The Concept of Computerized Overall Equipment Effectiveness Management in LISCO.

Authored By:

Yousif Kalifa Hawil. Libyan Iron and Steel Company (LISCO). yousif@libyansteel.com

Prof: Marai Mohammed Abousetta. School of Applied Sciences and Engineering - The Libyan Academy.

Abstract

In this paper the objectives and benefits of the implementation of TPM in LISCO is studied, and it is going to focus on testing computerized calculation of the overall equipment effectiveness LISCO and some other industrial KPIs, and it also discusses the six major losses in any industrial process (Quality, Availability and Performance). A conceptual computerized OEE management System in LISCO will be introduced, the data taken from the Managerial Dash Board (MDB) system will help LISCO to realize the benefit of a multidiscipline teams formation from different department for the elimination of any boundaries between the industrial departments and make the maintenance processes more effectively, Workers on the production lines are also included and encouraged to adopt the autonomous maintenance activates. As a result LISCO will achieve higher quality rate of overall equipment effectiveness equation, higher availability rate and higher performance rate. Set of techniques like Single minute exchange die, computer maintenance management system CMMS, Managerial Dash board system (MDB) and production planning are suggested to be implemented in LISCO after the computerization of OEE calculation to improve their maintenance procedures and improve the productivity.

1. Introduction

Previously maintenance of industrial plants such as in LISCO was traditional work activities where companies apply it without the knowledge of its importance, but after the improvement of industrial production strategies and the improvement of the flexibility of production lines to produce a wide variety of different products, the need for a good maintenance strategy becomes bigger, because of automation and large-scale processing, higher plant availability, better product quality and long equipment life had assumed considerable significance [1]. Currently many companies have great focusing on the optimization of their assets, and use industrial equipment's more effectively, and one of the main parts of the company which has a great influence on the assets is the maintenance department and the employees responsible for maintenance [2]. The main idea behind the maintenance is to make the machines ready to do what are required to do within the time allocated and do it with the right amounts of resources. Total productive maintenance (TPM) is new maintenance strategy developed to meet the new maintenance needs, TPM is an American way of productive maintenance which has been modified and improved to fit in the Japanese industrial environment. Currently it is popular in Japanese industry where TPM is defined as follows: **(TPM seeks to engender a company-wide approach towards achieving a standard of performance in manufacturing, in terms of the overall effectiveness of equipment, machines and processes, which is truly world class).** Another US advocate of TPM, Wireman (1991) proposes that TPM is maintenance that require the involvement of all employees in the company and includes all human resources from top management to the line employees (it encompasses all departments including, maintenance, operations, facilities, design engineering, project engineering, instruction engineering, inventory and stores, purchasing, accounting finances, plant /site management). There are many different definitions for TPM and the cause behind this variety in definitions is found in the way of adoption of this strategy, some industries focus on the group working more than equipment management, and other focus on equipment effectiveness, this diversity shows how important implementing TPM in company that it covers all factors affecting the production process [1].

2. TPM Objectives

TPM requires the minimization of all the potential losses in the production process and to operate equipment with full design capability. TPM takes the quality in to consideration by reaching zero product defect rate, this means zero production scrap or defect, zero breakdown, zero accident, zero waste in the process running or changeover [2]. TPM is defined by taking in to consideration the following objectives:

2.1 Equipment Effectiveness Improvement: This means investigating into the six big losses which is divided in to three main losses:

- **Down time losses:** they are classified as Equipment breakdowns, Setup and adjustment stoppages.

- **Speed losses:** which identified as Idling and short-term stoppages and Startup/Restart losses.
- **Defects or Quality losses:** Scrap and rework and Startup losses.

(Definition of the root causes of these losses starts the improvements process. The idea is to make the equipment work as it should be always working and produce as much as it is supposed to produce [2]).

2.2 Involvement of operators in daily maintenance: This requires the achievement of autonomous maintenance where the employees who operate the equipment are allowed to take responsibility for some of maintenance activities [3] such as:

A. **Repair level**: Here the operators take the action to repair the machine according to given structure paper.

B. **Preventive level**: the operator will take a corrective action to prevent the problems.

C. **Improvement level**: the operator will be uncharged in any improvement strategy; moreover, he will take the corrective action too on the problems when occurred.

