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Optimization of Manufacturing System through Group Technology: A Case Study of Fastener Industry

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ABSTRACT

Aiming at the manufacturing system optimization of the Industries in modern aspects, important objective has been to identify a set of families integrated by products with similarities. This classification would help Production Mangers to minimize unwanted activity on shop floor, changeover time, allowing them to further reduce production timesand reduced overall cost. The basic concept of “exploiting similarities”, taken from the Group Technology (GT) philosophy, has been used to solve the problem in a creative way. One way of achieving this is to implement GT approach, by creating product and machine groups and simplifying material flows. This research has already been applied in the framework of a real case, getting quite positive results (actual reduction in both setup and production costs, easier planning and short-time scheduling, more accurate setup time estimates for new products, etc.). The paper presents benefits of synergy created by using GT and PFA. A proposed solution was eventually obtained through the combined use of material flow simplification based on PFA and the exercise of some sound common sense and judgement.

Keywords: Group Technology, Production Flow Analysis, Mass Customization

1. INTRODUCTION

GT is a manufacturing philosophy which advocates simplification and standardization of similar entities (parts, assemblies, process plans, tools,instructions, etc.) in order to reduce complexity and achieve economies of scale effectsin batch manufacturing. One vehicle for implementing GT is classification and coding(CC), a methodology which organizes similar entities into groups (classification) andthen assigns a symbolic code to these entities (coding) in order to facilitate informationretrieval [1].

Fastener Industries are kind of cold forming type manufacturing industry, where two kind of section divided: (1) Bolt Department & (2) Nut Department, which manufacturing process flow chart shown in fig1.1. In cold forming process, Tools are the most important part of manufacturing system in Fastener industry. So, always availability of tools is necessary, which is going to optimized through GT. So, first we required the material flow chart of part group of tool and starting matrix of machine with different part groups.

(1) Bolt– Forging Department

(2) Nut– Forging Department

Fig. 1 *Manufacturing Process Flow Chart*

2. LITERATURE OVERVIEW

2.1 LITERATURE REVIEW

Mass customization (MC) is a relatively new paradigm based on the production of customized products with mass production efficiency [2]. Emerged in late 20th century the paradigm is today more relevant than ever. Companies which embraced this strategy in sales and production added a new value to their business [3]. This has proven as a good strategy for some small and medium enterprises (SME's) [4] as well as for big multinational companies (Dell, Nike, Adidas, etc.) [5]. Nevertheless, implementation of MC strategy still presents a challenge for companies and dealing with the new combination of company resources is seen as crucial by many authors [6].

The concept of GT[7] is based on the simplification and standardization process, which appeared at the beginning of 20th century. It originally emerged as a single machine concept that was created to reduce setup times [8]. This concept was further extended by collecting parts with similar machine requirements, completely processing them within a machine group or cell [9].

Part family formation is the outcome of the process that puts together similar parts or separates different ones, based on predetermined attributes. Therefore, this process should be considered as a prerequisite for the efficient sequence of parts into groups and other manufacturing advantages [10,1].

Parts can be sorted out into groups according to their design attributes, which include part shape, size, surface texture, material type, raw material estate, or according to their manufacturing attributes, which include operations and sequences, batch sizes, processing time or amount of production. The first approach allows design engineers to retrieve existing drawings to support new parts design standardization and make accurate cost estimation. The second one produces improvements in the control process, reduction of the setup time and standardized process plans [11].

Many authors have adapted the approach of exploiting part similarities to solve the scheduling problem has been used by many authors, with most applications being in the metal processing industry [8], but no reference can be found in the tile sector. In this case, setups are not negligible in these productive systems and there are some available resources in each of the phases of production. This is known as the ‘‘hybrid flowshop problem with dependent setup times on the sequence’’ [12].

In order to achieve an improvement of setup times, an estimate of them is needed. There are few papers related to these questions; an approach based on statistical regression can be found in [13]. The authors developed a method for sequencing jobs in one machine looking towards minimizing total setup time. A procedure based on the decomposition of the setup time in a computer numeric control (CNC) environment is presented in [14], but it is based in the geometry of the parts and therefore it is not applicable to more complex environments.

2.2 GROUP TECHNOLOGY

GT is an approach to production system organization which has existed for many decades. GT first appeared in the book of Mitrofanov [8]. GT is based on the idea of grouping parts by using similarity. The approach results with cellular organization of machines in production systems [1] and [2]. This approach gave many benefits to solving problems like long lead times, large setup times, increased Work-In-Progress inventories, large inventories of finished goods, poor part quality and high unit costs, as shown in Wemmerlöv and Hyer [15] and in Wemmerlöv and Johnson [6].

