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Material Flow Evaluation Mathematical Model for Layout Re-design

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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 material flow and also provides opportunity/area of improvement on frugal way.

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.

We have to focus onof all *activities* associated with the flow of material from receiving area to Warehouse and then supply to manufacturing line. 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 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. Objective

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).

The problem genesis led to the formulation of the following objectives:

- To study the current flow pattern and relation of overallplant layout and develop a new material flow layout.
- Re-engineering of layout to optimize flow and reduction in check points.
- To improve the efficiency of the material flow layout using simulation.

III. DATA COLLECTION

- **Existing layout:**Over all material flow layout (Primary, Secondary, Storage etc)
- **Outline Process Chart:**Outline process chart (OPC) was used to get and overall picture of primary activities OPC for the studied process.
- **Flow Process Chart:**Flow Process Chart was used to document the detailed sequence of operations.
- **String Diagrams:**String Diagrams were used to trace and measure the path of material. String diagrams were made both by hand and by software.
- **Simulation:**Time taken by each machine to process the component is collected and recorded. The standard time for each process is also recorded. These data are used in simulation in order to find out the overall Man/equipment utilization.

IV. Mathematical Model

This model is aimed to below aspects:-

- Can the material movement be eliminated ?
- Can the material movement be combined with another or within an in-transit operation ?
- Can the material movement be simplified ?
- Can the sequence of material movement be changed to advantages ?

Based on data collection we have to flow below principles and model:-

L1 – To avoid process walls- To improve parts flow performance by reducing the number of process walls. Process wall can increase the distance of the flows, split teams or add extra cost to install standard process. This principle will take into account situation creating process wall inside the shop floor

This principle is based on demerit points. The assessment for this principle is done for all the shop (not section by section). For each installation or

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facility, we assign demerit points if we generate process wall. The number of demerit points is different depending on the situation.

To do the assessment, you need to list all the situations creating a process wall, assign the right number of demerit points and calculate the total. The score for this principle will depend on this total. The different levels are the following:

- **0**: L> 200
- **1**: 150 < L ≤ 200
- **2**: 100 < L ≤ 150
- **3**: 50 < L ≤ 100
- **4**: 25< L ≤ 50
- **5**: L ≤ 25

L2 – To decrease distances of secondary & inter-process flows (indoor flows)- To improve parts flow performance by minimizing distance of secondary and inter-process flows. By reducing the length of flows by simplifying the flows inside the shop. This principle focuses on flows inside the same building.

$$L_2 = \sum_1^n \frac{(d*w)\sim n}{w\sim n} = (\ )m$$

Where-
L - Layout
w – Secondary flow weightage
d – Distance

The grid concerns the average length of the secondary flow and inter-process distances. Score from 0 to 5 are awarded according to the following levels:

- 0: Average distance > 300 m
- 1: Average distance ≤ 300 m
- 2: Average distance ≤ 250 m
- 3: Average distance ≤ 200 m
- 4: Average distance ≤ 150 m
- 5: Average distance ≤ 100 m

Below example makes it possible to understand the method for calculating the secondary flow average distance.In this example, a secondary flow supplies
Flow-A- Part supplied for 1 Assembly
Flow B- Part supplied for 4 Assembly
Flow C- Part supplied for 2 Assembly

Table-I-Material Flow and Weightage

	Secondary flow weightage	Distance
secondary flow A	1	45
secondary flow B	¼	130
secondary flow C	½	70

Average distance of secondary flow:

$$L_2 = \sum_1^n \frac{(d*w)\sim n}{w\sim n} = \frac{45*1+130*\frac{1}{4}+70*\frac{1}{2}}{1+\frac{1}{4}+\frac{1}{2}} = 64\ m$$

Based on the grid, the score will be: **5**

L3 – To decrease distances of supply for primary flows-Decreasing supply distances of the primary flows makes possible to rationalize the number of man power involved
to optimize supply times- Cycleto reduce crossing flows.

$$L_3 = \sum_1^n \frac{\left(p_f*\frac{l}{p_l}\right)\sim n}{p_f\sim n} = (\ )m$$

Where-
l – Loop distance
p_l – Number of packaging supplied by loop
p_f – Total no of packaging supplied by this flow