2.3 Improving maintenance efficiency and effectiveness: This requires having a systematic approach to all maintenance activities. It requires the identification of the nature and level of preventive maintenance needed for each individual Machine, the establishment of standards for condition-based maintenance, and the definition of respective responsibilities for operation and maintenance staff. The respective roles of "operation" and "maintenance" staff are considered as being distinct. Maintenance staff are considered as responsible for developing preventive actions and general breakdown services, whereas operation staff take on the "ownership" of the industrial plants and their general care. Maintenance staffs typically move for more facilitating and supporting role where they are responsible for the training of operators, problem diagnosis, and devising and assessing maintenance practice [2].

2.4 Educating and training personnel: This requirement is one of the most important aspect in the TPM approach; it needs the involvement of all employees in the company: Operators are trained on how to work on their machines and how to maintain them properly. Because operators are required to do some of the inspections, routine machine adjustments, and other preventive activates, training involves the teaching of operators how to do those inspections and how to do maintenance work in a partnership. Training of supervisors on Supervision in a TPM team work environment.

2.5 Designing and managing equipment for maintenance prevention: Industrial Machinery is costly and must be seen as a productive asset for its entire life. Designing machines that is easier to operate and maintain than previous ones is a fundamental part of TPM. Recommendation from operators and maintenance technicians help engineers design, specify, and procure more effective equipment. By evaluating the costs of operating and maintaining the new equipment throughout its life cycle, long-term costs will be minimized. Low purchase prices do not necessarily mean low life-cycle costs [2].

3. **Major Losses** in TPM

One of the main objectives of TPM is to minimize or eliminate the six big losses which they are the most common causes of efficiency reduction in manufacturing. The relationship between the losses and the effectiveness in TPM is defined in terms of quality rate of the product, equipment availability rate, and performance rate. Any industrial processing time may face losses and these losses can be seen like scrap, changeovers and breakdowns or cannot be seen such as the slow running, the frequent adjustment to maintain the production within tolerance, Nakajima concluded the loss in a six main losses as following:

3.1 Downtime Losses: It is present when the production output is zero and the system produces nothing, where the unused time segments, during the examined period are downtime losses, and mainly it can be one of two:

A. **Breakdown losses**: This loss is caused by parts failure where they cannot work anymore and they require either repair or replace. These losses are measured by how long it takes from labor for fixing the problem.

B. **Setup and adjustment time**: These losses are caused by the changes in the operating conditions, like the start of the production or the start of the different shifts, changes in products and condition of the operation. The main examples of this kind of losses are equipment's changeovers, exchange of dies, jigs and tools. These losses consist of setup, start-up and adjustment down times.

3.2 Speed Losses:

Speed Losses are present when the production output is less than the output at references speed. This can be present in two forms:

A. **Minor stoppage losses**: These losses are caused by machine halting, jamming, and idling. Many companies are considering these minor stoppages as the breakdowns in order to give more importance to this problem [4].

B. **Speed losses**: These losses are due to the reduction in speed of the equipment. This means that the machine is not running at the original or theoretical speed. If the quality defect and minor stoppages occurs regularly then the machine is run at lower speed to cover the problems. It is measured by comparing the theoretical to actual running load.

3.3 Quality losses:

The produced output confirms or dose not confirm to quality requirements. When it does not comply, this is consider as a quality loss. This can be present in two forms:

A. **Rework and quality defects**: These losses are caused by the defective products during the routine production. These products are not according to the specifications requirements. So rework is required to remove the defects or scrap these products. Labor is needed to make rework which increases the cost for the company and material becoming a scrap is also another loss for the company. The amount of these losses is calculated by the ratio of the quality products to the total production.

B. **Yield losses**: They are caused by wasted raw materials. The yield losses are of two types. Type one is the raw materials losses which are caused by the product design, manufacturing methodology… etc. Type two is the adjustment losses caused by the quality defects of the products which are produced at the start of the production process, changeovers ….. etc.

4. Overall Equipment Effectiveness (OEE).

OEE is a result that can be expressed as the ration of the real output production of the equipment divided by the maximum production output of the equipment under the best performance condition. OEE was originated from the Total Productive Maintenance practices, developed by S. Nakajima at the Japan Institute of Plant Maintenance, the objectives of TPM is to realize the ideal performance and realize the Zero loss which means zero production scrap or defect, zero breakdown, zero accident, zero waste in the process running or changeover. The quantification of these accumulations of waste in time and its comparison to the total available time can give the production and the maintenance management a general view of the actual performance of the industrial plant. And it can help them to focus the improvement on the major loss [4].

