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Optimization of Manufacturing System through World Class Manufacturing

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Abstract: Each company struggles with the same question: How can I provide – at the lowest possible costs and with an acceptable delivery time – products or services that add maximum value for my customers? Firms must develop strategic objectives which result in a competitive advantage in the market place. There are many different methods which address this problem: Lean (the value adding organization), Six Sigma (the perfect organization), TOC (the unlimited organization), TPM (the smooth organization), RCM (the reliable organization) and QRM (the cellular organization). In addition, combinations of these methods exist, like Lean Six Sigma (value adding and perfect organization) and World Class (value adding and perfect and smooth organization). The aim of this work is to present establishments of the basic model of WCM for the logistics system in the automotive industry in order to improve the work standards. The result of this research was to develop principles on strategic objectives, performance measurement systems and performance measurement system linkages for improved organizational coordination.

Keywords: World class manufacturing, control processes, measurement, efficiency, optimization.

1. INTRODUCTION

Global competition has caused fundamental changes in the competitive environment of manufacturing industries (Bruzzone and Longo, 2010). Most companies would like to find the formula for the ultimate productivity improvement strategy. Thus, environment firms must be able to respond quickly to customer needs in order to regain their dominance as a major producer of high quality, price competitive goods (Black, 2002). Innovation is a necessary process for the continuous changes in order to contribute to the economic growth in the manufacturing industry, especially to compete in the global market (De Felice and Petrillo, 2013 a; Longo, 2011). In addition to innovation as a mode for continued growth and change, there are many other vehicles for growth in the manufacturing industry (Monsey, 2005). One in particular that has been gaining momentum is the idea of *World Class Manufacturing* developed by R. J. Schonberger (in the 80s) (Schonberger, 1986). In World Class Manufacturing the focus is on continuous improvement. As organizations adopt world class manufacturing, they need new methods of performance measurement to check their continuous improvement (De Felice and Petrillo 2013 b). Traditional performance measurement systems are not valid for the measurement of world class manufacturing practices as they are based on outdated traditional cost management systems, lagging metrics, not related to corporate strategy, inflexible, expensive and contradict continuous improvement. World Class Manufacturing (WCM) is a concept which has proven effective in regaining competitive edge. Several firms have adopted the approach. However, the majority of manufacturing organizations need to adopt WCM for an national effect. Approaches to establishing a creative climate to facilitate adoption of WCM are discussed (Kangis and Williams, 2000; Chan, 2002). Use of these techniques should enable the remainder of manufacturing organizations to replicate the success of the progressive firms that have adopted WCM. Definitely and in any case World-class manufacturing has attracted the attention of industries all over the world. This paper aims to develop and validate performance measures for world class manufacturing (WCM) in Italian context that could be used by managers/ practitioners in assessing and improving their logistics performance. The validated results are in Italian context, however, the instrument developed can be used in global context. The paper is structured as follows: Section 2 analyzes basic concept of the world class manufacturing system; Section 3 presents a real case study and finally section 4 analyzes results and conclusions.

2. WORLD CLASS MANUFACTURING SYSTEM

A review of literature reveals that there is no universally recognized definition of world class manufacturing (Kodali *et al.,* 2004). Schonberger coined the term "World Class Manufacturing" to cover the many techniques and technologies designed to enable a company to match its best competitors. Schonberger defined WCM as analogous to the Olympic Games motto – citius, altius, fortius, which translates to faster, higher, and stronger. Similarly, its equivalent, as applicable to WCM, is continual and rapid improvement. Performance measurements should therefore

