

Conference Paper

Manufacturing Execution Systems and a Sectoral Application

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Abstract

Information systems have widespread usage on Manufacturing Systems. Most companies need tracking production processes with information systems to become prominent in highly competitive environment. There are some specific metrics need to be followed and important to access these datas on time and also should be reliable. These metrics include all manufacturing and quality processes. In this context; efficiency, line stoppages, malfunction and interruptions, body and supplied part trace ability informations are needed. This study MES (Manufacturing Execution Systems) is the system developed for tracking production processes.

MES is working from receipt of order to delivery of the product that are the essentials for the production activities to achieve real time status of all manufacturing data. In this way, all information which not manually recorded or takes long process time to record or can be tracked instantaneously and these records can be reached and analyzed in the future. The system also provides accurate data for us.

In this study all phases from design to implementation of an automotive subindustry firm's MES application designed based on integrated software process requirements are depicted. Relevant system's integrated software will be implemented to Module Line. This study will allow tracking related product's all process, decision making and traceability data with serial numbers.

Keywords: MES, Manufacturing Execution Systems, Information Systems, Traceability

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1. Introduction

Global manufacturers must aim to achieve better control and increased transparency of their manufacturing processes across all sites. Here, our manufacturing execution systems (CMES) come into play. These systems control and trace all processes connected to the research and manufacture of fuel filter products using seamlessly integrated enterprise resource planning systems, automation, and other components in the value chain, for targeted production and real-time transparency. CMES are indispensable

technology solutions for optimum operational procedures at paperless production line, as it guarantees reliable traceability and cover all manufacturing processes.

2. Production and Production Operations Management

Production can called purpose raises the demands of the people. Primitive human has no doubt that a large part of his/her time was spent to meet their basic needs. Those times the important things were clothing, eating and civilization like now. However, they stopped their vehicle showed significantly changed. Using the moneraty system has facilitated with this development process. So that moneraty system, forecasted to pay money to employees and let the money used for the purchasements later. (Hulusi & Gümüşoğlu, 2004).

Production management means that the company in the hands of material, machinery and manpower resources of the required quality products in a certain amount of quality, in the mean time putting together in a way that provides the lowest cost producer.

In amount of large quantity productions, while reducing the cost of production per product inventory may increase the cost of transport and the resulting the remaining stock. Therefore, managers are faced with the trade-off because of the conflicting options in decisions about production. The purpose of production management discipline can be defined as the development of appropriate tools and methods for using executive decision-making ability [6].

3. Production Efficiency and Productivity

The business and manufacturing strategy allows organizations to become more competitive situation in the market. All production operations to meet customer needs, flexibility, time, while performance criteria such as quality in an attempt to make it the most cost-effective. Used to measure success in this area is the most common indicator of manufacturing activity efficiency. The outputs can be services and the inputs can be labor, raw materials, consist of energy and other resources in the organizations.

$$\text{Efficiency} = \text{output} / \text{input}$$

Efficiency is generally described as the ratio of input to output is used to produce it. If the organizations uses the resources more effective, than can be more efficient. Efficiency is generally described as above.

Efficiency calculations can be changed in every organization. For the nonprofit organizations, high efficiency means that low cost, but for the profit companies, efficiency means that the most important thing is the competition power. The efficiency increase ratio is very important for the development and growth of a country. Productivity growth is considered to be an indicator of how changes compared to the previous period's data in a specific period (Rivest, 1992).

4. Manufacturing Information Systems

Production information system, covering goods or services for the planning and control of manufacturing processes and all related activities identified in the form of an integrated information system that supports the production function of the company. The most common sense of the information systems, the regulation to address the diverse needs of the information, the processing is stored and organized a body of rules to be delivered at any time.

Information: Information means, decision making, execution, planning and controlling for the managers. That is why information must be formal and correct; otherwise it will not provide enough information to user [11].

Data, information relationship: When we need to check the data, information relationship, the process of turning data into information, and therefore it is possible to add value to the data in various ways [2].

Modern production systems foresee the product from design to production with computer controlling in every step. Production area reflections to the Computer Technology happened with Computer Numerical Control (CNC), Flexible Manufacturing Systems (FMS) and Computer Aided Design / Engineering / Manufacturing Systems, briefly covering them all Computer Integrated Manufacturing (BBU) [5].

