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Designing and Prototyping Record System for Machine Usage Time

Antonia Karima Yanti and Erwin Sitompul
Study Program of Electrical Engineering, President University, Bekasi 17550, Indonesia
Corresponding author: sitompul@president.ac.id

ABSTRACT

Machine cost is one of the components of production cost. Accurate record of machine usage time is thus crucial to obtain accurate production cost calculation. Besides, machine usage time can be used as parameter to assess the performance of the machine operator. Furthermore, the data can be used as input to the machine's maintenance and reparation plan. The author is motivated by the current problems found at Akademi Teknik Mesin Industri (ATMI) Cikarang, where it is still possible to use one machine simultaneously by more than one operator. This causes inaccuracy in calculation of machine usage time and production cost. In this paper, the author proposed a design of device to record detailed data of shop drawing and machine usage time. By the use of this device, a certain machine will be activated and deactivated by using RFID technology, with the whole system controlled by Arduino Mega 2560 microcontroller. Furthermore, the shop drawing and machine usage time will be able to be accessed through a Windows-based interface application, implemented by using Visual Studio. A database is also made available by using Microsoft Access. The use of the proposed device makes possible of accurate measurement of production time efficiency and machine operator performance. Through this improved accuracy, further analysis can be made in order to achieve production improvements in planning, process, and maintenance.

Keywords: RFID, monitoring, production

I. INTRODUCTION

Production cost is the sum of all costs of all resources consumed in the process of making a product. The production cost is classified into three categories: material cost, labor cost, and overhead cost. Overhead cost includes machine, energy, and transportation cost. Machine cost is calculated based on the machine usage time or the production time, which is the time required in the making of a product.

Besides to be used to calculate the production cost, machine usage time can be used as performance parameter for an operator on how efficient the operator works. Furthermore, the machine usage time can be used for machine maintenance planning. An extensively recorded historical data of a machine will ease the planning of scheduled or preventive maintenance [1].

In common practice, machine usage time and production time are recorded and calculated manually. This does not consider the time lost due to operator breaks and setting time or preparation time. Thus, manual calculation of machine usage time and production time leads to inaccurate production cost and machine maintenance planning.

ATMI Cikarang already implemented a system to record machine usage time with the objective to obtain reliable reference data for machine cost calculation. The existing system requires every operator to log in his name to a computer in the workshop by using QR code, along with an identification number of the product's shop drawing he intends to work with. The existing system has some drawbacks. Firstly, log in can only be conducted one time for one shop drawing. This is in opposite to most situations where a product cannot be finished directly in one operator session, or, there are changes of operators using the same machine although the product is not yet finished.

Secondly, it is possible that an operator session is over before he completes making the product. At a new session, the machine is then used by another operator working with his own shop drawing. The previous operator, not yet competed his work, cannot log out from the machine, while the new operator already logs in to the machine. This causes simultaneous calculation of machine usage time.

Thirdly, after logging in, an operator needs time to perform initial preparations, walk to the machine, and conduct machine setting. There is significant time interval between the moment when the operator logs in until the moment when the operator activates a fully-ready-to-operate machine. In the current situation, this time interval is calculated as machine usage time, which makes the calculation of machine cost calculation becomes inaccurate.

Due to the reasons mentioned above, as the solution, the author proposed the design of new record system for the machine usage time. The proposed system will be directly connected to the main power supply of the machine. It must

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have a secure identification procedure, by utilizing radio frequency identification technology [2]. Besides, the system must be able to record and display the machine usage time in real-time.

Initially, an operator still needs to log in and chooses the machine he intends to operate. If the machine is available, the operator inputs the identification number of the shop drawing. Using an RFID card, he now has access to activate the main power supply of the machine. Microcontroller Arduino Mega 2560 will be used to read the signal from the machine's main power supply, recording the exact activation time of the machine. This serial data is to be processed and shown in a Human-Machine Interface (HMI) at the main console. The HMI shows what machine is currently in use, to work what shop drawing, done by which operator. By the use of this system, it is expected that the production time, machine usage time, and operator working efficiency can be measured accurately. Eventually, correct analysis and correction regarding the production process can be undertaken.

