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Material Flow Integration Evaluation Model considering Automation at Manufacturing Shop Floor

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Article Info
Volume 82
Page Number: 4010 - 4015
Publication Issue:
January-February 2020

Article History
Article Received: *18 May 2019*
Revised: *14 July 2019*
Accepted: *22 December 2019*
Publication: *21 January 2020*

Abstract:
With economic globalization and the advent of the knowledge-based economy era, as well as the emergence of global manufacturing, supply chain management in the automotive sector have universal application. Material flow throughout the supply chain, the merits and demerits of the material flow in the supply chain is vital impact. Because the rapid growth of market demand the first challenge is production volume of the present assembly line can not satisfy the market demand. Another problem is when the production volume increased the inventory space is too small to store the parts. The objectives of the research include improving the current Material handling Operations productivity. This mathematical model can help to evaluate what is percentage of automation in material flow and which focus area to automate in-order to improve productivity.

I. INTRODUCTION

It has been my good fortune to experience the inception and growth of business logistics, and now supply chain management, as an area of academic study, research, and business practice. As a logistician, I will trace the evolution of thought in the field and make some predictions as to where the field may be headed. There is no documented historical record withstanding scientific scrutiny that can be used to validate what occurred and why. Conclusions in this article come from my impression of the events surrounding business logistics, their basis, and their meaning.

With economic globalization and the advent of the knowledge-based economy era, as well as the emergence of global manufacturing, supply chain management in the automotive sector have universal application. Material flow throughout the supply chain, the merits and demerits of the material flow in the supply chain is vital impact. Because the rapid growth of market demand the first challenge is production volume of the present assembly line can'ot satisfy the market demand. Another problem is when the production volume increased the inventory space is too small to store the parts. The objectives of the research include improving the current Material handling Operations productivity.

Also getting the *right goods* or *services* to the *right place*, at the *right time*, and in the *desired condition* at the lowest cost and highest return on investment.Process integration and interaction management exceptions, alerts, and relationship management in logistics, Information integration. Facilitating decision support. The key is to achieve information and process integration for efficient and effective decision support.

There is a strong concern to adjust the supply system in a company to achieve a higher service level internally and to the outside customers. This brings to a higher operational level and even a possible differential when compared with the other competitors (Milan, Paiva & Pretto, 2006; Paiva, Carvalho Jr. & Fensterseifer, 2004).

Materials handling management is among many factors that contribute to improve a company's performance. TheMaterials Handling Industry of America [MHIA] defines materials handling management as "Material Handling is the movement, storage, control and protection of material, goods, and products throughout the process of manufacturing, distribution, consumption and disposal. The focus is on the methods, mechanical equipment, systems and related controls used to achieve these functions" (mhia.org/learning/glossary). Then it is observed that handling is broader than simple materials movement, Although both terms are sometimes used as synonyms.
The present work is specifically related to materials handling management. By means of effective materials handling management, the company's operational performance may improve (Chopra & Meindl, 2001; Rosenbloom, 2003) aiming to satisfy the customers or meet their expectations in terms of their needs, desires and demands (Oliver, 2010; Stock & Lambert, 2001).

Building the model with variances of the most critical stations is a shortcut to analyze problems of a production flow. Subsequent to the analysis of the material flow, evaluation based on reliability helps tofilter the possible solutions. System reliability is the probability that the system willperform its intended function under specified working condition for a specified periodof time. Analysis of system reliability together with feasibility and cost leads to

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theoptimal solution.In order to set up a simulation model the first thing have to do is build up a basic model and find out the parameters required. The challenges in logistics share similar traits, notwithstanding the scale of the focus area, more explicitly company's internal logistics systems have alike characteristics; and therefore, alike challenges as its external logistics systems. The heart of logistics is managing inventory levels; in global supply chains the challenge is decreasing inventory levels at retailers and warehouses, while in company-scale it is lowering buffer levels by decreasing variation in the system; in any term, from customer demand to supplier delivery, and attaining a smooth, just-in-time material flow (Goldsby&Martichenko, 2005).

