAM DE MENTENANȚĂ PREVENTIVĂ A MAȘINILOR DINTR-UN
SISTEM DE PRODUCȚIE

(Rezumat)

Articolul prezintă o interfață grafică Matlab, dezvoltată pe baza unui algoritm de calcul care permite dimensionarea unui sistem de producție dat, ținând cont de valoarea producției comandate și a informațiilor din documentația tehnologică a produsului. În același timp, interfața grafică permite stabilirea unui program de mentenanță preventivă planificată, având informații cu privire la starea utilajului în timpul programului de fabricație. Interfața grafică este aplicată pentru cazul în care utilajul selectat este un strung iar programul de mentenanță preventivă este stabilit pentru un motor electric, care este componenta cheie a acestuia. Datele de ieșire pot fi salvate în fișiere de date sau pot fi afișate pe fereastra de lucru a interfeței grafice.