This grid is based on the average distance for primary flows. The primary flow is the flow from the last storage to the workstation (un-sequenced flows). In this principle, we consider no of packaging. Score from 0 to 5 are awarded according to the following levels:

- **0**: L> 400m
- **1**: L≤ 400m
- **2**: L≤ 300m
- **3**: L≤ 200m
- **4**: L≤ 150m
- **5**: L≤ 100m

Score from 0 to 5 are given according to the average daily distance of primary flows.The distance considered is the distance of the loop: round trip for forklift, delivery loop for dollies. For delivery by dollies, we will consider also the number of dollies in the same loop.To calculate the average distance for each section:

- we need to have the list of parts for the section.
- We should group parts with the same storage and same workstation areas to identify the list of primary flows and to calculate the number of packaging per day for each primary flow.
- We should calculate the distance for each flow.
- With the distance, the number of packaging supplied by loop and the total number of packaging for this flow, we can calculate the average distance. These distances are averaged by weighting them by the total number of packaging supplied for each flow

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The following example shows how to calculate the distance and to assign the right score for this principle.

Table-II-Distance covered by MHE in one Loop

Flow name	**Loop distance**	**Number of packaging supplied by loop**	**Total number of packaging supplied by this flow**
Forklift A	300m	1	20
Dollies A	550m	4	60
Forklift B	350m	2	20

In this example, the average daily distance is:

$$L3 = \sum_1^n \frac{\left(p_f * \frac{l}{p_l}\right)\sim n}{p_f \sim n} = \frac{20*\frac{300}{1}+60*\frac{550}{4}+20*\frac{350}{2}}{20+60+20} = 178m$$

Based on the grid, the score will be: **3**

L4 – Together storage areas -This principle makes it possible to gather the storage areas:to optimize Manpower workload to reduce and simplify flows.
The assessment for this principle is done for all the shop (not section by section). We group these areas by zone. Score from 0 to 5 are awarded according to the following levels:

- **0**: More than 6 zones by shop
- **1**: 6 zones by shop
- **2**: 5 zones by shop
- **3:**4 zones by shop
- **4**: 3 zones by shop
- **5**: Max 2 zones by shop

We consider that 2 areas are in the same zone if there are not separated by a process wall. The following drawing is to clarify how we consider that 2 areas are grouped in the same zone

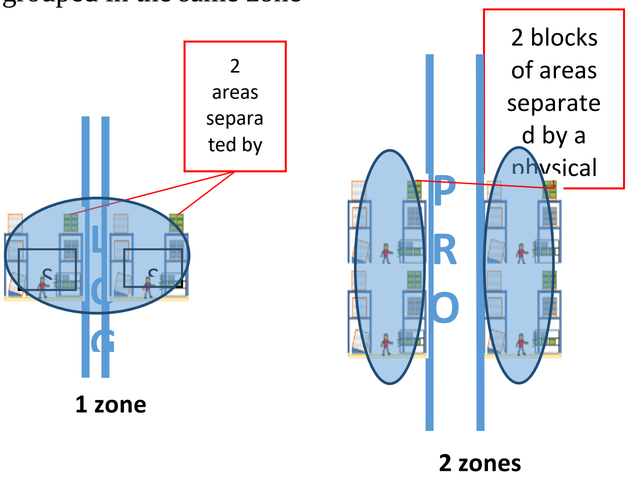

Figure-1- Zone wise grouping example of two areas

L5 – To avoid crossing flows from different types-
To avoid crossing flows is mandatory to automatize the different flows inside the plants and to reduce the number of AGV (Automated Guided Vehicle) or auto forklift/auto tractor (AMH) (we reduce the waiting time each time we reduce the crossing points)
This principle is also based on demerit points. The assessment for this principle is done for all the shop (not section by section). For each crossing, we assign demerit points. The number of demerit points depends on the typology and on the frequency of the crossing flows.
To do the assessment, we need to list all the crossings, assign the right number of demerit points and calculate the sum. The score for this principle will depend on this sum. The different levels are the following:

- **0**: $x > 300$
- **1**: $200 < x \leq 300$
- **2**: $150 < x \leq 200$
- **3**: $100 < x \leq 150$
- **4**: $50 < x \leq 100$
- **5**: $x \leq 50$

Crossing between FG/Sub Assy and Material Handling Flow.Blocking a logistics aisle by supply handling:
We check if a logistics aisle is blocked by the supply handling. This situation happens when the logistic aisle is too tight.The diagram below explains the situation.

