Automatic Data Capturing and OEE Calculation System on Vertical Machining Centre by Implementation of Lean Principles in CNC Shop Floor

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Abstract- *Lean manufacturing is a management philosophy that pursues continuous reduction of wastes in an organization. Implementation of Lean manufacturing with the existing system enables at small reduction of wastes in the organization which will yield an incremental growth in business, performance, quality, efficient time management etc. A detail study of problems related with Computer Numerical Control(CNC) machines on the shop floor was made. Manual collection of data and preparing an Overall Equipment Efficiency(OEE) report was literally difficult in the organization. These reports are time consuming, needs more man power. The reports are not accurate. The OEE report reflects the performance of the machine however it was not able to find the reasons for downtimes and uptimes. An electronic wireless hardware device was installed inside the CNC machine connected to the machine control system and RS232 ports. With the help of LEANworks software we could track the machine activities and generate the OEE reports in no time and the reasons for downtimes were found. Non value activities results the downtimes are captured and eliminated. By reducing the wastes use of man power was minimized, decrease in manufacturing lead time, minimum rejections, cost of production reduced, growth in performance of the organization improved.*

Keywords- Overall Equipment Efficiency, automatic data capturing in CNC machine, automatic OEE calculation

I. INTRODUCTION

In any production company money is made in the shop floor. But the machines making money or just chips are every management's doubt. The main objective of this project is to implement the Lean manufacturing method in the CNC shop floor to monitor the activities of the CNC machine and to improve the performance. By implementing LEANwork shop floor productivity tracking system in the CNC shop floor the problems related to CNC machines which has a major impact on the overall equipment efficiency becomes more visible. The result of Value stream mapping is accurate. There are various tools to implement the Lean manufacturing like Just in time, Kaban, Kaizen, Root cause analysis, Muda, OEE, Key performance indicator, Andon, 5s etc. These Lean tools help to improve the performance in any production company.

Firm's efficiency and competitiveness are two important challenges in today's global market that have motivated many manufacturing firms to plan novel manufacturing management strategies. The most critical issue faced by manufacturers today is how to deliver their products or materials quickly at low cost and good quality. Several methods and approaches exist such as computer simulation, statistical analysis, and lean tools for improving the efficiency and productivity by determining the best combination of resources in production lines, construction process, energy, services and supply chains. One of the effective management approaches is Lean Manufacturing (LM) system that has taken by many manufacturing firms in different forms and names. The concept of LM was proposed by a Japanese automotive company, Toyota, during 1950's which was famously known as Toyota Production System (TPS). The first goal of TPS was to improve productivity as well as to decrease the cost by eliminating waste or non-value added activities. Lean manufacturing is one of the important steps that many major businesses in the United States have been attempting to implement in order to sustain their competitiveness in a rising global market. Main goal of this approach is on cost reduction by decreasing non-value activities. Based on the Toyota Production System, lean manufacturing tools and techniques such as just-in-time, cellular manufacturing, total productive maintenance, single-minute exchange of dies, and production smoothing have been consistently applied in different discrete manufacturing systems involving automotive, electronics. These improvements based on cost reduction are obtained by eliminating the wastes related to all activities done to deliver an order to a customer. Wastes include all activities that used resources by imposing cost to the product, but do not have a significant value on the customer.

II. LITERATURE SURVEY

From the works of Pankaj Taywade[1] it is clearly mentioned that the effectiveness and efficiency plays important role in any organization to stay in the competitive environment. Greater the value of efficiency and effectiveness, greater will be the productivity of the organization. Overall Equipment Effectiveness (OEE) is a key performance indicator, showing the current status of the production with least calculations..

From the works of Puvanasvaran P[2], Unavailability of infeasibility of data to be collected in the form required for each formula is another issue of OEE implementation. The paper also states that the common problems faced in the companies is to define the ideal cycle time, particularly in non machinery and less well automated manufacture. The data capturing for unscheduled maintenance time requires considerable time and cost since the event occurs randomly or entirely unexpectedly.

From the works of Aurelien Narses [5], it is observed that Data are defined as symbols that represent properties of events and their nature. These are the products of observation, but are of no use until they are in the relevant form. Data collection consists of collecting of those symbols in order to have good foundation for deeper studies on the subject. Data collection can be of two types as described Quantitative or qualitative.

