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A Novel Index for Maintenance Operations in All Industries

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Abstract: *Maintenance operating system 4.0 (MOS4.0) is a new philosophy for maintenance operations in all industries to create more value. This study aims to create a maintenance index for machines, shop floor and plant maintenance operations in all industry. MOS4.0 index is a new key performance indicator (KPI) which including impact of preventive maintenance, predictive maintenance, prescriptive maintenance and cognitive maintenance for a machine, shop floor and plant in any industry. MOS1.0 means the machine or plant has just preventive maintenance that time based maintenance operations done. MOS2.0 means the machine or plant has preventive and predictive maintenance that data based maintenance operations done. MOS3.0 means the machine or plant has preventive, predictive and prescriptive maintenance that data based maintenance operations done. In this level, maintenance content will be applied is dynamic and can changeable depends to failures or problem happen in machine/systems. MOS4.0 is including MOS3.0 capabilities and additionally cognitive maintenance that maintenance operation done by machine itself. MOS4.0 is also a horizon in the maintenance which today not applicable for many industries. There is simple matrix defined in this study to help the people that they can calculate their MOS4.0 index. MOS4.0 index is too important for machine or whole plant efficiency. This KPI gives great idea related with maintenance cost, operation efficiency and also how they can optimize their machines or facilities. Another great impact is this KPI will let industry will check or request MOS4.0 index from machine producers for their purchasing decision.*

Keywords - *Maintenance, Preventive, Predictive, Prescriptive and Cognitive.*

I. INTRODUCTION

Maintenance operations has been done with conventional methods since a long time in all industries and sectors. The most known conventional method is preventive maintenance which is time based. This method is the first step in maintenance. The content and scheduling in this method are based on user experiences comes from machine failures and breakdowns. Improvement and efficiency in this conventional maintenance operation have always been research area [1-5]. It was too difficult create a link between maintenance activities and machine or system output. All calculations for efficiency were either paper based or some package software based which manually operated. Today, digital transformation lets we create a relation between the maintenance and system output. Recently, this transformation makes possible develop and improve predictive maintenance applications for machines or facilities [6-11]. Also, another one of the big step in maintenance operation is prescriptive maintenance. Prescriptive maintenance defines alternative actions in case of any failure predicted. This maintenance method create radical efficiency in production or machine output and bring creative application for systems [14-19]. The horizon maintenance operation method is cognitive maintenance which today not applicable for many industries due many restriction in machine and production line design. Technologies available in the market is also not enough robust to makes possible use cognitive maintenance. Currently, there many researches to improve cognitive maintenance and develop new technics in this field [20-23]. MOS4.0 philosophy redesign the maintenance operations based on digital transformation and define methodology how the industry should manage this philosophy for more value.

II. MOS4.0 INDEX

MOS4.0 is a new philosophy for maintenance operations in all industries to create more value and increase the efficiency. The main aim in this study to create a maintenance index which is a new key performance indicator (KPI) which including implementation of MOS4.0 for in all industries. MOS4. KPI is consist of preventive maintenance, predictive maintenance, prescriptive maintenance and cognitive maintenance activities for a machine, shop floor and plant in any industry. There are four steps in MOS4.0 philosophy. The first step is MOS1.0 that means the machine or plant has just preventive maintenance that time based maintenance operations done by operator as periodically. The second step is MOS2.0 that means the machine or plant has preventive and predictive maintenance that data based maintenance operations done by operator with fix content but dynamic scheduling. The third step is MOS3.0 that means the machine or plant has preventive, predictive and prescriptive maintenance that data based maintenance operations done. In this level, maintenance content will be applied is dynamic and can changeable depends to failures or problem happen in machine/systems with a dynamic scheduling as well. The last step is MOS4.0 is including MOS3.0 all capabilities and also cognitive maintenance that maintenance operations done by machine itself according to required maintenance content. MOS4.0 philosophy is shown in Figure1.