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activate continuous improvement (Digalwar et Metri, 2005). As organizations adopt world class manufacturing, they need new method of performance measurement to check the continuous improvement (Francisco et al., 2003; Gosselin, 2005). To know the world class performance, measurement is important because "*if you can't measure it, you can't manage it and thus you can't improve upon*". This concept is a strategic vision of how a firm's productive resources relate to one another and to the environment. While there is no generally accepted definition of the WCM vision, several have been proposed depending on the nature of the firm. Companies attempting to adopt WCM have developed a statement of corporate philosophy or mission to which operating objectives are closely tied (Nandi and Banwet, 2000). One of the most comprehensive definitions of WCM has been set forth by Gunn (1987). His approach suggests that the achievement of world class manufacturing involves continual interaction with customers, suppliers and the integration of total quality control (TQC), computer integrated manufacturing (CIM), and just-in-time production (JIT). A sustained organizational framework is an essential prerequisite for progressing perfection. Achieving the zero state, and even progressing towards it, calls for a great deal more than just initiating studies and redesigning factory layouts. It demands a radical change in mindsets. From this literature survey it has been inferred that it is not possible to use the specific single tool to achieve world-class performance and address all the manufacturing components (Nachiappan and Anantharaman. 2006). However there are 10 tools which are being suggested by different authors to get the world-class status: 1) Total Productive Maintenance (TPM); 2) Lean Manufacturing (LM); 3) Six Sigma (SS); 4) Benchmarking (BM); 5) Total Quality Management (TQM); 6) Integrated Information System (IIS); 7) Agile Manufacturing (AM); 8) Manufacturing Strategy (MS); 9) Supplier Relationship Management (SRM) and 10) Cellular Flow Manufacturing (CFM). Based on the literature review, a tentative list of performance measures of world class manufacturing was developed. Main principles of WCM are: 1) *Dedication to Quality*: Absolute focus on satisfying the customer with increased responsiveness, high reliability and high quality; 2) *Employee Involvement:* Motivating and treating employees like appreciating assets; 3) *Measurement*: All decisions to be made based on objective measured data and its analysis; 4) *Continuous Improvement*: Having a culture of continuous improvement by doing more with less, eliminating waste, reducing lead time and 5) *Achieving growth in top line*: Constant innovation in the products and services by being first to market and provide end-to-end solutions.

WCM foresees 10 technical pillars and 10 managerial pillars. The levels of accomplishment in technical fields are indirectly affected by the level of accomplishment in administrative fields. The pillar structure represents the "Temple of WCM" (Figure 1). In the present study we focus our attention on Logistic & Customer Service. The aim of this pillar is: 1) to create favourable conditions for the flow of materials within the company and between the suppliers and the plant, 2) to reduce inventory level, 3) to minimize the amount of displacement, 4) to reduce the number of kilometres and transit time inside the company and from direct suppliers (De Felice *et al.,* 2013 c).

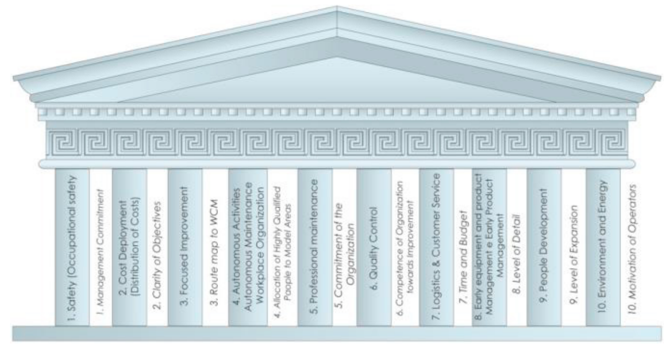

Fig. 1. Temple of WCM.

3. CASE STUDY

In order to achieve WCM it is helpful to use an analytic framework to understand the tasks required to "move" to a World Class Manufacturing approach. The case study refers to an Italian company that operates in automotive sector. Figure 2 shows some products.

Fig. 2. Figure 2: Products.

The company considers the logistics process a core activity fully integrated with manufacturing, sales and purchasing and, thereby, having a significant influence on performance. The control and the optimization of logistics processes is also a key factor and therefore should be recognised and fostered as a part of a world-class business approach. World Class Logistics extends World Class Manufacturing methodologies to supply chain processes. With World Class Logistics, the company aims to establish a supply chain that is fully synchronised with the production system.