The proposed record system allows an operator to log in and log out for multiple times while finishing the same shop drawing. Thus, simultaneous usage time record of the same machine for more than one operator is not possible anymore.

II. Block Diagram of The Proposed System

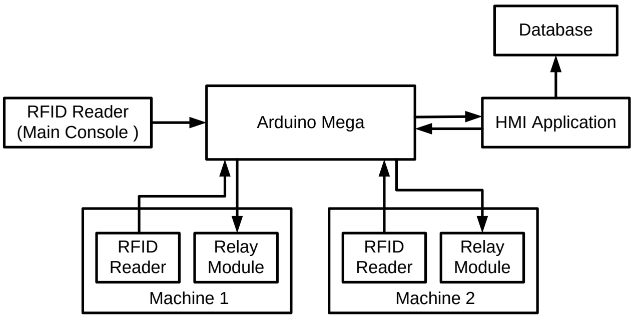

Figure 1 Block diagram of the machine usage time record system

The connectivity of the machine usage time record system is shown in Figure 1. Arduino Mega 2560 is used as microcontroller, connected with three RFID RC522 devices. One unit of RFID reader serves at the main console for operator identification. Every operator is to be given unique RFID card. The other two RFID readers serve at each machine for machine activation. Arduino Mega controls the power supply to the machines via a connection to SRD-05 relay. The relay separates the operating voltages of Arduino Mega (5 VDC) and the one of the machines (220 or 380 VAC).

Besides, the microcontroller is connected via serial communication to an HMI application that will provide user-friendly display on a PC monitor and arrange the writing of database. The database is programmed by using MS Visual Studio and implemented by using Microsoft Access.

This constructed prototype is expected to depict the real-life operating conditions of the machines whether they are in use or not, and how the machine usage time is recorded and calculated.

III. Design Implementation

In this phase, the RFID readers are connected in parallel to the Arduino Mega, as can be seen in Figure 2. The power for the RFID RC522 reader is readily supplied by the Arduino Mega. Through different pin for serial data connections, the status of each reader can be exactly identified.

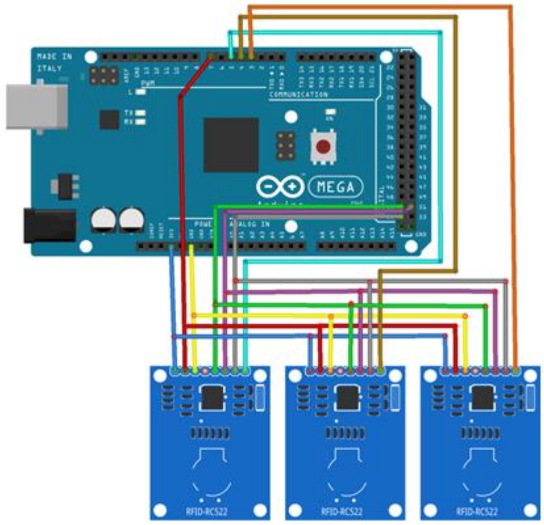

Figure 2 Connections of RFID readers to Arduino Mega

The connections of the relays to Arduino Mega are shown in Figure 3. As can be seen in the figure, two buttons are installed, referred to as *change buttons*. The *change button* is used to mark the end of a working session. It will only function when the machine is in active condition. At the power line of every machine, a *break button* is also installed. This button is used to temporarily switch off and switch on the power supply to the machine. The number of pins provided by Arduino Mega fulfills the requirement for the connection of the RFID readers, the relays, and the buttons [3].