5. Manufacturing Execution Systems

Usually collected datas from business and ERP are used to calculate the efficiency of the machines. These informations are collected in a central server platform and used for detailed questioning and analysis. In this platform, including database and Web servers, data security, query speed and ease of use, ease of backup, flexible, variable and generates the necessary technological base for traceable reporting from the web. Other clients that connected to the platform can use both control and system monitoring purposes. Data collection is often used for the purpose of communication ports of PLC present in the machine. New data collection equipment in non-PLC device is added to the system. Overall input and output in numbered pieces will be taken from each machine intended to transfer to the MES system in case of important information about the machine center.

Standard manufacturing execution system comprises the following components;

- Data Tracking Software
- Central Hardware (server)
- Data Collection Hardware/Software
- MES Operations Module
- Operator Interfaces and Hardware
- Reporting System. (ST. Otomasyon Dergisi, 2009)

The most common approach in industrial practice in the face of disturbances is a monolithic MES implementation that heavily resorts to an optimized schedule achieved

through mathematical optimization techniques representing a reference or target for execution control at the shop-floor level over the chosen time horizon [7].

5.1. Planning System Interface

The MES should be directly coupled to the planning system to accept work orders and all other input and to provide upload information as necessary. The communications should be two way so the MES can keep the planning system properly informed about plant activities such as labor data, inventory changes, and work order progress. Other methods of data entry and reporting can easily be accommodated, and in some cases, such as more continuous process, production orders may not be used at all [8].

5.2. Work Orders

The MES accepts the Work Order through automatic or manual entry. It manages changes on orders, establishes and changes schedules, and maintains a prioritized sequenced plan.

Releasing orders to production and establishing a current order priority list based on your sequencing rules is a normal part of MES. Frequently changes must be made to release orders. Within MES, order modifications such as these examples can be done easily:

- Enter schedule changes.
- Mark for material shortage.
- Place on hold.
- Split order or combine orders [9].

5.3. Work Stations

This part of the system is responsible for implementing the direction of the Work Order plan and the logical configuration of the workstations. The planning, scheduling, and loading of each operational Work Station is done here, providing the current and total shop load by operation using routing data and time standards. Based on this plan, the system will request and manage delivery of inventory, tooling, and data in response to the Bill of Material requirements and will issue and execute commands to move the required items to the planned workstation. The MES can and should include the direct control interface and connection with each workstation [1].

6. Aim of the Project

CMES is manufacturing execution system that can easily follow production values in real time. CMES system's basic functions;

- Real time data collection from production

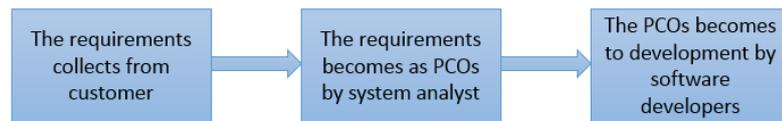


Figure 1: PCO (Plant Custom Objects) development flow.

- Data processing and reporting

CMES can help to collect efficiency and OEE values in real time for lean and traceable production management. This project planned to be implemented due to efficiency concerns up to 3% in module assembly line, it can be calculated as 2550 pieces per year. Nowadays manufacturing business focused on three targets;

- To reduce the costs
- Increase the productivity
- Increase the quality

7. Scope

Application will be implemented to Module Assembly production line in Cummins Filtration Izmir. Totally working 8 operators with 2 shifts in module line. Daily production target is 325 and yearly 85000 pieces. The other target in this study to meet the operational excellence requirements. Operational excellence means that using human, material and equipment resources as a stage 100% effective.

8. Method

Cummins is using a global MES solution firstly started to use in Darlington – UK. We made a system analysis to find a solution and made a decision that Cummins Filtration Turkey plant has developed own solution to use in Module Assembly Line. It's called as CMES Assembly. CMES assembly uses global brand of MES systems Apriso with building their own plant custom objectives. Those PCOs includes station based operations, process flows and data collection points and all logics are developed and prepared by myself. We examine "Pump Test Station" functional assessment document in below.