From the works of Norani Nordin[9], it is observed that among all the lean manufacturing practice, kaizen is found to be the leading lean practice with a maximum score. Other lean practices that have been extensively adopted are the 5s practices and preventive maintenance. However the least practiced lean tools are cellular manufacturing and supplier involvement in product design and development.

III. IMPORTANCE OF AUTOMATIC DATA CAPTURING SYSTEM

The core idea of all the Lean manufacturing tools is to identify and reduce the waste which adds no value to the job. Reducing the waste is interesting and easy if waste capturing procedure or technique is simple. In most of the cases these wastes or problems are unnoticed or they come to light when enough financial loss to the company has already occurred. Problems cannot be resolved if they are unnoticed. Hence capturing the problems is very essential and challenging task to CNC shop floor engineers. In order to calculate the performance of the machine one has to manually make a report of activities occurring in the machine, this process requires lot of human working hours and accuracy of the data collected is debateable. On the other hand manual program entry is error prone. Here is an attempt to solve the all major problems related to CNC shop floor with help of automatic shop floor tracking system.

IV. PROJECT OBJECTIVE

The main objective is to minimize the use of human resource and time for recording, documenting and calculating the performance of the CNC shop floor by implementing the automatic data capturing and OEE calculation system in the CNC machine.

Database Software

All tracked data will be stored in MSQL Miscrosoft server database capable of handling large quantity of data. We recommend SQL Server 2008 R2. Database software shall be provided by user. CADEM does not provide access to LEANworks database, the format of the database is proprietary to CADEM and confidential information.

Data capturing from machines

Machine statuses will be tracked automatically without any human intervention or manual inputs. The following statuses of the machine will be tracked through 24V digital signals tapped from the machine:

Table 1.1 shows 24v signals tapped from the machine

Cycle OFF / ON	24 Volt signal to tracker	Required
SPINDLE OFF / ON	24 Volt signal to tracker	Used for long cycles
MACHINE OFF / ON	24 Volt signal to tracker	Optional
TOOL CHANGE	24 Volt signal to tracker	Used for long cycles

Manufacturing unit must have the required signals from the machine for tracking. 24 V digital hardware signals must be tapped from electrical relays at appropriate locations on the machine panel for CYCLE START and END, SPINDLE ON and OFF, TOOL CHANGE, MACHINE ON and OFF. These signals will be wired to the tracker. CADEM will interface the tracker to LEANworks Server.

Locating, identifying and tapping of hardware signals that signify CYCLE START and END, SPINDLE ON and OFF, MACHINE ON and OFF events may need services of persons skilled in the area of CNC and tracker etc.

Operator input capturing on Tablets

The automatic OEE calculating system also captures operator's responses or inputs along with the automatically captured machine status to co-relate the machines uptime and downtime and the reasons for the downtime. Operator PC will be used for capturing the above inputs from the machine operators. Depending on the space between machines you may have a single operator PC or multiple PCs.