II. LITERATURE REVIEW

Materials handling makes production flow possible, as it gives dynamism to static elements such as materials, products, equipments, layout and human resources (Stock & Lambert, 2001; Chopra & Meindl, 2001). Groover (2001) highlights that despite its importance, materials handling is a topic that frequently is treated superficially by the companies. However, other authors have perceived its relevance. During the period in which Shingo (1996) contributed to the development of the Toyota Production System, he developed the Production Function Mechanism that proposes to explain how the production phenomenon happens.

Shingo (1996) indicated that, in the West, production was treated as a process of a sequence of operations. In the Production Function Mechanism, the concepts are directly related to a production analysis focus. A process analysis consists of an observation of the production flows that turn raw materials into final products. From this concept, the author highlights that the main analysis is the one associated with the process, because it follows the production object. The analysis of the operations comes later because it focuses on production subjects (operators and machines). When making this distinction, it is possible to perceive the relevance of materials handling.

Beyond the basic function of movement, it is also relevant to cite the functions of storage and information transfer, which occurs simultaneously and has both strategic and operational dimensions. Organizations are relying on information systems using tools like Electronic Data Interchange (EDI), or similar information technology resources, to gain in precision and reliability, in the interchange, and availability of information (Lambert & Stock, 2001; Laudon & Laudon, 2006, Milan, Basso & Pretto, 2007).

According to Asef-Vaziri & Laporte (2005) an important proportion of manufacturing expenses can be attributed to material handling and the most critical material handling decisions in this area are the arrangement and design of material flow patterns. This idea is shared by Ioannou (2002), which argues that an important aspect of any production system is the design of a material handling system (MHS) which integrates the production operations

The relevance also occurs in another context. Ballou (1993) states that the storage and handling of goods are essential among the set of logistics activities, and their costs can absorb 12% to 40% of its costs. In addition, the MHIA estimates that 20% to 25% of manufacturing costs are associated to handling (Groover, 2001, p. 281). According to Sule (1994) apud Sujono & Lashkari (2006), material handling accounts for 30–75% of the total cost of a product along the production chain, and efficient material handling can be responsible for reducing the manufacturing system operations cost by 15–30%.

III. FLOW AUTOMATION EVALUATION MODEL:

There are five attributes defined for material flow integration with automation. We can evaluate as below:-

A- A1– To automatize loading / unloading of material at assembly line-

The goal is to improve the workflow performance with the automation of loading/unloading of material at line. This is the automation of the last meter of the flow (and not the automation of the parts).

The grid concerns the rates of automated loading and unloading points for packaging interposts on the manufacturing line. In this principle, it is necessary to list the points of loading / unloading of packaging on the manufacturing line, for each section and if it is automatic or manual.To make the assessment, we need to check the frequency of all points.

The percentage of automated loading / unloading must then be calculated in relation to the total number of loading / unloading points to be able to assign score from 0 to 5.
Each point of loading / unloading must be weighted by the frequency with which the material is loaded or unloaded on the chain. This weighting is calculated based on the cycle time of the line.

B- A2 – To automatize indoor flows-

The goal is to improve the performance of part flows by automating secondary and inter-process flows.
For the assessment of this principle, We need the layout of the shop with the drawings of the flows. For each flow, we need to know the frequency of each (based on the number of parts by collection, sequenced delivery of by the number of packaging delivered in the same time).

C- A3 – To automatize outdoor flows-

The goal is to improve the performance of part flows by automating internal synchronized flows.
A secondary flow is considered automatic when there is no human intervention for the transfer of the kitbox or the interposts.

With outdoor flows, you can have the situation where the flows is semi automatized (transfer between building by truck and transfer inside the building by AGV), in this case, the flow will be considered automatized with a weight of 50%.