The PCO is a document for the developers that explains all the process and data flows machine by machine. We can see the PCO developments flows in Figure 1.

Functional Description/Business Flow: Functional Assessment defines the "Custom Logic" PCO that will be executed at the Pump Test Station. The logic will be called by the IPV Upload PCO and used to process the AMI string after the prefix and suffix have been stripped. (The AMI Upload logic does not parse the upload string and save the values, because the IPV data needs to be saved before the AMI data is saved.)

Background Information:

Pump Test is the first background station on the GZM line after the two assembly stations. There are two operations performed at the Pump Test station.

- The first operation is a Vacuum Test. This is a standard test performed on all parts. If the test equipment cannot create a vacuum with the module, the product fails the test and it is routed to the Repair Station.
- It is currently not possible to collect any actual values from this test; however, Pass/Fail information can be captured. When new machinery is procured and installed, then actual test values will be collected.
- The second operation at this station is a Pressure Test. A screwdriver applies pressure to the handle, and if a force of 3.26 Nm is not reached, the test fails. The product is routed to the Repair Station. This is a standard test performed on all parts.
- If both tests pass, the part is routed to the next station for a vision test.

The AMI Upload string processed by the "Custom Logic" PCO will include a final Handle Torque value and a final Pump Pressure value. Each test may be performed multiple times but only the last value for each test will be uploaded to CMES.

If there is a mechanical issue at the workstation before the test procedures actually begin, (e.g., the lifting operation fails to work before the test process) then the operator will hit the Reflow Button. A Failure Code of "999" will be sent to CMES via the IPV Upload that executes immediately before this "Custom Logic" PCO. In this case, the test values will be the highest values in the respective ranges, while the Test Results and Overall Pass/Fail will indicate a Bypass situation.

If the Overall Pass/Fail value is 0 (Fail), a query in the PCO will retrieve the Failure Code that was posted by the IPV Upload. The query will also retrieve the associated Defect Category 1, Defect Category 2, and Defect Name values. A Stop Build defect will then be posted accordingly. (The IPV Upload PCO will not post a defect; therefore, the plant will not have duplicate defects for a single issue.)

The custom logic described in this document will allow CMES to parse the AMI upload string, and save the final values and results to the Test Data History and Test Data Detail History tables in the CMES database.

The AMI Upload string that is passed to the Custom Logic PCO from the IPV Upload PCO will have the 3-character prefix and 2-character suffix removed. The custom logic will parse the string based upon semicolons located between the individual values. It will then write the values to the appropriate tables and perform validation checks. It will post App Logging messages and/or defects if validation fails.

This functional assessments includes below contents;

- PCO Requirements
 - Workstations
 - Data Collection Point from machines
- Data Processing
 - Variables
 - Parse Values

Value	Item Name
039	String Length
0	Process Type
106	Pallet number
104	Recipe Number
002	Handle Torque
-00.25	Pump Pressure
03.00	Pump Sustain
111	Pump Test Results
0	Test Count
1	Overall Pass/Fail

TABLE 1: AMI upload string detail.

- Error Handling – Defects and Application Logging
 - Missing Data
 - Extra Data
 - Data Validation
 - Test Limit
 - Overall Process Bypassed
 - Overall Process Failure

For example if we examine the “data validation” under “error handling” content, see that what happens after overall pass/fail portion of the upload string is not 0,1 or 2 in Figure 2. Also we can see a sample AMI upload string in below.

AMI Upload String: 0390;106;104;002;-00.25;03.00;111;0;10K

9. CMES Application

Cummins started to use MES in Darlington-UK due to traceability requirements and efficiency concerns. It is considered as an advantage for the company to reach the high level of production efficiency in an increasingly competitive environment. Furthermore a system has become necessary for the traceability of side pieces additionally attached to the main mounting portion of the engine. Manufacturing execution system in different business units are implemented using different modules.

Some MES modules that is using in company;

- CMES Assembly; using in engine assembly operations
- CMES Machining; using in machining operations
- CMES-NSPT (non-serialized product tracking); especially using in filter production without serial number products.