3.1 Logistics & Customer Service

Taking into account efficient operation of a company the pillar of the WCM, i.e. Logistics & Customer Service plays a very important role. Despite the ongoing work to improve the results companies are continuously striving to reduce inventory levels, more efficient supply of workstations with necessary components, accessories, assemblies, etc. Sometimes, shortages disturb the production process and it is necessary to reschedule production planning (Pałucha, 2012). Therefore, main objectives of this pillar are: 1) to reduce inventory levels; 2) to minimize internal displacement of materials (frequency and distance); 3) continuous optimization of flow between organizational units and between the company and its suppliers; and 4) integration of purchase, production and sales Network. Objectives can be achieved through continuous system improvement especially using the following methods: Value Stream Mapping, Just In Time, Kanban, FIFO, etc. There are seven steps to be introduced within this pillar: 1) modernization of the so called production line re-engineering; 2) reorganization of internal logistics; 3) reorganization of external logistics; 4) production levelling; 5) improving internal and external logistics; 6) integrating purchase, production and sales network and 7) use of sequence and just-in-time programming. In the present study we focused our attention on the first three steps.

3.2 Definition and implementation of the case study

In the present paragraph definition and implementation of the case study is presented. Areas under study are shown in Figure 3.

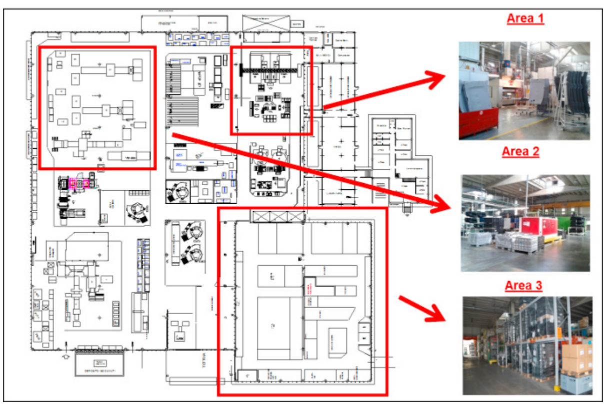

Fig. 3. Model Area.

A description of each steps is following and methodological approach is shown in Figure 4.

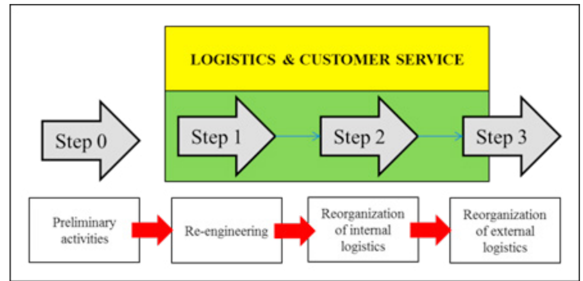

Fig. 4. Methodological approach.

STEP 0: Preliminary Activities. In order to implement the optimization, we identified the main "losses" in the production line (Figure 5).

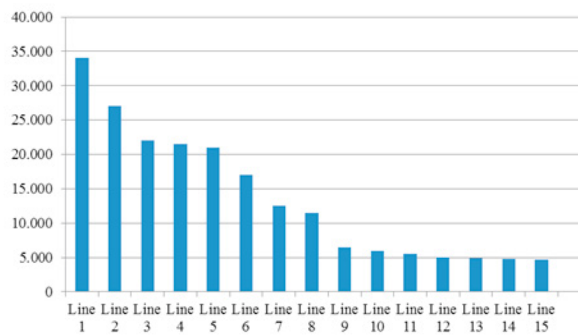

Fig. 5. Pareto Chart "losses".

STEP 1: Re-engineering. The aim of the present step was to reorganize the flow of materials in order to: 1) Create a smooth flow by reducing inventories; 2) Synchronize production and sales to increase customer satisfaction and 3) Minimize the handling of the material. Great attention was given to the collection of data and the definition of appropriate indicators: Key Activity Indicator (KAI) and Key Performance Indicator (KPI). KAI and KPI data collection is shown in Table 1 and Table 2.