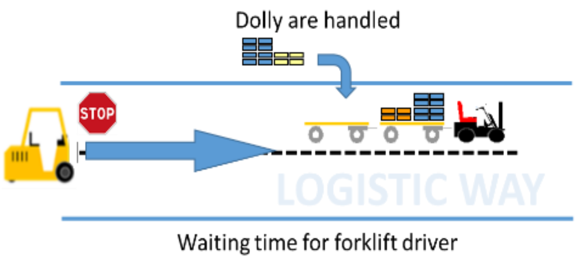

Figure-2- Logistics Flow

In this diagram, in the same logistic aisle, one forklift is blocked by dollies in the middle. The driver needs to wait parts supplied to assembly line

Cohabitation between AGV flow and Handling flow:
We also check if there is one cohabitation between AGV and handling flows on the same shared way.

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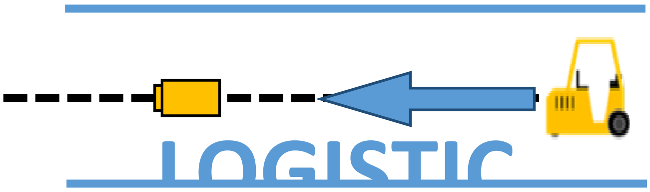


Crossing flows in the logistic way if there are 2 flows that are on the same way

Figure-3- Material Flow fro AGV and MHE

In this diagram, in the same logistic aisle, a forklift shares the aisle with an AGV. It is in this case slowed by the AGV because it is obliged to move at the same speed as this one.

Crossing between AGV flow and Handling flow:
We also check if there is a crossing between AGV flows and handling flows on two crossed lanes (crossed lanes). See the example below.

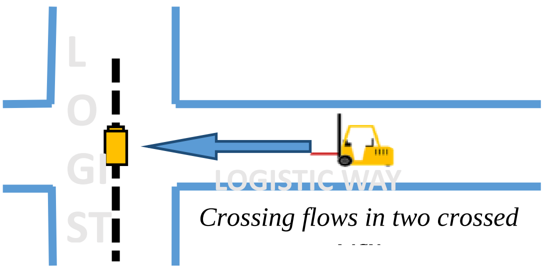
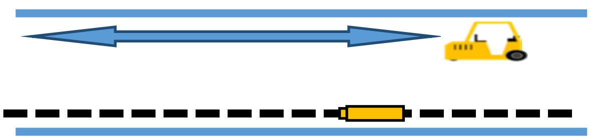


Figure-4- AGV & Manual MH Flow Crossing

Crossing or cohabitation between automated handling flow (AMH) and manualorCrossing or cohabitation between AGV:
For these two types, it is the same drawings for crossing or cohabitation but between AGV or between AMH and Manual Handling, the number of demerit points is not the same. It is due to the speed of AGV.
Based on the grid, the score will be: **2**

Special cases:
Several cases can be confusing in the case of share the same logistic aisle, but with two dedicated way.



No crossing flows in the shared logistic way

Figire-5- Separate Lane for AGV and Manual MHE

In this diagram, in the same logistic alley, a forklift shares the same logistic aisle with one AGV. However, it is not disturbed by the AGV because the flows are separated,

V. Conclusion

This research paper has provided a good exposure to facility planning and layout designs for the improvement of the efficiency.
We can take average of above principle result and compare with grid value, which will give idea about what action can be taken further to streamline the flow. The choice of which type of facility layout to adopt can have a significant impact on the long-term success of a firm. This decision, therefore, should not be considered lightly, but only after a through analysis of the operational requirements has been completed. A major issue to be addressed in facility layout decisions in manufacturing is: How flexible should the layout be in order to adjust to future changes in product demand and product mix. The study of layout has become extremely important. The most common objective of layout design, that is to minimize distance travelled, is not always suitable for all the manufacturing industries. Congestion in a specific area may have to be tolerated while maintaining minimum separation between facilities. Instead of criterion of minimizing total distance travelled, one may wish to minimize the total distance of the material travelled

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