We can see the overview of CMES operations in Figure 3. We provide the information related product references and work orders from Oracle ERP system. CMES uses the

Data Validation

If the 'Overall Pass/Fail' portion of the upload string is not 0, 1 or 2 then the following will occur:

1. The invalid value will be saved in memory for use in the App Logging message.
2. A zero (Fail) be written to the Test Data Detail History table in CMES.
3. The following App Logging message will be posted to SHR_T_APP_LOGGING:

App Logging Message	"The Overall Pass/Fail value for Serial Number <SN> at Station <WORKSTATION> is invalid. The uploaded value is "<uploaded value>", but only 0,1 and 2 are allowed."
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4. In addition, the following Stop Build Defect will be posted:

Defect Category 1 (up to 20 characters)	Automatic Defect
Defect Category 2 (up to 20 characters)	Invalid Value
Defect Name (up to 50 characters)	Pump Test Overall Pass/Fail is invalid.
Defect Code (REASONCODE) (up to 20 characters)	GZMPumpOAPFInval
Defect Comment	"The Overall Pass/Fail value for Pump Test is not valid. Please contact CMES Support."
Build Property	Stop Build

Figure 2: Functional assessment "Data validation".

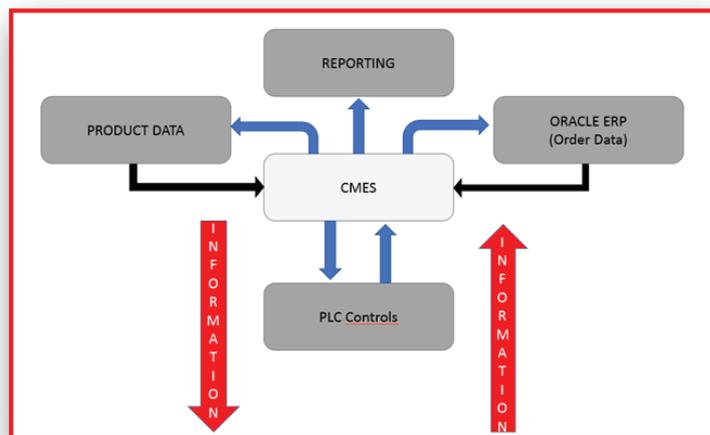


Figure 3: Overview of CMES operations.

PLC infrastructure for managing the production machines. There is a dataflow between CMES to PLC system as you see in above Figure 3.

In Figure 4, we can see CMES operator interface, it calls also as an assembly screen and the functions are including;

- Assembly informations
- Operating Procedures

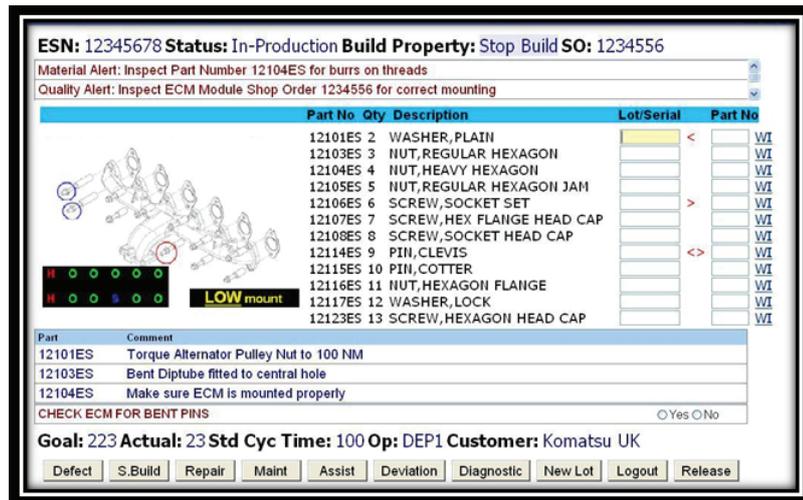


Figure 4: CMES operator interface.