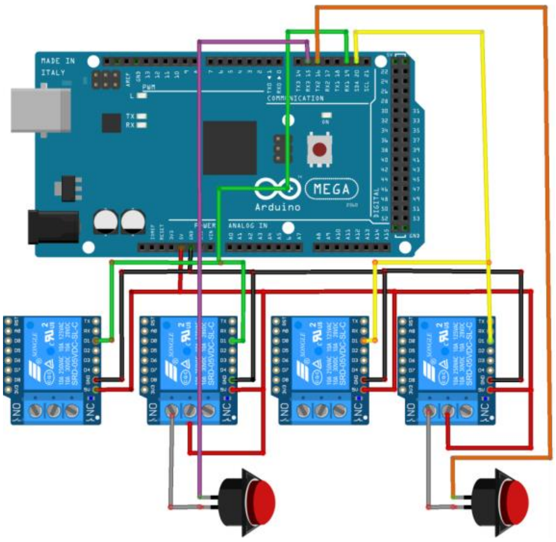

Figure 3 Connections of relays and *change button* to Arduino Mega

The flowchart of the implemented system is presented in Figure 4. It starts at the main console, with an operator choosing a certain machine he plans to use, followed by the operator tapping the RFID card to the reader. If the operator is authorized to operate the machine he already chose, a message will inform that he can now proceed to the machine, otherwise he must repeat from the beginning.

The operator may take time for material preparation, machine preparation, and machine settings, which will not be counted as machine usage time. When ready, the operator needs to activate the machine by first tapping his RFID card to the RFID reader placed next to the machine. If the registered RFID card serial number matches the tapped RFID card, the machine can be activated. Arduino will switch on a relay so that electric current may flow to the machine. Here, the machine usage time starts to count.

Two ways are provided in order to turn off the machine. The first is momentary turn off for taking breaks, machine setting, or tool changing. For this, the operator needs to release a *break button*. The second is permanent turn off when an operator wants to finish his working session. For this, the operator needs to press the *change button*. This marks the end of a working session. The machine usage time stops to count. The mentioned machine can now be chosen by other operator at the main console.

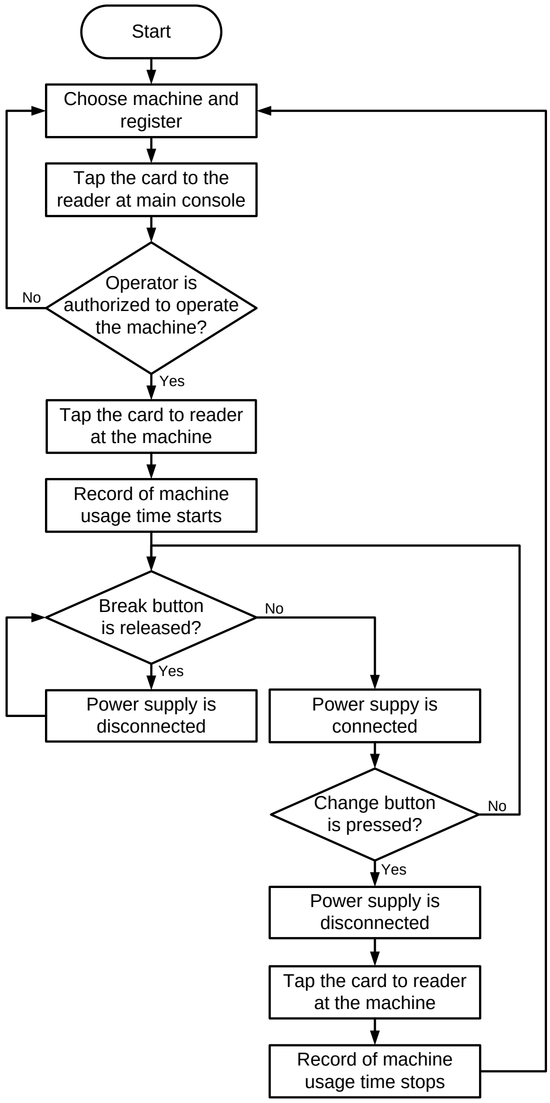

Figure 4 Flowchart of the system

The prototype requires one relay module for each machine connected to the system. A relay module consists of two DC relays and one AC relay, all functioning as actuator for the Arduino Mega. Logical circuits can be built up by using a group of relays, to support the function of the system [4]. The relay circuits can be seen in Figure 5 and Figure 6.