Table 1. KAI and KPI – Year 2012

Ind.	Description	UM	Year 2012											
			Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
KAI	Number of project	n.	4	4	6	6	6	8	8	8	9	10	12	13
	Number flow analysis	n.	0	0	1	2	4	4	4	4	4	4	7	9
	% Staff involved	%	1,5	3	4,6	4,6	6,8	10	10	10	11,5	13	13	15
	% Classified materials	%	7	13	18	22	30	38	52	69	75	82	94	100
KPI	Area occupied and warehouse	mq	1503	1500	1492	1492	1492	1492	1432	1432	1432	1432	1432	1432
	Volume occupied.	m^3	6423	6405	6365	6365	6365	6365	6005	6005	6005	6005	6005	6005
	Utilization of surface (I_s)	cost.	0,735	0,733	0,729	0,729	0,729	0,729	0,700	0,700	0,700	0,700	0,700	0,700
	Volumetric use (I_v)	cost.	0,393	0,391	0,389	0,389	0,389	0,389	0,367	0,367	0,367	0,367	0,367	0,367
	Selectivity index (S) *	cost.	0,564	0,573	0,576	0,576	0,576	0,576	0,729	0,729	0,729	0,729	0,729	0,729
	Use of surface (CUS)	UDC/mq	0,766	0,766	0,766	0,766	0,766	0,766	1,02	1,02	1,02	1,02	1,02	1,02

* Selectivity index means that materials can be withdrawn or deposited in stock without the need to move other materials.

Table 2. KAI and KPI – Year 2013

Ind.	Description	UM	Year 2013											
			Jen	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
KAI	Number of project	n.	15	21	22	25								
	Number flow analysis	n.	17	19	21	23								
	% Staff involved	%	17,5	20,6	23	25,2								
	% Classified materials	%	100	100	100	100								
KPI	Area occupied and warehouse	mq	1417	1377	1310	1300								
	Volume occupied.	m^3	5930	5730	5395	5354								
	Utilization of surface (I_s)	cost.	0,693	0,673	0,641	0,636								

	Volumetric use (I_v)	cost.	0,362	0,350	0,330	0,327								
	Selectivity index (S)	cost.	0,732	0,756	0,832	0,863								
	Use of surface (CUS)	UDC/ mq	1,02	1,02	1,02	1,02								

The first improvement was the definition of the layout and the re-engineering of the warehouse (as shown in Figure 6).

Fig. 6. New layout of the re-engineered warehouse.

STEP 2: Reorganization of internal logistics. The aim of this step was the reduction of WIP (Work In Progress), as well as the internal movements (Material Handling). For this purpose, it was necessary to classify the materials (raw materials and semi-finished) using specific criteria, as well as on the basis of the value assumed by some parameters. An example of classification of materials is shown in Figure 7.

ID	Description	Expensive material (Yes / No)	Cumbersome (Yes / No)	Moltitudine (Yes / No)	CLASSES
147	XAD	NO	NO	NO	B
148	YGF	NO	YES	NO	AA.2
149	AAV	NO	NO	YES	B
150	CGF	YES	NO	NO	AB.2
151	FHU	NO	NO	NO	C
152	ZCD	NO	YES	NO	B
153	AFD	YES	NO	NO	AA.2
154	FDF	NO	NO	YES	B

Fig. 7. Example of classification of materials.

Once that the classification was completed, all materials were analyzed considering the relative distribution by type of class (Figure 8) and type of flow (Figure 9). In Table 3 type of classes is shown.