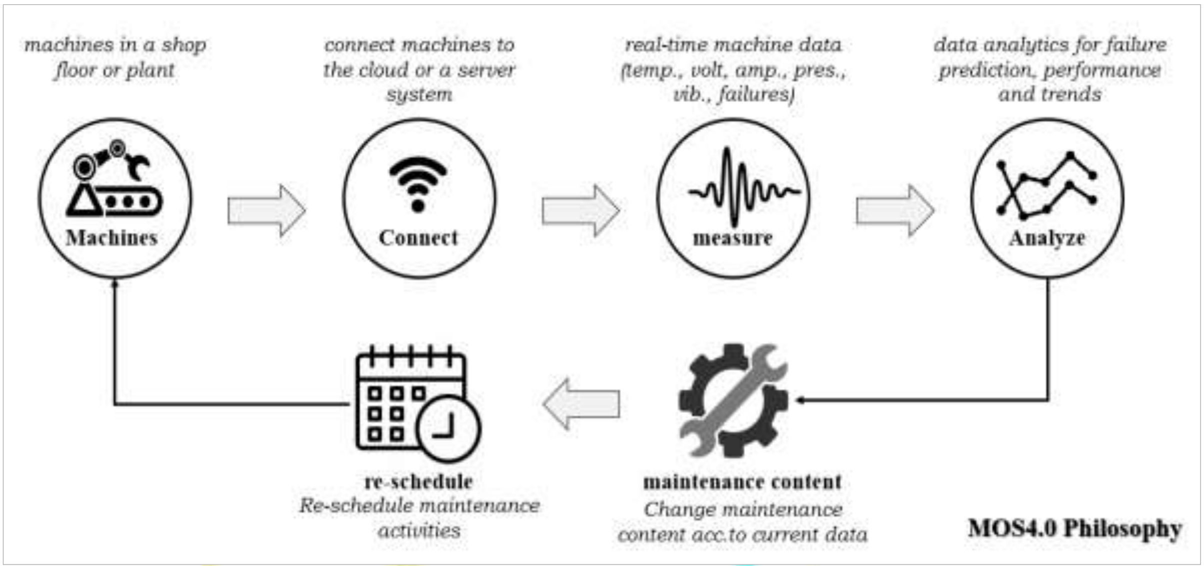

Fig. 1. MOS4.0 philosophy

Maintenance levels in this philosophy is indicated in the Table-1. The first approach is MOS1.0 that takes reaction after problem or failures happen. The second approach is MOS2.0 that takes reaction before problem or failures happen. The third approach is MOS3.0 that takes reaction before problem or failures happen and re-arrange the maintenance content. The last approach is MOS4.0 that takes reaction before problem or failures happen, re-arrange the maintenance content and also the action done machine itself.

Table 1. Philosophy and Approach for Mos4.0 Index

Maintenance Operation	Philosophy	Approach
MOS1.0 -Preventive	*Time based scheduling*	*What happened?*
MOS2.0 - Predictive	*Prediction based scheduling*	*What will be happened?*
MOS3.0 - Prescriptive	*Prediction based scheduling and analytics based for correction actions*	*What needs to be done for that will happen?*
MOS4.0 - Cognitive	*Full autonomous system*	*Do it what needs to be done for that will happen.*

Content and actions in MOS4.0 philosophy are shown in Table-2. Mos4.0 expect the industry change their maintenance operation from time based to data based. Also existing maintenance content and scheduling need to dynamic according to data that maintenance system produced.

Table 2. Content and actions in MOS4.0 index

Maintenance Operation	Maintenance Content	Maintenance scheduling	Machine data collection
MOS1.0 -Preventive	*static*	*time based*	*Manual or auto*
MOS2.0 - Predictive	*static*	*data based*	*auto*
MOS3.0 - Prescriptive	*dynamic*	*data based*	*auto*
MOS4.0 - Cognitive	*dynamic*	*data based*	*auto*

III. MOS4.0 Index Requirement

MOS4.0 index requirements are start from machine itself. Basically, if the machine has no any capability to generate data that means it cannot be implemented any step above MOS1.0. The core data of machine like vibration, current, voltage, temperature, torque and failures data. Additionally, the machine shall has interface that a data analytics platform able to collect these data. MOS4.0 index requirements are shown in Table-3. This table define requirement for a shop floor or a plant.

Table 3. Requirements for MOS4.0 Index

Maintenance Operation	Sensors & machines data	Data analytics	Dynamic scheduling	Content producer
MOS1.0 -Preventive	*no*	*no*	*no*	*no*
MOS2.0 - Predictive	*yes*	*yes*	*yes*	*no*
MOS3.0 - Prescriptive	*yes*	*yes*	*yes*	*yes*
MOS4.0 - Cognitive	*yes*	*yes*	*yes*	*yes*

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MOS4.0 index requirements will force machine manufacturers to improve their products in this digital era. Otherwise the customer will be under the investment cost pain. The best way is together (machine manufacturers and customers in industry) create a value. This collaboration makes possible fully penetration of MOS4.0 index in all industries. MOS4.0 index calculation is basically very simple and it helps the user that they will be able to figure out their machine or facility capabilities according to MOS4.0 levels.