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Model for A1, A2 & A3 Principles:

$$A_{1\sim3}= \frac{\sum_1^n \frac{F_{1\sim n}}{s}}{\sum_1^n \frac{1}{s}\sim n} = (\ )\%$$

A – Evaluation Principle

- *A* 1 -To automatize loading / unloading kitbox/interposts on the main line
- *A* 2 - To automatize secondary & inter-process flows (indoor flows)
- *A*3– To automatize internal synchronized flows (outdoor flows)

F – Material Flow

- $F_{1\sim n}$ =M (manual) = 0
- $F_{1\sim n}$ = A (automatic) = 1
- $F_{1\sim n}$ = SA (half automatic) = $\frac{1}{2}$* $F_{1\sim n}$

s – Sub-Assembly (Coverage of Material)

The grid concerns the rates of automatized of above flows. Score from 0 to 5 are awarded according to the following levels:

- **0**: $A_{1\sim3} < 25\%$
- **1**: $25\% \le A_{1\sim3} < 50\%$
- **2**: $50\% \le A_{1\sim3} < 70\%$
- **3**: $70\% \le A_{1\sim3} < 90\%$
- **4**: $90\% \le A_{1\sim3} < 100\%$
- **5**: $A_{1\sim3} = 100\%$

<u>**Example:-**</u>A secondary flow is considered automatic when there is no human intervention for the transfer of the kitbox or the interposts.

With outdoor flows, you can have the situation where the flows is semi automatized (transfer between building by truck and transfer inside the building by AGV), in this case, the flow will be considered automatized with a weight of 50%.

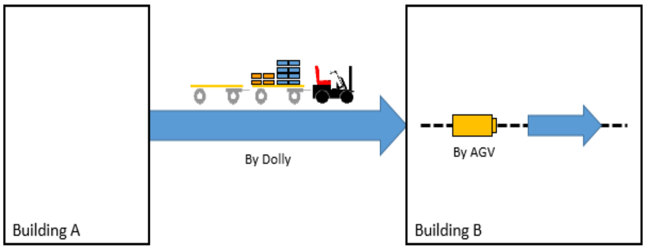

Figure-1-Indoor & Out-door Material Flow

This example also makes it possible to understand the method of calculating the automatic internal synchronized flow binding rates.

Each flow is evaluated if it is automatic (1), manual (0) or a combination of manual and automatic (1/2)

Calculation of percentage of automatized secondary & inter-process flows will be weighted by its frequency

Example with 3 flows:

- Flow A : Sequenced parts delivered by 30 by dollies (manual)
- Flow B : Sequenced parts delivered by 15 by AGV (automatic)
- Flow C : Sequenced parts delivered by 20 by dollies outside and by AGV inside (half automatic)

Automatic internal synchronized flow:

$$A_{1\sim3}= \frac{\sum_1^n \frac{F_{1\sim n}}{s}}{\sum_1^n \frac{1}{s}\sim n} = \frac{\frac{1}{15}+(\frac{1}{2}*\frac{1}{20})}{\frac{1}{30}+\frac{1}{15}+\frac{1}{20}} = 61\ \%$$

Based to the grid, the score will be **2**

D- A4 – To automatize primary flows-

The goal is to improve the performance of part flows by automating primary flows.

To evaluate the automation, we will check how many steps for each flow are automatized.

We consider that one flow corresponds to all packaging, delivered from a storage area to a consumption/assembly area with the same mode of operation.

- Taking packaging from the storage
- Transfer from the stock to the workstation
- Positioning on the workstation
- Transfer into the Assembly line

For each flow, each step can be manual or automated. For each automatized step, we have 1 points and we will have a result of 0, 1, 2 or 3 points for each flow.

For the calculation of the average for the flows of a perimeter, each flow is weighted by the quantity of packaging per day.

E- A5 – To automatize unloading flows and storage flows-

The goal is to improve the performance of part flows by automating unloading and storage flows. In this principle, to evaluate the automation, we will check how many steps for each flow are automatized. We consider that one flow corresponds to all packaging, from a truck station to one storage area with the same mode of operation.