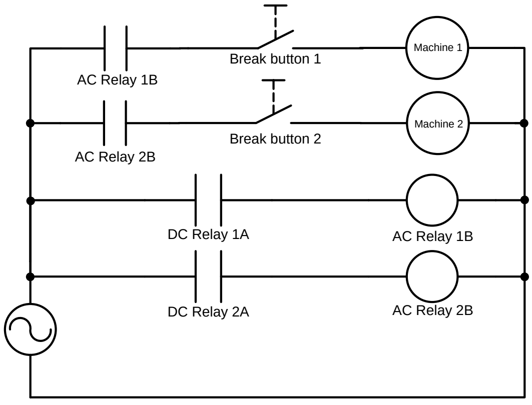

Figure 5 Circuit of AC relays

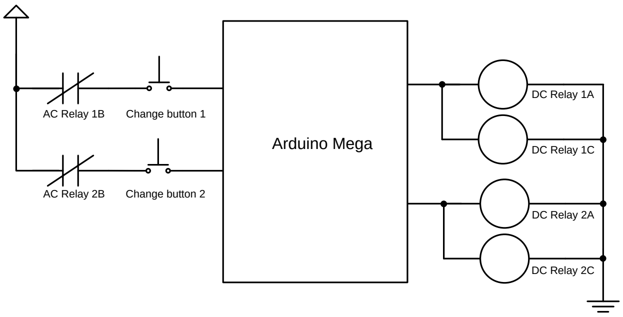

Figure 6 Circuit of the DC relays

When the microcontroller sends output to turn on a machine, say machine 1, relay 1A and relay 1C will be set high. In turn, relay 1A will activate relay 1B, which is an AC relay. The contact of relay 1B is connected in series to the *break button*, and then to machine 1. During a break or in the occurrence of emergency situation, machine 1 can be turned off by using this *break button*. Otherwise, if the *change button* is pressed, high signal is sent to Arduino which then switches off relay 1A and machine 1.

The programming for the microcontroller is conducted by using Integrated Development Environment (IDE) 1.8.5 provided by Arduino. The codes, written in user-friendly C/C++ language, are divided into setup function which runs once at the initiation and loop function which runs repeatedly [5]. The main programming page of Arduino IDE 1.8.5 is shown in Figure 7.

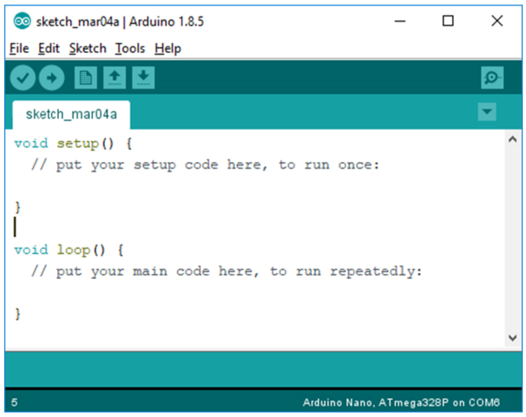

Figure 7 Arduino IDE 1.8.5

In the making of the HMI, the author used the MS Visual Studio and C#-based .net programming. The final appearance of the interface can be seen in Figure 8. The provided information are operator's names, machine types, date, start time, and stop time. The radio buttons are used to choose the machine which will be used.

The interface display also acts as indicator whether a certain machine is active or not, by the changing color of the rectangles top left of each machine's display box. Data grid view mode can be chosen, and this will show the data stored in the database. The data stored in the database can be updated by pressing the *load button*.

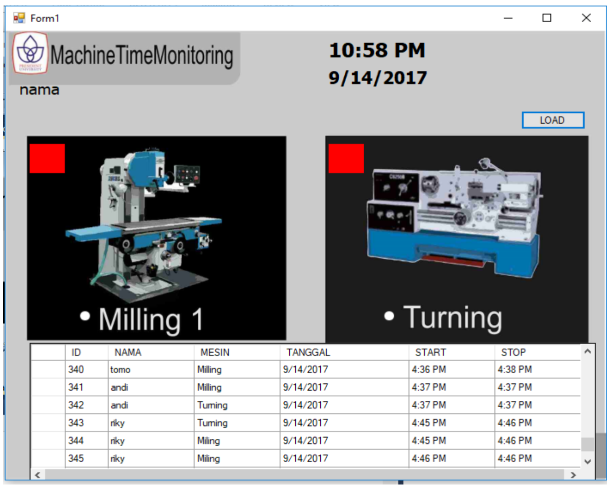

Figure 8 Appearance of the HMI

Furthermore, Microsoft Access is used to store the acquired data. The name of operators, date, and machine start time, and machine stop time are recorded securely and updated periodically. The recorded data is converted to a database file compatible with Microsoft Access.

