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APPARATUS AND METHOD OF TRACKING WORK PRODUCTIVITY

BACKGROUND OF THE INVENTION

The present invention relates generally to an apparatus and method of determining and recording the productivity of a worker in performing designated operations.

The welding as a form of metal jointing is a major process in the Singapore Marine Engineering Industry and will continue to be a major element in steel work fabrication. Welding in the Singapore shipyard's context, refers largely to manually operated welding, such as Shielded Metal Arc Welding and Flux-Cored Arc.

Manually operated welding is not only labour, but also skill intensive. To date, there is no electronic means of monitoring productivity for welders. In this context, the accumulated time spent by a welder creating the arc (arc time) is deemed to be proportionate to the amount of work done by the welder (assuming that quality issues are taken care of). Hence it can be regarded as one of the elements, used in conjunction with traditional manual monitoring, for electronically-enabled measurement of productivity for the welders. This in turn provides a basis for appraisal of the individual welder.

One of the methods of measuring efficiency of welding operation is disclosed in the European patent No. EP 0930125 A1. For this method, the duty cycle, average amperage, and/or the number of arc starts will be determined during a welding operation. The process is intended to measure the productivity and arc welding efficiency. The arc welding efficiency, in other words, could be described as the ratio of the time the welder spends actually arc welding divided by the welder's total time performing arc welding and related processes during the welder's work day.

However, the method described in EP 0930125 is designed solely to monitor productivity and efficiency of welding operation at a single location; it does not cater for the process of remunerating a welder based on the welder's individual job performance.

There exists therefore a need for a method or process for allowing the time spent on arc welding to be monitored for every single welder who may be performing the welding operation at different locations. The present invention contemplates that elimination of drawbacks associated with the prior art and provision of an apparatus and



method of quantifying the inconsistent and fluctuating nature of productivity among individual workers, will allow better formulation of policies to improve productivity.

SUMMARY OF THE INVENTION

It is, therefore an object of the present invention to provide an apparatus for monitoring and recording weld time of an individual welder.

It is another object of the present invention to provide a method of monitoring and recording weld time, based on the welder's arc time, as a means of measuring productivity of an individual welder.

These objects are achieved through a provision of an electronically-enabled and more efficient means to quantify accumulated arc time that is designed to appraise individual welders on their job performance. The apparatus of the instant invention not only measures the cumulative time the welder spends on arc welding but also records and stores the arc time data on a personalized storage device. The idea of personalizing such device is to allow the welder to move about from one place to another whilst having the time spent on arc welding captured and stored even for a plurality of welding machines, while establishing an electronically-enabled yardstick to gauge individual welder's productivity.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the accompanying drawings in which:

Figure 1 is a schematic view of the personalized accumulated storage device in accordance with the present invention. (ATSD 20).

Figure 2 is a schematic view of the arc time sensor and processing unit (monitoring device). (ATS 24)

Figure 3 is a schematic view of the arc time sensor and processing unit with PC interface (docking station). (PC Interface 22)

Figure 4 is a flow chart illustrating operation in the method of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

For a further understanding of the nature and objects of the present invention, reference should be made to the following description, taken in conjunction with the

attached drawings /diagrams. A preferred embodiment of the present invention provides an apparatus and method of providing an accumulated storage device operationally connected to a sensor and a processing unit, which can be connected to a docking station for reading the recorded data as well as downloading of recorded data. The following description provides an example of welder's productivity measuring device and method only. This invention can be applied to other types of work machines and other types of implements as is well known in the art.

The apparatus of the present invention comprises several major components, including an arc time sensor and processing unit (ATS) 24, a personalized accumulated arc time storage device (ATSD) 20, a means for connecting the ATSD device 20 to a central processing unit (CPU 28) via PC interface device (docking station) 22, and a supervisor interfacing device. Each welder is issued a single personalized accumulated arc time storage device that bears a unique user ID that is also associated to the welder's name and other data in the central database.

Figures 1 - 3 illustrate exemplary embodiments of the time controller device of the present invention. It will be understood that other electronic circuits can be employed for the apparatus of the present invention, if desired. In the embodiment shown in Figures 1-3, the data controller, ATS 24 is provided with an independent power supply, which can be a 230VAC to 5V DC converter. The ATS unit 24 further comprises a main microcontroller, which can be PIC16F887 a real time clock I.C. with full calendar a 64k-Byte EEPROM and three I/O co-processors PIC16F877. The data controller 24 also has signal conditioning circuits for the weld current sensors and weld current sensor (inductance sensor). A visual display, such as for instance and LCD digital display is provided in the housing containing the ATS unit 24. Necessary user interface software is uploaded in the unit 24.