IV. Impact of MOS4.0 Index

The most important key metrics in maintenance are investment, maintenance labor, maintenance efficiency and of course the production line or equipment's OEE (Overall Equipment Effectiveness) value. The MOS4.0 index impact on these major metrics are shown in Fig.2. As it shown, MOS1.0 require less investment, more labor, less efficiency and also it has low output for OEE.

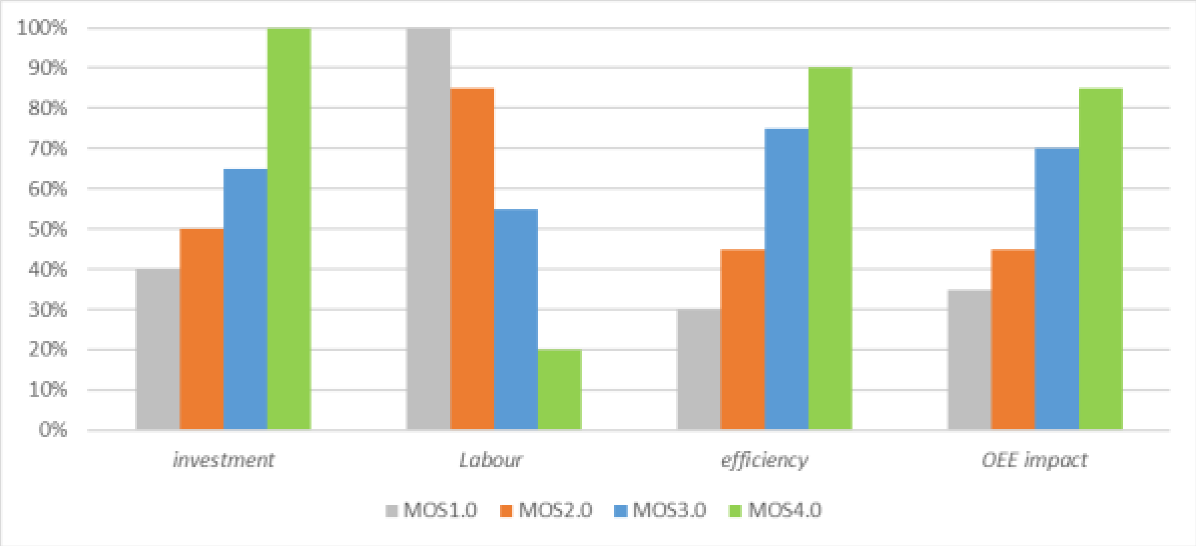

Fig. 2. Impact of MOS4.0 Index.

MOS2.0 require additional %25 more investment according to MOS1.0 but create more value for other metrics. %15 less labor, %50 more maintenance efficiency and %28 more OEE. MOS3.0 require additional %30 more investment according to MOS2.0 but create more value for other metrics of MOS2.0. %35 less labor, %66 more maintenance efficiency and %77 more OEE. MOS4.0 require additional %53 more investment according to MOS3.0 but create more value for other metrics of MOS3.0. %63 less labor, %20 more maintenance efficiency and %21 more OEE.

V. CONCLUSION

MOS4.0 index is completely a new philosophy redesign the maintenance operations based on digital transformation and define methodology how the industry should manage this philosophy for more value. MOS4.0 index identified as a new key performance indicator (KPI) which including impact of preventive maintenance, predictive maintenance, prescriptive maintenance and cognitive maintenance for a machine, shop floor and plant in any industry. All requirements are defined for MOS4.0 index. There is simple matrix defined in this study to help the people that they can calculate their MOS4.0 index. The last level of MOS4.0 index is 4.0 that is also a horizon in the maintenance which today not applicable for many industries. MOS4.0 index is too important for machine or whole plant efficiency. This KPI gives great idea related with maintenance cost, operation efficiency and also how they can optimize their machines or facilities. Another great impact is this KPI will let industry will check or request MOS4.0 index from machine producers for their purchasing decision.

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