IV. Results and Analysis

After the whole system is completely assembled, a number of tests were conducted to the machine usage time record system. One results is now presented as representive of all other tests.

The data saved in a Microsoft Access file is processed into a number of sections, based on machine usage time, shop drawing production time, and operator's working time. This information can later be used for machine maintenance planning, production cost calculation, and operator's performance assessment.

In this case, the system is tested to handle the record of 10 operators using two available machines with different shop drawing. The start time and finish time for the operators are varied randomly, along with repeated log in and log out for the operators. The results can be seen in Figure 9.

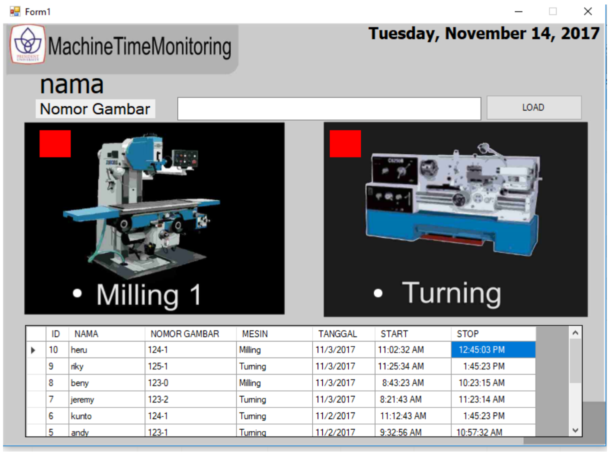

Figure 9 HMI display of the representative test

The data from the test is automatically saved in a Microsoft Access file, as can be seen in Figure 10. The data consists of shop drawing number, name of operator, date of working session, machine's start time and machine's stop time. As can be clearly observed, there is no machine that can be used by more than one operator at the same time. The proposed system thus solves one of the problems of the existing system already stated previously.

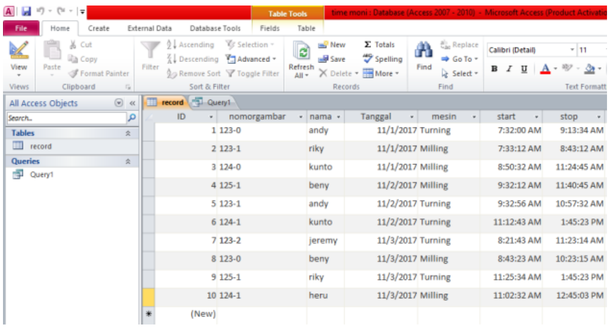

Figure 10 Recorded data of the representative test (shown in Microsoft Access)

It can also be seen, that operator's log in and log out can be done smoothly. Log in and log out can be done repeatedly with the same shop drawing. This proves that the proposed system solves the problem where operators cannot input the same shop drawing althoug the related product is not finished yet. Operators can then also share the use of the same machine without any condition that the product must be finished first.

Each machine usage time is automatically summed up, as shown in Figure 11. Based on this data, well-directed machine maintenance measure can be planned and undertaken.

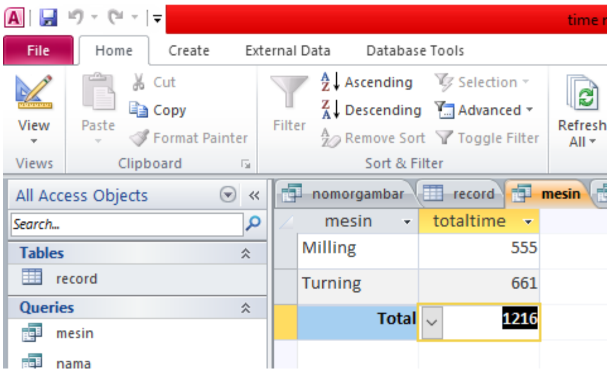

Figure 11 Total machine usage time

The total production time of each product, classified based on the shop drawing number, is presented in Figure 12. The amount of production time of a certain product is shown in minute, indicating the total amount of time used in the production process of a certain product.