The ATS unit 24 generally refers to the device housed at the welding blocks to detect, record and provide the translation of induced voltage signal from the arc sensor into arc time data. Each ATS unit 24 is designed to support 3 welding sets. The ATS unit 24 performs the functions including but not limited to the following:

- i) Inductance sensor to detect magnetic flux in wires when the arc is formed and produces a corresponding voltage signal;

- ii) Power supply unit to convert 230V ac power supply to 5V dc;
- iii) The processing unit has two i²c buses (internal and external), the external bus connects to the personalized accumulated arc time storage device, while the internal bus connects the main micro-controller; real-time clock, EEPROM and co-processing units;
- iv) Signal conditioning circuit amplifies and rectifies the signal voltage from arc sensor;
- v) Real-time IC clock allows the accumulated arc time to be recorded by registering the time the arc is formed;
- vi) LCD displays total accumulated arc time, welder ID and welding machine ID;
- vii) I/O co-processors shield the internal i²c bus from transients during plug in and out of the ATSD 24.

The personalized accumulated arc time storage device ATSD 20 comprises two non-volatile EEPROM/micro-controller chips with nine-pin male connector. The two EEPROM chips allow backing up of data in the event of a faulty chip. The docking station/PC interface 22 comprises a micro-controller PIC16877, DB9 9-pin D-subminiature female connector.

The personalized accumulated arc time storage device ATSD 20 refers to a portable data storage device with unique ID depicting permanent welder ID and rewritable welding block /location ID. It is also programmed to record accumulated arc time during a 24-hour time frame and a maximum of 250 corresponding welding machine/block ID, the ID required to identify the location of the welding being done.

The supervisor interface device refers to the device used to update the welding machine block /location ID in the ATS unit 24 as well as synchronize the real-time clock in the ATS unit 24 via a 9-pin D connector and compatible software and hardware. The supervisor interface unit, or central processing unit is provided with a connection cable with nine-pin D connector (male connector). The supervisor interface device can be a computer or any other portable visual display devices (eg notebook, PDA etc), with compatible software to allow interfacing with the ATS 24.

Figure 4 is a flow chart illustrating the method of the present invention, where the ATS unit or module 24 performs data collection by logging welding activity of an individual welder.

Figure 4 step 0 schematically illustrates the initialization of the welder's personalized accumulated Arc Time Storage Device (ATSD) 20. The PC application software registers the ATSD 20 via the docking station. This is a one time process.

Step 1 is the actual data logging process. The welder may weld with any welding machine and his arc time will be accumulated as long as he plugs in his ATSD into the ATS of the corresponding welding machine. The ATS 24 checks the conformance of welder ID when it detects a new plug-in and displays the welder ID, name and his accumulated welding time on its LCD screen.

Step 2 uploads the welding records of the ATSD 20 to a PC 28. The ATSD 20 connects to the docking station 22 via i²c bus similar to the way it connects to the ATS. The docking station 22 uses EIA232 serial data transfer protocol to interface to the PC. The accumulated arc time can only be cleared by the PC software via the docking station 22. The docking station 22 circuit has a 4x40 line LCD, real time clock and micro-controller for user interface, time keeping, detection of the ATSD and transfer of data.

The ATS unit 24 creates a new record in the ATSD 20 containing the following information:

- ☐ The chronological time of the first and last weld, for example, 9th March 2007, 1032 hours.
- ☐ Weld Time (this is the total weld time during this plug-in)
- ☐ Welding set ID (transformer).

The ATS unit 24 writes the time of the first and last weld and welding set ID onto the personalized accumulated arc time storage device. For every "plug-in", the process is repeated such that in the event that a welder changes his welding set, the history of his "plug-ins" is recorded provided he actually performs a welding operation with the machine.

Up to 250 new records can be recorded on the storage device 20. After exceeding the 250th record, only the accumulated time will be updated. Subsequent new plug-in cum welding (251 onwards) will overwrite the 250th record so that the last record time and the

total accumulated time is still correct. The 24-hour time frame allowable is handled by higher level software in the PC at the back end, when the worker plugs his ATSD 20 into the docking station.

When the welder plugs out his ATSD 20, the ATS 24 creates in its 64kB EEPROM, a record which contains the following:

- ☐ Welder ID (Who just finished using the machine?)
- ☐ Weld Time (Total weld time he accumulated in this session.)
- ☐ Transformer ID (Which machine did he use?)

A maximum of 4000 of such records could be stored in the EEPROM, beyond which the 4000th record is always overwritten by the latest one. The supervisor is responsible for uploading and clearing the stored data.