Table 3. Type of classes

Type of Class	
AA.2	Expensive and bulky
AB.2	Bulky
B	Normal
C	Small parts

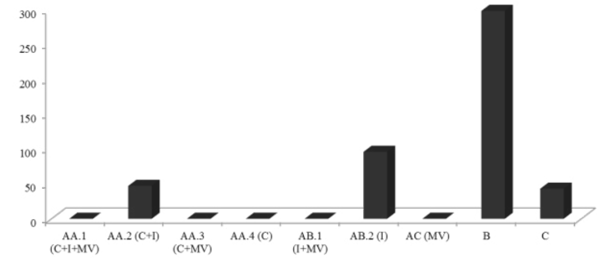

Fig. 8. Distribution by Class.

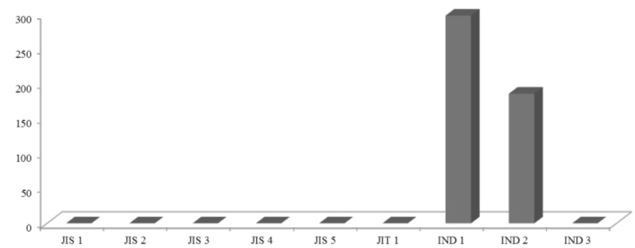

Fig. 9. Distribution by Flow.

Data were analyzed using a combination of *Matrix Class-type Flow*. Using this matrix, it was also possible to determine the flow relative to the operators, and define in detail the individual activities (description AS IS), indicating the times, distances, and the number of cases / duty of each activity. In other words it is possible to assign the proper flow to each class of material. In Figure 10 is shown an example of the matrix used for the analysis of flow in the area concerned.

				Stock Level			Flow								
				WCM Road Map			JIS					JIT	Indiretto		
Class		Type	Sub Class				JIS1	JIS2	JIS3	JIS4	JIS5	JIT1	Ind1	Ind2	Ind3
A	A	EXPENSIVE	AA.1	< 2h	< 1h	< 30m	1°	1°	2°	3°	3°				
			AA.2	< 2h	< 1h	< 30m						1°	47	4°(*)	3°(*)
			AA.3	< 2h	< 1h	< 30m	1°	1°	2° (kit)	3° (kit)	3° (kit)				
			AA.4	< 2h	< 1h	< 30m						1°	2°	4°(*)	3°(*)
	B	BULKY	AB.1	< 2h	< 1h	< 30m	1°	1°	2°	3°	3°				
			AB.2	< 2h	< 1h	< 30m						1°	96	3°	2°
	C	MULTITUDE	AC	< 2 days	< 1day	< 0,5 days				1° (kit)	1° (kit)				
B		NORMAL	B	< 2 days	< 1day	< 0,5 days						1°	155	143	2°
C		SMALL PART	C	< 7 days	< 5 days	< 2 o 3 days							1°	43	1°

Fig. 10. Matrix Class-type Flow.

The matrix shows that the types of ideal flow are: 1) Just In Time" (JIT), where the production lines are enslaved by material coming directly from outside, for classes AA.2, AB.2 and B; 2) "Indirect 1" (through buffers) or "Indirect 3" (Warehouse advanced), for the materials that are part of the class C of small parts.
At the end of the analysis were development, through Kaizen Method, improvement projects for the most critical processes. In Figure 11 an example of the improvement made to optimize the Packaging is shown.

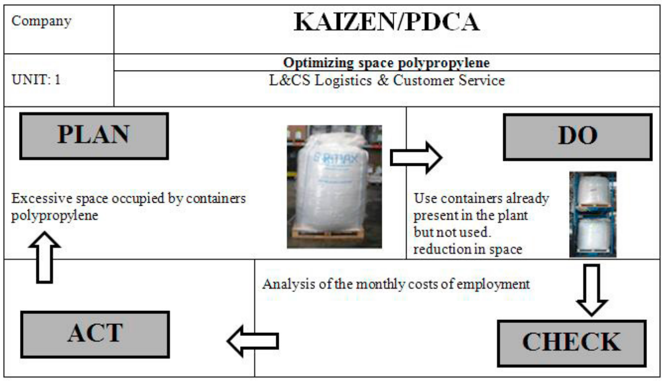

Fig. 11. Example of Kaizen.