4.1 Calculation of OEE

OEE can be obtained by the multiplication of the three basic bases for the main six major losses:

A. Availability indicates the problem which caused by downtime losses.
B. Performance indicates the losses caused by speed losses.
C. Quality indicates the scrap and rework losses.

***OEE = Availability rate x Performance rate x Quality rate*……………………………………….(1)**

4.2 Availability

The availability is calculated as the required availability minus the downtime and then divided by the required availability. This can be written in the form of formula as

***Availability = ((Required availability – Downtime)/ Required availability) * 100*
…….…………………………… *(2)*

The required availability can be calculated as the time of production to operate the equipment minus the other planned downtime like breakdowns, meetings….. etc. The down time can be calculated as the actual time for which the equipment is down for repairs or changeovers. This time is also sometimes known as the breakdown time. The output of this formula gives the true availability of the equipment. This value is used also in the overall equipment effectiveness formula to measure the effectiveness of the equipment.

4.3 Performance

The performance rate can be calculated as the ideal or design cycle time for the production of an item multiplied by the output of the equipment and then divided by the operating time. This will give the performance rate of the equipment. The formula to calculate the performance rate can be expressed as

***Performance rate = ((design cycle time * output)/ Operating time) * 100*…………………………. (3)**

The design cycle time or the production output will be in the unit of production, like parts per hour and the output will be the total output in the given time period interval. The operating time will be the availability value of the availability formula. The result of this formula will be in the percentage of the performance of the equipment.

4.4 Quality

The quality rate can be expressed as the production input into the process or equipment minus the volume or number of quality defects then divided by the production input. The quality rate can be expressed in a formula as

***Quality rate = ((production input – quality defects)/ Production input)* 100*………...……………. (4)**

The production input means that the unit of product being feed into the production process. The quality defects mean the amount of products which are below the quality standards i.e. the rejected items after the production process. This formula is very helpful to calculate the quality problems in the production process [9].

5. Proposed conceptual managerial dash board (MDB) network in LISCO.

Based on the on the survey study conducted in LISCO the conceptual layout of the computer network required for managerial MDB connectivity includes 6 types of switches utilizing fiber optical cables and wireless connectivity as shown in the following figure:

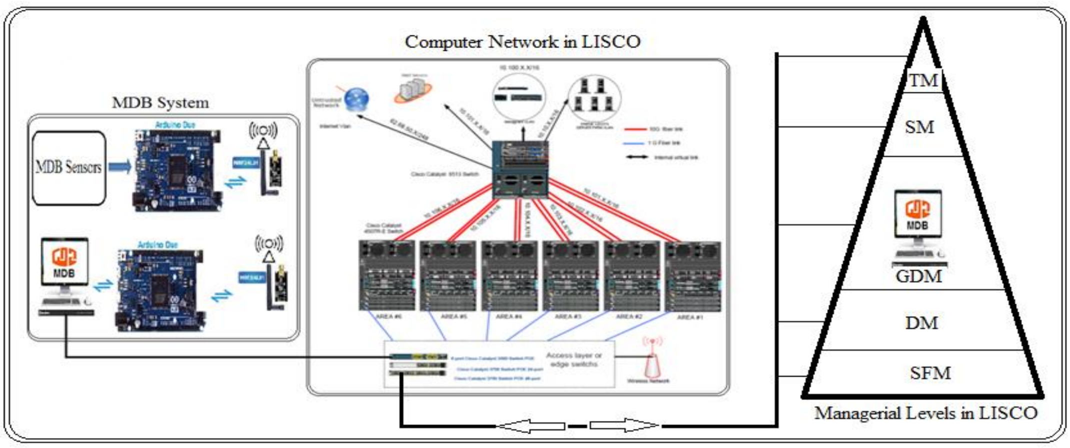

Fig. (1) : Conceptual managerial dash board (MDB) Network Layout in LISCO.

The network includes one core switch Cisco 6513 Series that connects Six Distribution Areas using six 4507 Cisco switches, the connectivity between the core Switch and the distribution Switches using 10 G Ethernet link (two Links for each distribution Switch for higher Transmission Medium Reliability). Each distribution area includes access switch Switches connected by 1G Fiber Link (One Link from each access Switch to distribution Switch). The conceptual design objective of Managerial Dash Board (MDB) network in LISCO is to provide connectivity between managers in LISCO and the proposed MDBs using wire or wireless connection taking in to account reliability, resilience and maintaining network Security.