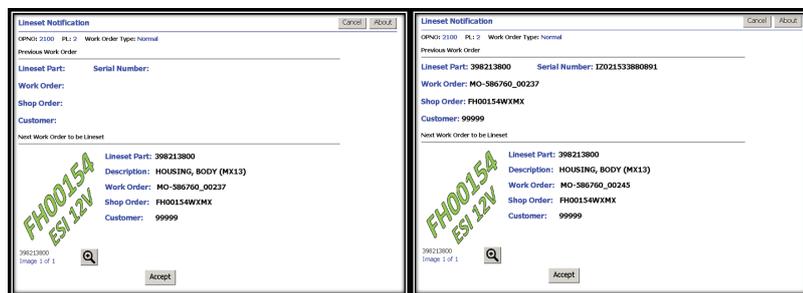


Figure 5: CMES lineset screen.

- Quality Alerts
- Product Repair History
- Cycle Time Collection
- Part Serial Number Traceability
- Real time Bill of Material Deviation

10. Application Steps

In Figure 6, we can see the lineset screen, lineset screen manages the work orders that comes from Oracle ERP system. "Next Work Order to be Lineset" section we see lineset part, description work order, shop order and customer details. When we push the "Accept" button, the next work order directly goes to assembly station. Manufacturing operations the most important client is Lineset.

In Figure 5, on the left side there is an image calls as "FH00154", it shares us the product's reference name. It also uses as a poke-yoke for the operator. Operator knows which product

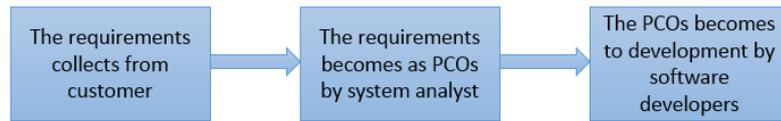


Figure 6: High level process diagram of CMES.

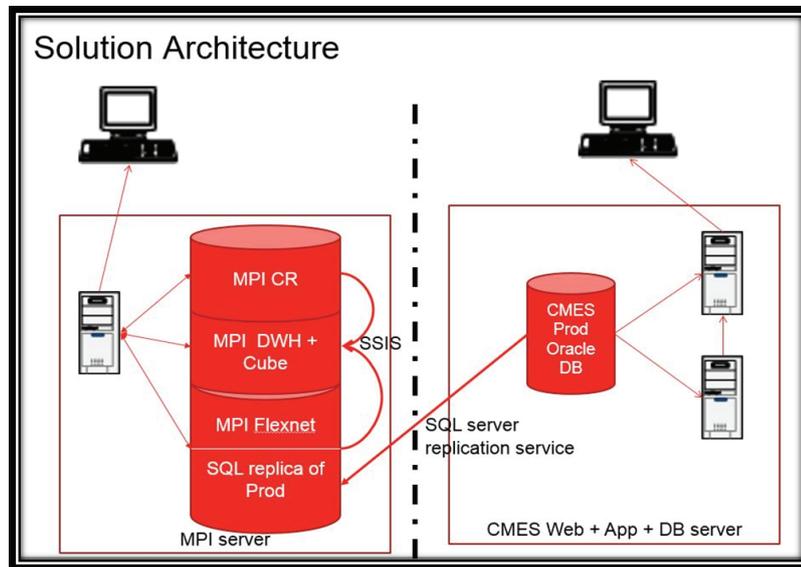


Figure 7: MPI (Manufacturing Process Intelligence) reporting solution architecture.

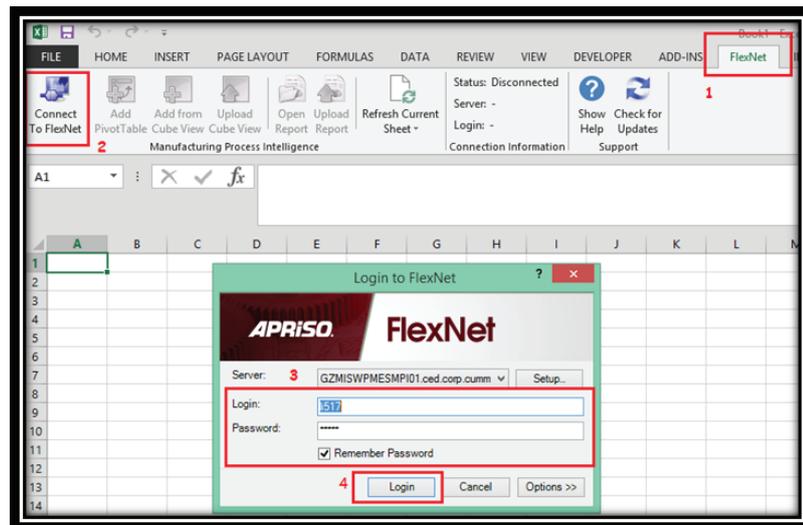


Figure 8: MPI Reporting excel flexnet add-in.