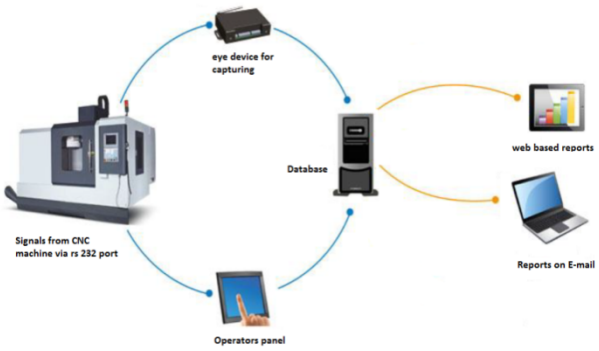

Figure 4.1 Schematic representation of data flow

V. RESULTS AND DISCUSSIONS

Setting Time	0	0	0	0	0	0	0	0	0	0	0	0
No operator	0	0	0	0	0	0	0	0	0	0	0	0
Material not available	0	0	0	0	0	0	0	0	0	0	0	0
Tool problem	0	0	0	0	0	0	0	0	0	0	0	0
Tool or Insert change	0	0	0	0	0	0	7	0	0	0	0	0
Inspection	0	0	0	0	0	0	0	0	0	0	0	0
Development	0	0	0	0	0	0	0	0	0	0	0	0
Mchine Cleaning	0	0	0	0	0	0	0	0	0	0	0	0
No setter	0	0	0	0	0	0	0	0	0	0	0	0
Fixture problem	0	0	0	0	0	0	0	0	0	0	0	0
Coolant Time	0	0	0	0	0	0	0	0	0	0	0	0
POWER CUT	0	0	0	0	0	0	0	0	0	0	0	0
Spindle off time	104	122	227	269	205	136	147	147	223	163	219	321
Axis off time	7	0	0	0	0	0	0	0	0	0	0	0
Machine off time	12	185	0	2	0	0	1	33	0	1	2	0
Rework	0	0	0	0	0	0	0	0	0	0	0	0
Setup	0	0	0	0	0	0	0	0	0	0	0	0
Maintenance	0	0	0	0	0	0	1	0	0	0	0	0
Excess Load Unload	112	16	90	31	29	129	43	11	55	57	0	0
Machine breakdown	22	11	1	5	0	0	3	13	0	2	4	1
Schdule closure	0	0	0	0	0	0	0	0	0	0	0	0
Small stop losses	0	0	0	0	0	0	0	0	0	0	0	0
Reason for Utilization Loss												
Non_Utilized_Time	257	334	318	307	234	265	202	204	278	223	225	322
Available_Time	480	480	480	480	480	480	480	480	480	480	480	480
Utilization_%	46.46	30.42	33.75	36.04	51.25	44.79	57.92	57.5	42.08	53.54	53.13	32.92

Figure 5.1 Utilization data captured by the machine tracker and automatically generated OEE report

Perfomance												
Total_Mins_Machine_Used	223	146	162	173	246	215	278	276	202	257	255	158
Standard_Cycle_Time	32	32	32	32	32	32	32	32	32	32	32	32
Parts_To_Be_Produced	6	4	5	5	7	6	8	8	6	7	7	5
Total_Parts_Produced	7	5	8	7	9	9	10	11	10	6	9	7
Perfomance_%	116.67	125	160	140	128.57	150	125	137.5	166.67	85.71	128.57	140
Quality												
Total_Parts	7	5	8	7	9	9	10	11	10	6	9	7
Accepted_Parts	7	5	8	7	9	9	10	11	10	6	9	7
Reason_for_Rejection												
Quality_%	100	100	100	100	100	100	100	100	100	100	100	100
OEE	54.2	38.03	54	50.46	65.89	67.19	72.4	79.06	70.13	45.89	68.31	46.09

Figure 5.2 automatic OEE results captured and generated after implementation of Automatic OEE System

Observed values over manual OEE calculation to the Automated OEE Calculation system

Human resource involved:

Human resource involved before implementation of automatic OEE system was six in number where manual data collection starts from operator and flows through supervisor, maintenance, quality and information management person.

After implementation of automatic OEE calculating system the involvement of human resource has been reduced to three personnel. Since the OEE system needs only an operator and supervisor to interact with it. We can conclude that about 50% of human resource involvement has been reduced after implementation of automatic OEE calculating system. Figure 5.3 shows the involvement of human resource has reduced to 50% after implementation.

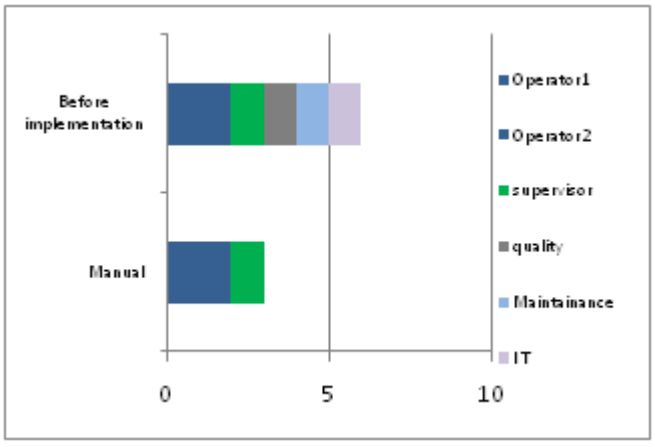

Figure 5.3 show human resource has reduced to 50% after implementation.