5.1 Conceptual managerial dash board (MDB) Hardware and software Layout.

The following Block Diagram presents hardware concept for managerial dash board (MDB) based on using wireless NRF24L01 for data transmission, Arduino Due for KPIs data collection and a PC Computer for MDB data processing , the cost effective proposed system can collect data from six location within the industrial Plant, then it Processes data to generate Industrial Managerial KPIs to function as computer aided industrial management, where managers in LISCO can accesses MDBs distributed all over the Iron and Steel Complex .

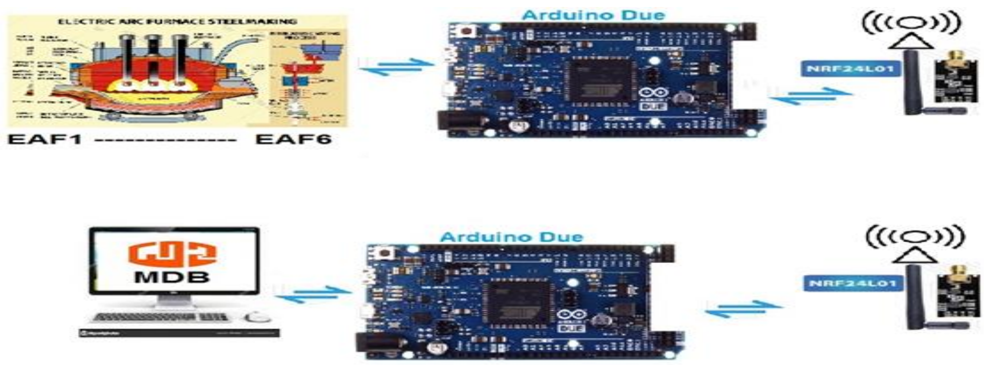

Fig. (2) Proposed conceptual MDB hardware layout for Steel Melt Shop Plant 1&2 for six electric arc furnace.