The definition of the steps is the following:

- Truck unloading
- Transfer to the storage
- Storage operation

For each flow, each step can be manual or automated. For each automatized step, you have 1 points and you will have a result of 0, 1, 2 or 3 points for each flow.

For the calculation of the average for the flows of a perimeter, each flow is weighted by the quantity of packaging per day.

Based on data collection, literature review and result of data analysis below mathematical model proposed to evaluate integration of automation:-

$$A_{4\sim5} = \sum_1^n \frac{(a*p)\sim n}{p\sim n} => \frac{Value}{No\ of\ flow} = (\ )\%$$

A – Evaluation Principle

- *A*4– To automatize primary flows
- *A*5– To automatize unloading flows and storage flows

a – No of automated steps

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p – Total number of packages transported by this flow

Below grid derived based on above model.

- **0**: $A_{4\sim5} = 0\%$
- **1**: $0\% < A_{4\sim5} < 5\%$
- **2**: $5\% \leq A_{4\sim5} < 15\%$
- **3**: $15\% \leq A_{4\sim5} < 30\%$
- **4**: $30\% \leq A_{4\sim5} < 50\%$
- **5**: $A_{4\sim5} \geq 50\%$

Example:-The following example shows how to calculate the average number of automated steps and thus assign the correct score for this principle

Table-1- Example of Various Material Flow

Flow name	**Operating mode**	**Number of automated step**	**Total number of packages transported by this flow by team**
Flow A	Delivery by forklift by Man	0	60
Flow B	Delivery by an automated stacker	3	10
Flow C	Material transfer by an automated tractor, placing material in gravity by an operator	1	10
Flow D	Distribution of Polyboxes by dolly	0	20

In this example, the average number of automated steps is:

$$\frac{0*60+3*10+1*10+0*20}{60+10+10+20} = 0.4 => \frac{0,4}{3} = 13\%$$

Based to the grid, the score will be **2**

IV. CONCLUSION

The results of the analysis provide a general overview of supply chain complexity management at shop floor This initiatives canbe utilized to assist decision-makers in formulating strategies to deal with complexity. The solutions thathave been implemented in each case in order to overcome the complexity related problems can becategorized according to type of complexity.

We can take average of above principles result and compare with grid value, which will give idea about what action can be taken further to streamline the flow.

From the analyses we can deduce that when dealing with static complexity the companies tend to usestrategies to reduce complexity while with dynamic and decision making complexity they try to managethe complexity and adjust their operations to cope with it. The use of tools and technologies to supportMaterial flow complexity management is widely used and recognized. The analyses results can be used to develop amore sophisticated decision matrix as a further research. This would assist decision-makers in identifying best material flow and integration of same.

In relation to specific established objectives, changes in material handling processes at the company were described (first specific objective); internal material handling flow in manufacturing was evaluated and improvements were made (second specific objective); and internal customers' satisfaction levels related to the new system were analyzed (third specific objective).

This way, the present work's general objective was attained: to evaluate, in a systematic way, the impact of the implemented changes in materials handling management through internal customers' perceptions, evidencing a relevant contribution to the company and to the studied area.

It is important to highlight that there were no losses of jobs although some employees were reallocated. One operator from the central warehouse was transferred to vehicle driving and his previous job was divided between two other people from the same department. Regarding inventories, there was a reduction in work-in-process; however there were no changes in raw material and finished goods stocks because the purchasing policy and customer delivery time were not modified.

Besides internal customer satisfaction improvement, which was evidenced by the present study, there was an effective improvement in the internal material handling. The improvement in material flow caused by the use of the proposed vehicle increased the accuracy of materials delivery time inside the company. Operations became safer. The system used was able to evaluate the perceptions of the implemented changes, as well as to identify factors and sub-factors that influenced satisfaction increase. These im-provements in the company operations resulted in new subsidies to perform similar studies.

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