The commencement of welding begins with the creation of the arc. The magnetic flux created by the current passing through the cable is picked up by the inductor sensor at the primary side of the transformer which in turn produces a signal voltage that is then amplified 200 times, rectified and shaped for digital interface by the signal conditioning circuits in the ATS unit 24. This corresponding digital signal is converted into arc time by the ATS 24 and recorded onto the ATSD 20. The ATS unit 24 is connected via wires to the inductance sensor used for detection of arc current. The inductance sensor is mounted, perpendicular to the flow of the electricity current, onto the exterior of the input power cable into the step down transformer at the distribution panel.

When the welder first strikes his weld, a strong current spike in the welding set is typically experienced passing through the cable at the primary side of the transformer where the sensors are located. This surge in current is momentary and stabilizes to a lower value very quickly. This surge causes magnetic crosstalk, which results in the neighboring sensor picking up the resultant superimposed magnetic field.

In order to resolve this resultant phenomenon, the ATS unit 24 is programmed such that upon detecting an arc, the unit 24 waits for approximately 2 seconds and if the arc is maintained after the interval, it is considered as a valid weld. Two seconds are added to the accumulated weld time to compensate for the lag. The interval of approximately 2 seconds is long enough for the transient spike to die down so that the neighboring sensors will not register a weld. To further prevent magnetic interference due

to the relative closeness of the cables at the distribution panel that also results in interference in the magnetic field being picked up by the sensor, the sensor is embedded in a protective shield comprised of ferric material. This shield is in the shape of two half rings, held together to form a ring enveloping the cable at the welding set distribution panel.

The conditioned signal voltage prompts the micro-controller to register the time from the real-time clock I.C. (time that arc is on). Each time the arc is on, the arc time reading is accumulated towards the previous registered timing. The arc time is thus accumulated for welding done with the same machine or subsequent welding done with other welding sets.

For welders who had been welding at different locations (whereby the welder would also have plugged in the storage device 20 at those locations corresponding to the welding set he had used), the total welding time based on the weld arc being on, is summed up to produce the total arc time for the day. The current invention allows for a total of up to 250 “plug-ins.”

The personalized accumulated arc time storage device ATSD 20 is removed after the welding for the day has ended. The storage device 20 is then plugged into the docking station 22 (ATS to PC interface), which interfaces with the PC 28, relying on ELA232 and compatible software to achieve the data transfer.

At the end of the work day, the personalized accumulated arc time storage device ATSD 20 will be taken by the welder to the docking station 22, where the data from the storage device will be uploaded onto the PC and the existing central database. The data can hence be further processed and segregated for further analysis and report generation indicative of the performance of the individual welder during a pre-determined period of time, whether by work day, a week, or a month.

The arc time data captured on the personalized accumulated arc time storage device 20 would be segregated by the welder's identification data and welding set's identification data. The former being unique to the personalized accumulated arc time storage device 20, and the latter captured by the storage device 20 from ATS unit 24. The data written onto the personalized accumulated arc time storage device 20 by the ATS unit 24 includes the welding set used, the date and time used, the total arc time for the

welding set(s) used, welder's ID (name, ID no, company name etc), the start and end timing for the weld as well as the longest continuous weld time.

The ATS unit 24 implements two methods to deter fraud:

Firstly, the ATSD device 20 is built using standard EEPROM chips which can be read/write using commercially available universal programmer, creating the possibility of the welder to write his own data into the meter. In order to deter such activities, the data is encrypted when recorded on the storage device 20.

The second fraud-prevention function is the inclusion of the parameter of longest continuous weld time as a means to check against the possibility of false welding data created by the user by shorting their electrodes, hence inducing current flow. Real welding will typically not be of too long a continuous timing due to the constraint of the welding electrode length and fatigue.

The common arrangements of welding sets typically used in the Singapore shipyards are that of installation on steel racks (commonly termed "block") consisting of rows of 3 welding sets in a single row, 6 machines in 2 tiers of 3 welding sets in each row or as a single welding set unit (the last is less common). The welding blocks are typically connected phase-to-phase to a 3 phase power source via a distribution panel at the welding block.

The ATS units 24 are housed in a water proof case with a flip-open door for access to the port for the connection of the ATSD device 20. The whole array is in turn mounted onto the welding blocks. Each standard ATS unit supports 3 welding sets. The ATS units 24 are connected via wires to the inductance sensor used for detection of arc current. The inductance sensor is mounted, perpendicular to the flow of the electricity current, onto the exterior of the input power cable into the step down transformer at the distribution panel.

Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of the invention as described and defined in the following claims.

CLAIMS

We Claim:

1. An apparatus for monitoring an individual user activity of a designated character, comprising an activity sensor unit adapted to provide an activity sensor signal representing personalized data of the individual user activity of the designated character, a personalized portable storage device assigned to the individual user for recording and storing accumulated activity time of the designated character within a pre-determined period of time and at a predetermined number of activity locations and a processing unit operationally connected to the activity sensor unit and capable of processing the signal and calculating total time of the individual user's activity during a pre-determined period of time.
2. The apparatus of Claim 1, wherein said data storage device for storing activity sensor signals is configured to record accumulated activity during a 24-hour time period.
3. The apparatus of Claim 1, wherein the processing unit is capable of receiving information identifying an individual user.
4. The apparatus of Claim 1, wherein the data storage device is capable of being connected to a central processing unit for analyzing data stored by the storage device, and wherein the data stored in the data storage device allows evaluating performance of the individual user.
5. The apparatus of Claim 4, wherein the activity of a designated character is a manufacturing activity, and wherein the activity sensor unit is capable of detecting the manufacturing activity performed by the individual user.
6. The apparatus of Claim 5, wherein the manufacturing activity is welding, and wherein the activity sensor unit is connected to a welding machine to detect magnetic flux from an electrical power source connected to a welding machine transformer.
7. The apparatus of Claim 5, wherein said storage device comprises at least one micro-controller memory chip capable of storing the manufacturing activity information and user identification information, and wherein the manufacturing activity information includes time periods needed to complete particular tasks and identification of particular

manufacturing devices which the individual user employed while performing the manufacturing activity.

8. The apparatus of Claim 5, further comprising a means for connecting the data storage device to a central processing unit, wherein the connecting means is capable of receiving individual user activity information from the data storage device and transferring the individual user activity information to the central processing unit; and wherein the central processing unit is capable of receiving the individual user activity information from the connecting means and generate a performance evaluation report on the individual user's activity during a pre-determined period of time.

9. The apparatus of Claim 6, wherein the data captured by the data storage device is accumulated arc time data identifying the individual user, identification of welding sets employed by the individual user, date and time the welding sets were used by the individual user, total arc time for the welding sets used by the individual user, start and end time of a weld and the longest continuous weld time employed by the individual user.

10. The apparatus of Claim 9, further comprising a means for preventing tempering with a process of data collection by the activity sensor unit, said means comprising an encryption means embedded in the data storage device.

11. The apparatus of Claim 10, wherein said tempering prevention means further comprises a means for comparing the longest continuous weld time employed by the individual user as captured by the data storage device to a standard continuous weld time.

12. A method of determining productivity of a worker in performing a specific work activity, comprising the steps:

- providing an activity sensor unit capable of detecting the specific work activity performed by the worker;
- providing a personalized portable storage device and assigning the personalized storage device to the individual user;
- initializing the activity sensor unit and capturing personalized information when the worker performs the specific work activity;
- recording and storing accumulated activity time of the designated character within a pre-determined period of time and at a predetermined number of activity locations;

providing a data processing unit for processing information captured by the activity sensor unit; and

generating a productivity report based on the information processed by the data processing unit.

13. The method of Claim 12, wherein the specific work activity is welding, and wherein the activity sensor unit is capable of being connected to a welding apparatus.

14. The method of Claim 13, wherein the activity sensor is connectable to a welding apparatus transformer and is capable of generating and recording signals indicative of data corresponding to real arc time employed by the worker, identification of welding sets employed by the worker, date and time the welding sets were used by the worker, total arc time for the welding sets used by the worker, start and end time of a weld and the longest continuous weld time employed by the worker.

15. The method of Claim 14, further comprising a step of providing a data storage device for storing data recorded by the activity sensor unit.

16. The method of Claim 15, further comprising the step of uploading stored data to a central processing unit and processing the uploaded data to generate a report of the worker's productivity.

17. The method of Claim 14, further comprising a step of minimizing effect of initial resultant crosstalk caused by commencement of welding during the step of generating the signals indicative of data corresponding to real arc time.

18. The method of Claim 17, wherein said step of minimizing effect of initial crosstalk comprises delay in real arc time signal generation sufficient for a transient spike to subside and adding the delay time to accumulated real arc time signal.

19. The method of Claim 16, further comprising a step of preventing tempering with data generated by the activity sensor unit, said step comprising encryption of data by the data storage device, destruction of stored data when an attempt to connect parallel activity sensor units is made and comparing the longest continuous weld time employed by the worker as captured by the data storage device to a standard continuous weld time.