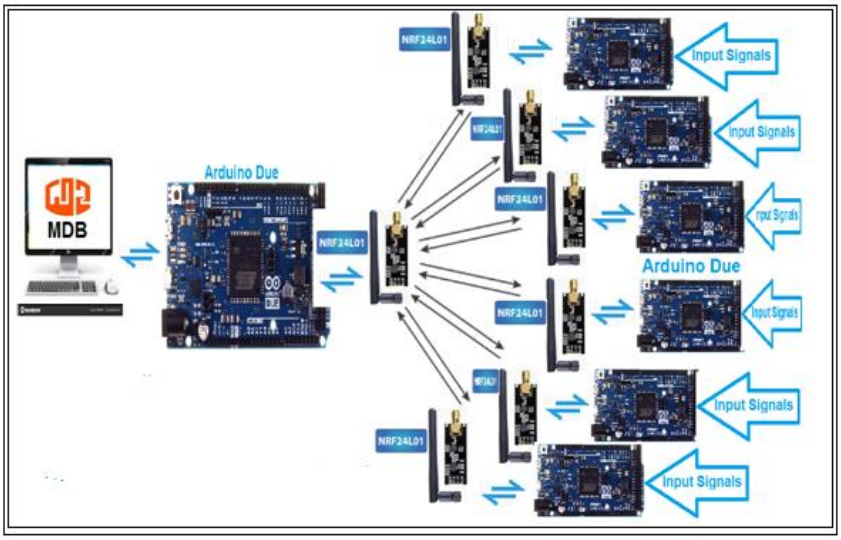

Fig. (3) Conceptual hardware layout for the proposed MDB In LISCO

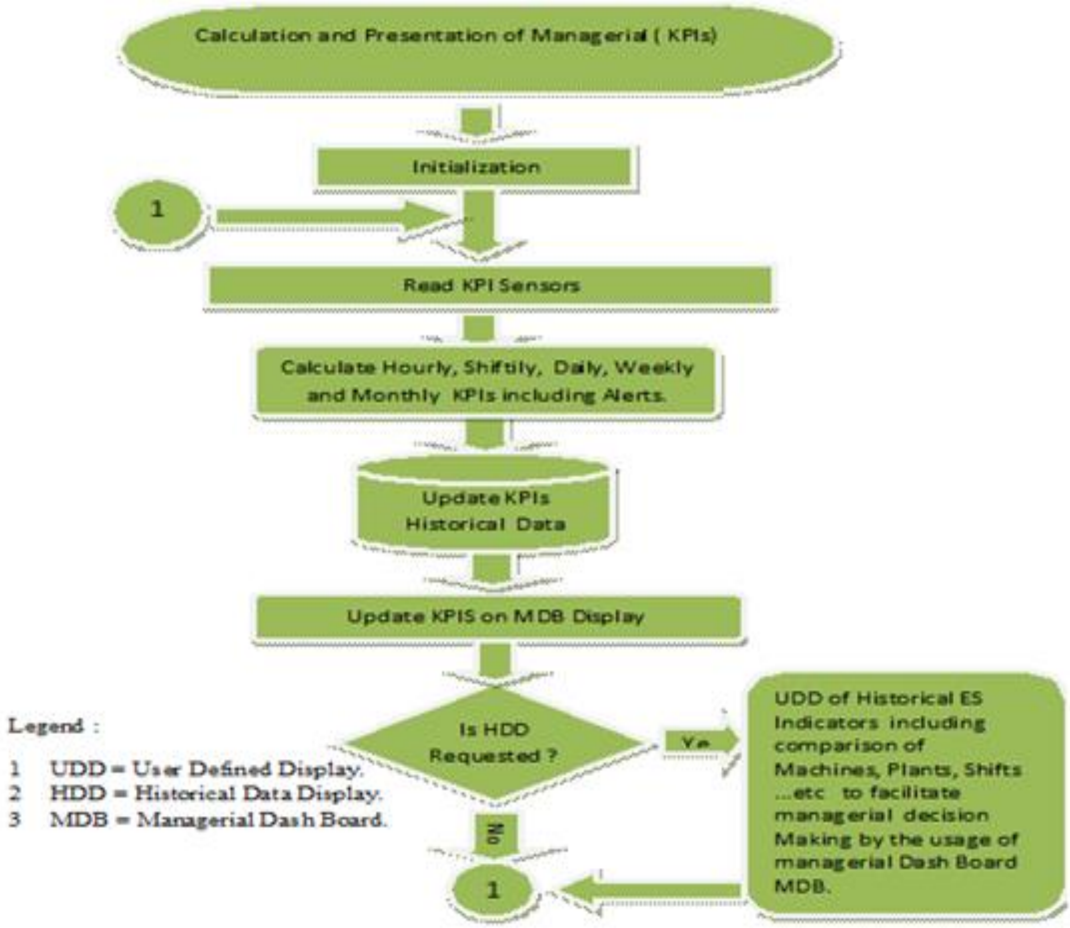

Fig. (4) Conceptual Flow Chart for MDB Software.

6. Discussion

In LISCO they never thought of having a digital system which calculates their performance. Without electronic calculation of OEE it is difficult to improve it, using digital OEE measurement system makes it possible to monitor the overall performance of the company and individual equipment, the overall availability of the company and individual equipment and the overall company quality and individual equipment. Table 1 shows the world class OEE, Availability, Performance, Quality.

Table (1): World-class measurements for OEE KPIs

Industrial Key performance Indicators (KPIs)	World-class Measurement (WCM)
Availability	90%
Performance	95%
Quality	99%
OEE	84.645%

Table (2) : A sample of managerial KPI Groups tested .

Serial Number	Managerial KPI groups tested	Industrial Plant	Output on MDB: Real Time	Output on MDB: Comparison of Historical KPIs	Output on MDB: Presentation of Historical KPIs
1	Utilities	DR, SMS1&2, , BRM, LMS, HSM, CRM, Calcining plant, PDP,CWS, Oxy Plant,	To be displayed Graphically or Numerically on Managerial Dash Board (MDB) for each Managerial Level with Reference to LISCO Managerial Hierarchy in Chapter One	To be made and Presented Graphically or Numerically for Shifts, Plants, Days, Weeks..etc	To be Presented Graphically or Numerically for Shifts, Plants, Days, Weeks..etc
2	Environmental Safety				
3	Process Input				
4	Production				
5	Productivity				
6	Human resources				
7	Mean time between failure				
8	Mean down time				
9	Delays minor & major stoppages				
10	Utilization				
11	Availability Rate				
12	Performance Rate				
13	Quality Rate				
14	Over all equipment effectiveness				

Fig. (5) OEE testing Human Machine Interface (HMI) for direct reduction plant module 1.