The improvement processes adopted, as shown in Table 3 made it possible to achieve good levels of relations benefits / costs.

Table 3. Example of achieved results

#	STANDARD KAIZEN	B/C
1	Re-Design the layout and addition of new shelving in stock	1,97
2	Improvement of the flow of raw materials	5,83
3	Reduction of the space occupied by polypropylene in stock	2,78
4	Introduction of new smaller containers for the storage of rolls of Luton	1,62
5	Improved transportation of small parts	1,56

STEP 3: Reorganization of external logistics. The aim of this step was the reorganization of the external logistics, reducing the working capital of the warehouses of raw materials, and optimizing transport outdoors. In particular, the optimization of the external transport, it is achieved through the saturation of the means of transport and of the containers, and the standardization of Packaging. The optimization of transport external is carried out mainly through the saturation of the means of transport and of the containers and a standardization of Packaging. To achieve these results, it was decided to introduce the use of new types of packaging, both for raw materials and finished products, by which we can obtain (as shown in Figure 12).

Fig. 12. Example of new types of packaging.

Then the Truck Kanban technique was used in the in order to optimize the flow of materials (raw materials, finished goods, means of collecting empty) inside the company and between the supplier and the end customer.

Fig. 13. Truck Kanban.

Finally, the methodology Windows of delivery was applied in order to optimize flow material arriving from the manufacturer to the final customer.

In Figure 14 some results are shown.

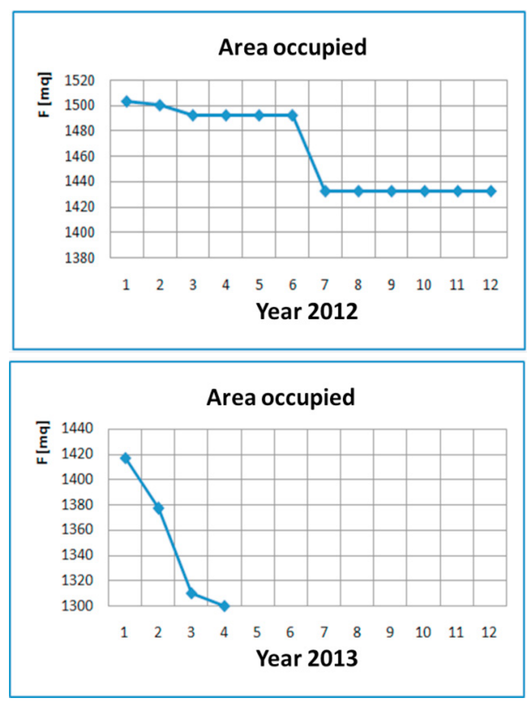

Fig. 14. Example of results.

The development of the project has brought about important benefits on management is an economic one (see Figure 15).

Fig. 15. Benefits achieved.

The development of the project has brought about important benefits on management is an economic one. Ultimately, the key results for each step are: 1) Step 1: B / C = 5.65; 2) Step 2: B / C = 2.60 and 3) Step 3: B / C = 3.15.

6. CONCLUSIONS

This paper presents a new methodological approach based on world class practices useful to measures performance within an industrial company. In fact, we believe that there is only one way for a developing country industry sector to successfully engage the global industry and have a reasonable chance of survival: continuously upgrade performance, skills and technology. From this point of view WCM represents an integrated system that encompasses all plant processes, from safety to the environment, and from maintenance to logistics and quality. The goal is to continuously improve performance in order to reach the objective of zero waste. Implementation of WCM helps to improve organization's internal system. There is a growing understanding of processes, employees better identify emerging problems and get involved in company's activities. WCM implementation creates a cultural change resulting in the total involvement of everyone in the organization improvement (process-wise and product-wise). Definitely a key industrial policy conclusion is that intelligently designed selective policies can be effective in the development of countries.

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