Time involved in generating the OEE reports in existing system.

In the existing system the OEE data collection and drafting it as a report was manually done hence the time involved was high. After implementation of automatic OEE calculating system the human resource involvement was reduced and the manual data collection has been eliminated. The system automatically captures data of events happening on the CNC machine simultaneously along with operations. Events like breakdowns, quality needs negligible amount of time of an operator. So the time involved in generating the OEE reports after implementing automatic OEE calculating system is very less.

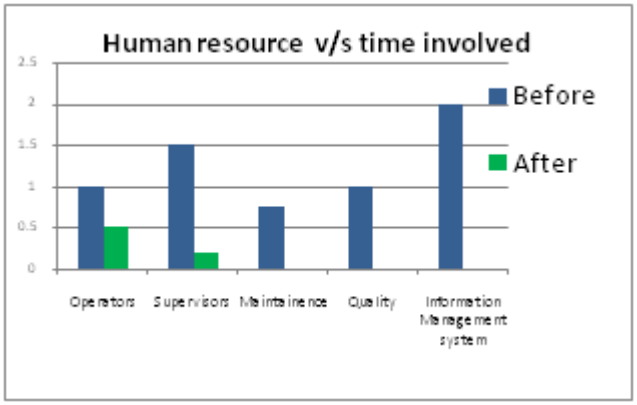

Figure 5.4 Comparison of time involved before and after implementation

Cost of OEE generation:

The data is captured by the wireless machine tracker which is interfaced with the CNC machine controller. All the data necessary for OEE generation is recorded continuously and transmitted simultaneously to the server. The involvement of human resource is limited to one personnel. Since only supervisor or admin handles the entire CNC shop data management the cost of OEE generation is the cost spent for that employee. The cost of implementation of this system in real time CNC shop floor is affordable and it's a onetime investment yielding lifetime returns.

After implementation of automatic data capturing and OEE calculation system on the CNC machine the result were observed that there is a reduction in human resource involved. Time and cost for OEE data capturing, documentation, calculation and generating the reports has also minimized

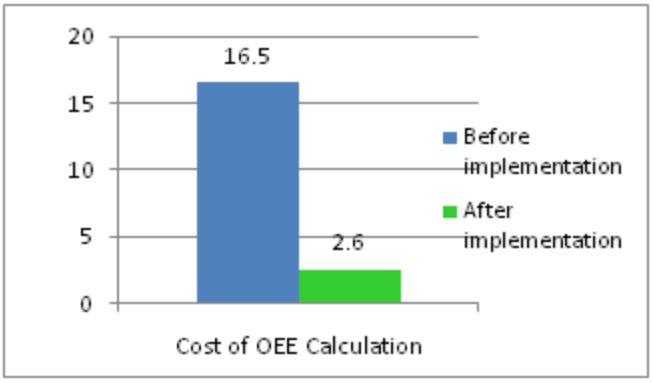

Figure 5.5 Show percentage reduction of cost of OEE calculation.

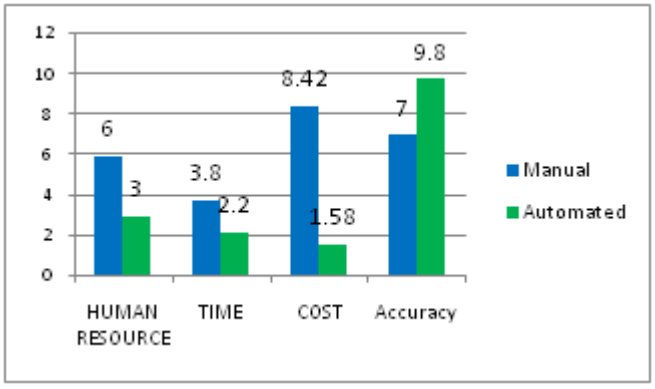

Figure 5.6 Comparison between Manual and Automated OEE calculation

VI. CONCLUSIONS

To address the shop floor productivity concerns and improve upon the profitability, an automatic tracking system can certainly help an organization immensely. This system not only tracks data truthfully and preserves the data safely, but also reports on critical performance parameters. All the productivity improvements can now be measured accurately and make them sustainable in the long term. Automatic data capturing and OEE calculation system also provides viable solutions to the shop floor problems.

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