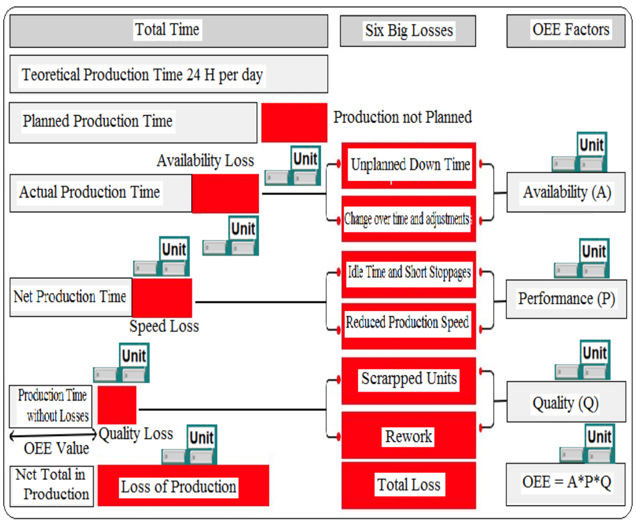

Fig. (6) Proposed OEE managerial dash board (MDB) display

Table (3) : Testing Requirements .

S.N	Items	Quantity
1	Laptop + LabVIEW Package	1
2	Arduino Due	7
3	NRF24L01	7
4	Signal Generator	1
5	Breadboard	1
6	Connection Wires Set	1

7. Conclusion

By implementing the TPM strategy they can eliminate most of the waste happened like the time waste while changeover or the downtime losses, with this maintenance strategy the responsibility of maintain the equipment is all operator and engineering responsibility, there will be no more "his or my" fault the break down will be solved as fast as possible. The operator in the shop floor should involve in each maintenance operation because he is the one close to the machine and he know what are the abnormality of the machine. There are three main techniques will have a very good impact to improve the production line and make the maintenance process more effectively, CMMS, production planning, those techniques will help the company to operate at high rate of performance without losses. The project gives new huge step to the company in calculation the performance and how they can focus on the problems, when we formed a group from each department the company got a chance to see how the team work is important in solving the problem. Another benefit of the project is to give them the chance to know what the best techniques that they can apply which will improve their performance. Calculating the OEE also give the company where they are and where is the weakness point and how to improve it.

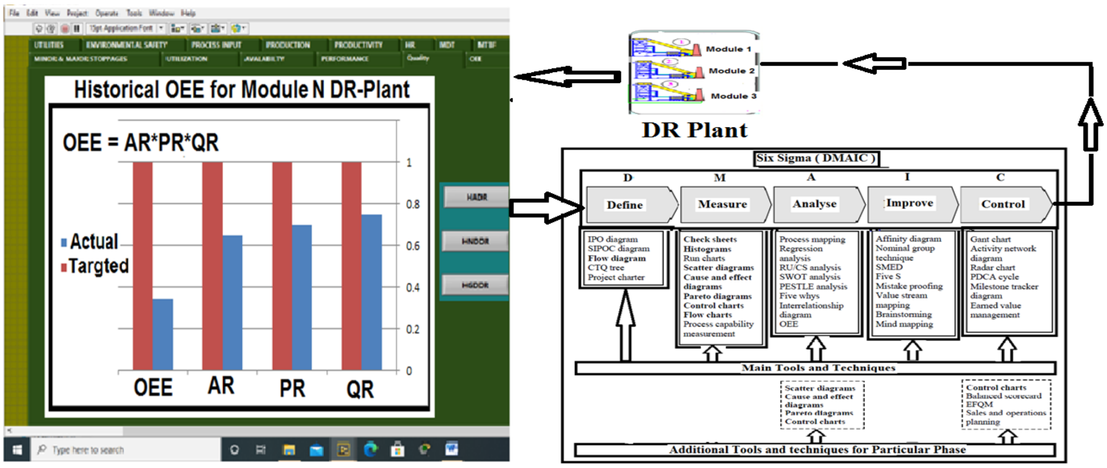

Fig. (7): Managerial Dash Board (MDB) based OEE improvement DMAIC methodology

8. References

[1] C.J. Bamber, P. Castka, J.M. Sharp, Y. Motara, "Cross-functional team working for overall equipment effectiveness (OEE)" Journal of Quality in Maintenance Engineering, Volume 9 Number 3, 2003.