11. Reporting

All the datas that collected by CMES system stored in database. We should have a reporting system to analyze this data. In case of any complaint from customer, the reporting system is so important to check the product history. Thus, we developed a reporting system for CMES.

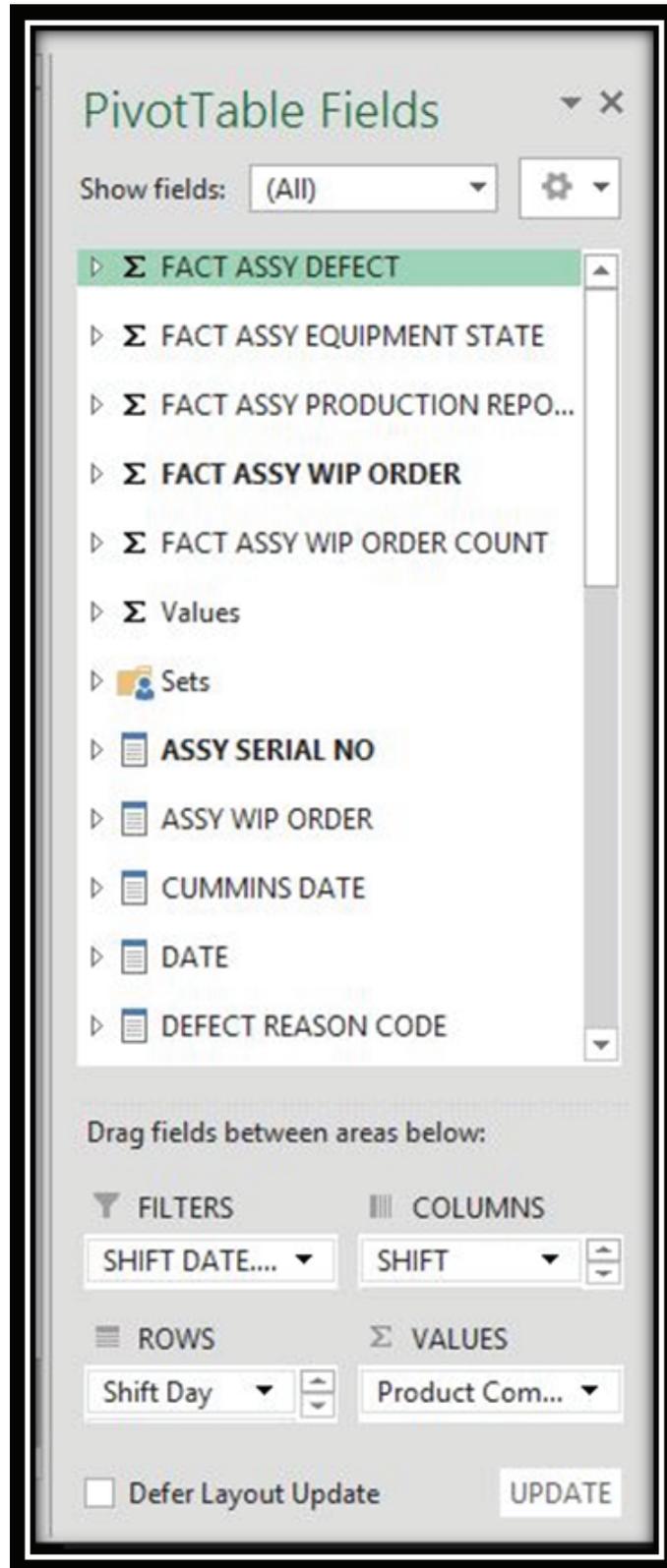


Figure 9: MPI Reporting prepared pivot fields.