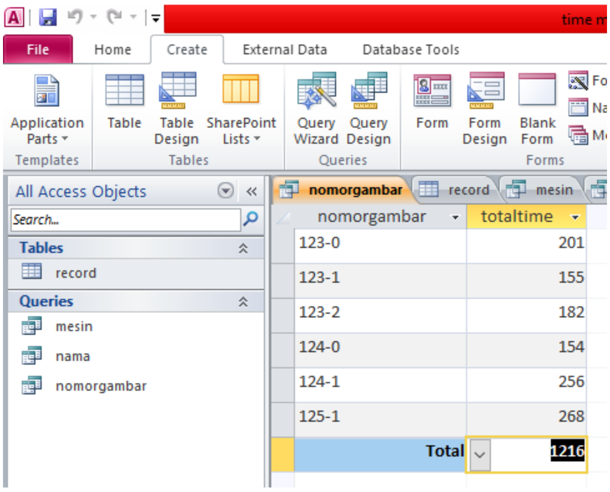

Figure 12 Total production time of shop drawings

Finally, Fig. 13 shows the data of operators' working time. This data records the time spent by every operator in all production process he is involved. This data can be used further to assess and analyze the operator performance. It also can be utilized in calculating the labor cost in a certain production process.

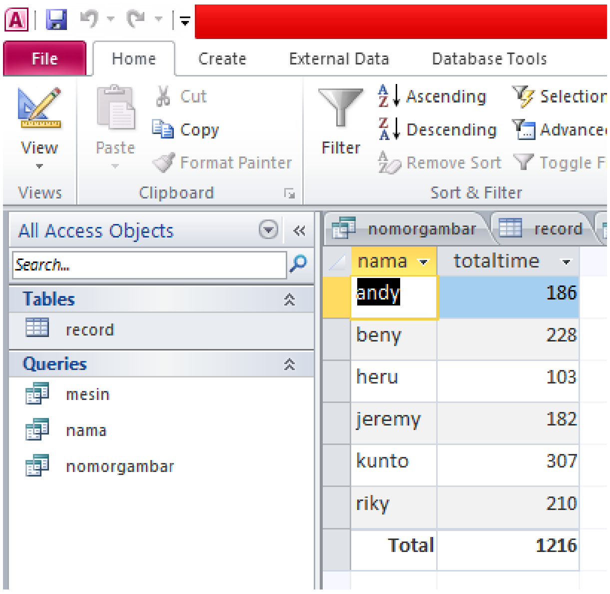

Fig. 13 Total operators' working time

V. CONCLUSIONS

The design and prototype of a machine usage time record system is presented in this paper. The effort is based on the problem found at Akademi Teknik Mesin (ATMI) Cikarang. The existing record system has low accuracy because the machine usage time cannot be stopped momentarily for operator breaks, machine setting, and tool setting. Besides, the existing system still allows usage time calculation of two operators using the same machine at the same time. The last problem is that one shop drawing can only be used to log in once, thus making an operator cannot complete a product in more than one operator session.

The proposed system emulates the real situation at ATMI Cikarang, on how it records the operators' data and machines' start time and stop time. The prototype is implemented by using Arduino Mega microcontroller and RFID identification device. The system is equipped with HMI interface and database, allowing thorough assessment for the purpose of improvement of production efficiency and maintenance effectiveness. It also solves all the problems in such a way that: a shop drawing can be completed in multiple number of operator sessions, simultaneous use of the same machine by more thatn one operator is excluded, and momentary operator breaks is facilitated.

Possible advancements of the proposed system are addition of IoT feauture which will enable it to send and receive data, connected at all time to the user for faster and updated decision making. Furthermore, the HMI can be given user-friendly features to ease add on of new operator data and new machines.

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