[2] Nich, Rich ‘total productive maintenance: lean approach’, 1999, Tudor Business limited.

[3] E. Nadarajah, M. Sambasivan, S. Yahya, "Autonomous Maintenance – An Effective Shop-Floor Tool to Improve Productivity, Institute of Technology Management and Entrepreneurship Kolej Universiti Teknikal Kebangsaan Malaysia, 2006.

[4] Nakajima S., Introduction to TPM, productivity press, Portland , 1988.

[5] Rajiv Kumar Sharma, Dinesh Kumar and Pradeep Kumar, "Manufacturing excellence through TPM implementation: a practical analysis", Industrial Management & Data System, Vol. 106 No. 2, 2006.

[6] Terry Wireman, Total Productive Maintenance, 2nd edition, 2004.

[7] Muhammad Shahid Tufail, Investigation of the ways to improve the performance of a plant, Växjö University School of Technology and Design, 2007, http://www.vxu.se/td.

[8] Heinz P. Loch, "Improving machinery reliability", 1998.

[9] Mobley R. K, An introduction to maintenance, 2nd ed,USA, 2002.

[10] C.J. Bamber, J.M. Sharp and M.T. Hides , "Factors affecting successful implementation of total productive maintenance A UK manufacturing case study perspective", Journal of Quality in Maintenance engineering, Vol. 5 No. 3, 1999.

[11] Wireman T, computerized maintenance management systems, 1994, 2nd ed, New York,USA.

[12] Willmott, P, TPM: Total Productive Maintenance: The Western Way, Butterworth-Heinemann, 1997, Oxford

[13] Robertazzi, Thomas G. ―Basics of computer networking, Book, Springer, 2012.

[14] GuWenwu, He Qingzhong, Zhou Tie, Zhang Yanling. Based on LabVIEW and Intelligent Instrument Data Acquisition System. Instrument Technology and Sensors, 2012.

[15] Wang Chenhui, Wu Yue, Yang Kai. Design of multi-channel data acquisition system based on STM32. Electronic Technology Application, 2016.

[16] Chen Cheng, Li Ruixiang, Liu Tingting, Liu Yi. Research on wireless data transmission system based on nRF24L01[J]. Electronic Science & Technology,2016.

[17] Ma Wei, Yan Dongxing, Zhang Shaojie. Wireless temperature and humidity test system based on nRF24L01. Electronic Design Engineering, 2012.

[18] Zhu Huiyan, Lin Lin. Design of wireless communication system based on MCU and nRF24L01. Electronic Science & Technology,2012.

[19] Steven Barre .“Getting Started” in Arduino Microcontroller: Processing for Everyone!, 2nd ed., San Rafael, California, USA: Morgan & Claypool 2012.

[20] S. A. Ram, N. Siddarth, N. Manjula, K. Rogan, K. Srinivasan . “Real-time Automation System Using Arduino”, 2017 International Conference on Innovations in information Embedded and Communication Systems (ICIIECS), Coimbatore, India.

[21] Y. Wang1, C. Hu, Z. Feng1, Y. Ren1 (2014) "Wireless Transmission Module Comparison", 2014 IEEE International Conference on Information and Automation (ICIA), Hailar, China.
[22] P. Christ, B. Neuwinger, F. Werner, U. R¨uckert . "Performance analysis of the nRF24L01 ultra-low-power transceiver in a multi-transmitter and multi-receiver scenario", SENSORS, 2011 IEEE, Limerick, Ireland.
[23] Sung H. Park Six Sigma for Quality and Productivity Promotion.Published by the Asian Productivity Organization 2003.
[24] Varsha M. Magar, Dr. Vilas B. Shinde . Application of 7 Quality Control (7 QC) Tools for Continuous Improvement of Manufacturing Processes. International Journal of Engineering Research and General Science Volume 2, 2014.
[25] Pyzdek, T., Quality Engineering Handbook, Second Edition, Marcel Dekker, Inc., New York, 2003.
[26] Pimblott, J.G., Managing Improvement – Where to start, Quality Forum, Vol. 16, 1990,.
[27] Juran J. M.. Quality Control Handbook, McGraw Hill, New York. 1974
[28] Kim, J.S. and Larsen, M.D: Integration of Statistical Techniques into Quality Improvement Systems. In Proceedings of the 41stCongress of the European Organization for Quality 1997.