We use Manufacturing Process Intelligence background for the reporting system. We can see the MPI Reporting system architecture in Figure 7. The data flows from CMES

Shift Day	Serial No	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Monday, February 15 2016		4	18	17	18	11	17	21	16	21	12
Tuesday, February 16 2016		22	19	17	22	12	8				
Grand Total		26	37	34	40	23	25	21	16	21	12

Figure 10: MPI Reporting – product count report.

Serial No	Wip Order No	Product Completed	Defect Count	FTQ
IZ021603992657	MO-590229_00232	1	2	0
IZ021604092716	MO-590229_00156	1	0	1
IZ021604092717	MO-590229_00161	1	0	1
IZ021604092718	MO-590229_00298	1	0	1
IZ021604092719	MO-590229_00307	1	0	1
IZ021604092720	MO-590229_00314	1	1	0
IZ021604092721	MO-590229_00324	1	0	1
IZ021604092722	MO-590229_00325	1	0	1
IZ021604092723	MO-590229_00334	1	0	1
IZ021604092724	MO-590229_00340	1	0	1
IZ021604092725	MO-590229_00349	1	0	1
IZ021604092726	MO-590229_00351	1	0	1
IZ021604092727	MO-590229_00363	1	0	1
IZ021604092728	MO-590229_00364	1	0	1
IZ021604092729	MO-590229_00366	1	0	1
IZ021604092730	MO-590229_00367	1	0	1
IZ021604092731	MO-590229_00368	1	0	1
IZ021604092732	MO-590229_00370	1	0	1
Values		333	290	50
FTQ=(NOK/OK+NOK)				13,1%

Figure 11: MPI Reporting – FTQ Report.

Reason Code Description	Defect Name	Serial No	Defect Count
Dunk test ok	1st Leak Test Error	IZ021604092720	1
	2nd Leak Test Error	IZ021604092874	2
	1st Leak Test Error Total		3
	2nd Leak Test Error	IZ021604092741	1
Dunk test ok Total	2nd Leak Test Error	IZ021604092897	1
	2nd Leak Test Error Total		2
	4th Leak Test Error	IZ021604092822	1
	4th Leak Test Error Total		1
Heater sızdırıyor klipsler yağlandı	2nd Leak Test Error	IZ021604193056	1
	2nd Leak Test Error Total		1
Heater sızdırıyor klipsler yağlandı Total	1st Leak Test Error	IZ021603992657	1
	1st Leak Test Error Total		1
Tekrar gönderildi (Açıklama Yazınız)	AMI String not Fully Transmitted	IZ021604092839	1
	AMI String not Fully Transmitted Total		1
Tekrar gönderildi (Açıklama Yazınız) Total	1st Leak Test Error	IZ021604193030	1
	1st Leak Test Error Total		1
Unknown Reason Code			1
Unknown Reason Code Total			1
H2N2 Test Station Total			10

Figure 12: MPI Reporting – defect report.

Oracle database to SQL database, and then become a report by MPI Cubes. We came together to define the reporting needings with production, manufacturing and quality teams. These reports will be;

- Product Count Report by Daily/Hourly
- OEE Report
- FTQ Report
- Cycle Time Report
- Defect Report

The reports will be used by MS Excel with a flexnet add-in as see in below Figure 8.

The cubes became pivot tables for preparing above mentioned reports. We can see the pivot table fields in Figure 9.

The first prepared report is daily/hourly product count report as you see in Figure 10. The target of this report to check the product counts in a real time just using an excel file.

In Figure 11, we can see the FTQ report by daily. FTQ means first time quality, calculated as in below formula. NOK means failed part and OK means passed part.

$$FTQ = (NOK / (OK + NOK))$$

In Figure 12, we can see the defect report for H₂N₂ test station. Defect report is using by quality team to follow the defects and solutions for each failed product.

12. Conclusion

As a result of the needs assessment conducted on the basis of the project, the company survived the downturn with developed a module to current MES system. Consisting of the respective sections of this mechanism is intended to provide service offerings to staff and administrators are below;

- Data collection from machines are automatized with using a web based mes application.
- The history of product can be traceable now for potential customer complaints.
- Open points might be more visible for continuous improvement.
- Machine breakdowns can be easily reporting and maintenance department analyze the reports and taking actions as soon as possible.
- Manuel reporting completely eliminated.
- Processes are more lean and traceable now.

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