Material Flow Management in Industrial Engineering

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INTRODUCTION

The material flow theory (MFT) proposes a general scientific model without taking into account the nature of the described material flow. Even if some of the considerations made are covering the entire MFT area, we are not interested here in the specific aspects of economic or social material flow, but only on the industrial engineering area of applications. In this context, the first main goal of this article is to present a synoptic view of the MFT concepts that could be used in material flow management of the manufacturing architectures. The second goal is to use these theoretical concepts for defining a general algorithm to increase productivity and profit using material flow management, emphasizing on this algorithm the particularities of manufacturing architectures optimization.

Although, our approach narrows MFT to industrial engineering applications, in the same time sets the theoretical base for using this theory in the design and optimization of any type of manufacturing systems. Moreover, the concepts described in this article can be used to accommodate new trends in industrial engineering, such as additive manufacturing, hybrid manufacturing, layout optimization, integration of virtual models and process simulations data in the manufacturing systems simulations and so forth.

BACKGROUND: MATERIAL FLOW THEORY FOR INDUSTRIAL ENGINEERING

An analysis of the literature in the field of MFT showed that the general focus is on presenting applications/case studies in different areas and, thus, obtaining specific conclusions, while the theoretical approaches and paradigms of MTF are considered only in few studies (Xu, 2008; Steinaecker & Jürgens, 2001; Hou, Xu, & Wang 2007; Swanson, 2008).

The most comprehensive MFT description embraces the concepts of physical distribution and logistics and refers as well to the flow of macroscopic and microscopic elements (Xu, 2008). From the seven major theories under the MFT (Xu, 2008) we are interested only in material flow engineering and industry theory. In this context we define here MFT as a support theoretical system for modeling, simulating, diagnosing and behavior prognosis of material flow.

Also, for the same area of interest in industrial engineering, we define the material flow as a group of mobile entities whose trajectories are determined by a generic associated architecture. This associated generic architecture is structured as a group of physical objects interacting with the material flow by a set of constraints determining the material flow trajectories (Figure 1.).

There are two kinds of interactions between the generic associated architecture (GAA) and the material flow trajectory.

- The structural elements of the GAA set bound to the material flow trajectories.
- The structural GAA elements determine the material flow trajectories by their movements.

More details about those interactions manufacturing architectures for industrial engineering applications are given further in this article.

Considering our approach to MFT, the classification of the material flow is based on the mobile entities nature:

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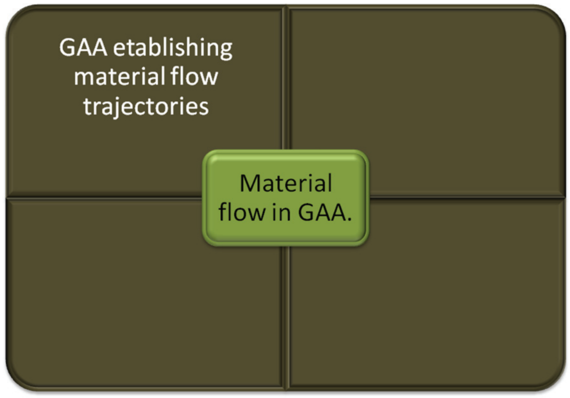
Figure 1. Interactions between the generic associated architecture (GAA) and the material flow trajectory

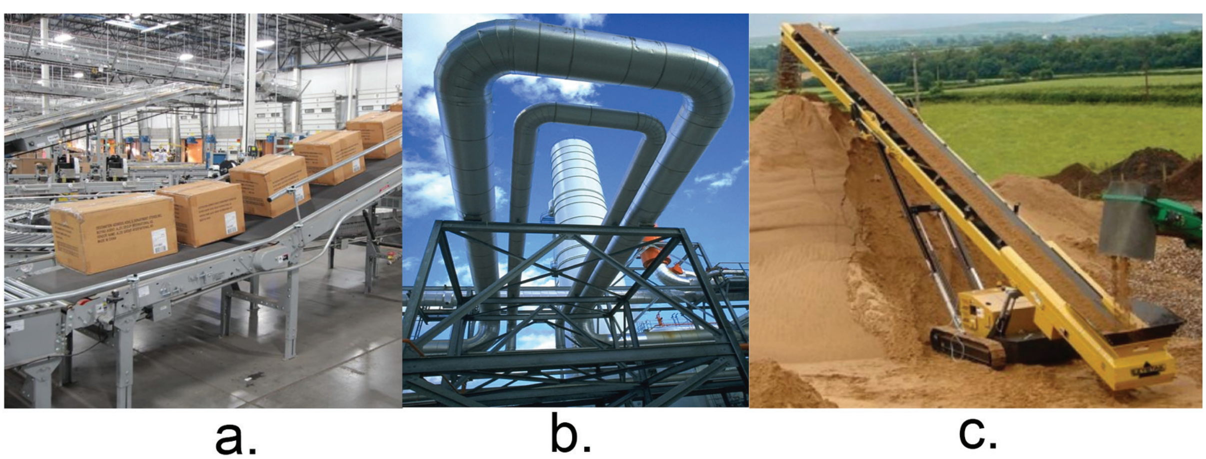


- We define discrete material flow when the mobile entities are distinct and countable.
- We define continuous flow when the mobile entities are not distinct and not countable.
- We define hybrid material flow when the mobile entities are distinct but not countable.

In order to clarify this classification, we could illustrate each category as follows: parts moving on a conveyor represent a discrete material flow (Figure 2.a), liquids streaming in pipes represent a continuous flow (Figure 2.b), and sand on a conveyor represents a hybrid material flow (Figure 2.c).

The modern manufacturing constraints should produce highly customizable and innovative products; continuously increase their quality and decrease the time-to-market and costs in order to gain competitive advantages. All these determined a focus on optimizing the manufacturing systems starting early from their design phase by using MFT and specific simulation software tools. Depending on product characteristics and production type, several classical architectures of manufacturing systems (assembly line, flexible manufacturing system, flexible manufacturing cell, job shop, etc.) can be deployed in a factory (Groover, 2008; Aized, 2010). These architectures can be analyzed in conjunction MFT applications and specific algorithms in the MFM area, and optimized based on mathematical and virtual modeling. To optimize a material flow, one should focus on maximizing or minimizing specific parameters according with their nature (for instance, cost is a minimizing parameter, while productivity is a maximizing parameter). One of the main methods is based on identifying the points where the material flow is slowed down or even blocked (flow concentrators or bottlenecks) and finding solutions to eliminate such problems with or without modifying GAA (Gill, 2008; Cotet, 2008; Cotet, Dragoi, Carutasu & Nica, 2006). Such methodology uses the virtual model of GAA and flow simulator software applications, which is meant to simulate the evolution and the material flow behavior in time.

Figure 2. Illustration of the material flow taxonomy



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