3. CASE STUDY OF FASTENER INDUSTRY

3.1 SHOP FLOOR

For the purposes of research a Fastenerproduction company was chosen. The chosen company produces wide range of Fastener product on mass production scale. Company produces250 different varieties of products, such as socket head cap screw (SHCS), socket head cap bolt (SHCB), hex head screw (HHS), hex head bolt (HHB) etc. Shopfloor process layout with transport routes is given in Fig. 1.Production starts with the cutting of basic shapes of product parts. The cutting operation consists of three cutting machines. The next phase of production which contains three machines for lathe operation. The whole product assortment is produced on a number of machines shown in Table 1. The production process is finalized with visual control of parts, final control and packaging.

Table 1. *The Machine List*

Machine Number	Machine Name
1	Saw Machine
2	Lathe Machine
3	Surface Machine
4	CNC Machine
5	Grinder Machine
6	Special Machining
7	Lapping
8	Centre less Grinder
9	Milling Machine
10	Polishing & Deburring
11	Tool Cutter
12	Inspection & Tool Etching Machine

3.2 SYSTEM ANALYSIS

The analysis of the system was done through several steps which consist of analysis of product assortment, machine line-up, material flow, as well as the technological capabilities of the machines. This company is not a complex system in terms of PFA, so the company flow analysis was not necessary. The analysis started with factory flow analysis (FFA). The whole product assortment of 250 products was analyzed part by part. Every product and product part needs to be compared with similar products and parts from the production assortment. Similaritiescan be found in the attributes of material, the quality of material and compatibility of parts embedded into multiple products. After analyzing the PFA of all products we find out same route following by the products which is sorted to 18 unique path followed product and make the starting matrix which is going to solve through clustering method.

3.3 CREATION OF DIFFERENT PART GROUPS

Based on production technology, available machines and analysis of product parts the part groups were created. During the creation of the part groups, several things were taken into account, like the work operations that are needed to be performed on the machines, the efficiency of the machines and the sizes of the parts which are produced. The parts which, at a first glance, have very similar (almost identical) production technology specifications are classified into different groups.

Obtained part groups as well as their routing and available machines in the system led to the creation of material flow diagram for part groups Fig. 2.

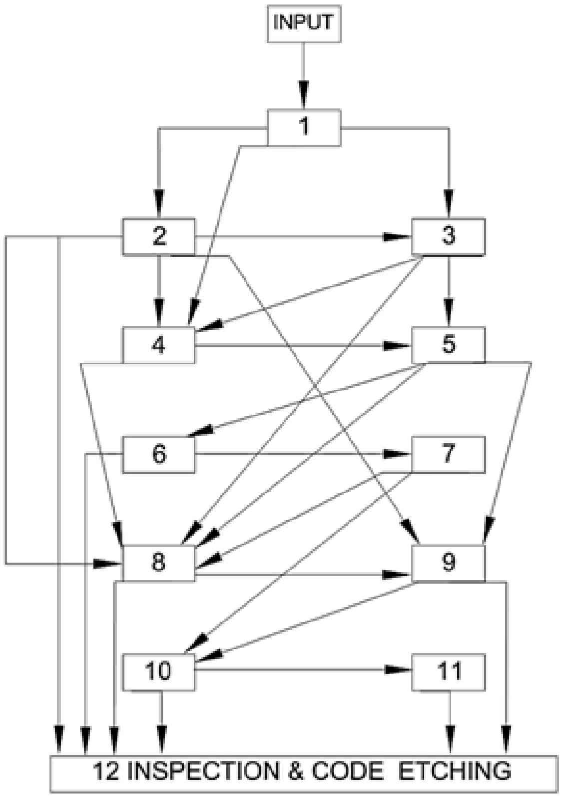

Fig. 2 *Material flow diagram for part groups*

3.4 Incidence Matrix (Clustering Analysis)

According to PFA methodology, the starting matrix with machines and part groups is given in Fig. 3

	Part Groups																	
Machines	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
2	●	●	●	●	●		●	●	●	●			●	●	●	●	●	●
3					●		●	●	●	●	●	●	●	●	●	●	●	●
4						●					●	●						
5			●		●	●			●	●			●	●		●	●	●
6														●				●
7													●				●	
8		●						●		●	●	●			●	●	●	●
9				●			●		●							●		
10			●								●		●	●	●	●	●	●
11															●			

Fig. 3 *The Starting Matrix of Machine with Different Part Groups*

	Part Groups																	
Machines	10	5	15	8	3	2	1	16	4	7	9	18	14	17	13	11	12	6
1a	⍰	⍰	⍰	⍰	⍰	⍰	⍰											
2a	⍰	⍰	⍰	⍰	⍰	⍰	⍰											
3a	⍰	⍰	⍰	⍰				G1										
5a	⍰	⍰			⍰													
8a	⍰		⍰	⍰		⍰												
10a			⍰		⍰													
11			⍰															
1b								⍰	⍰	⍰	⍰	⍰	⍰					
2b								⍰	⍰	⍰	⍰	⍰	⍰					
3b								⍰	⍰	⍰	⍰	⍰						
5b								⍰	⍰	⍰	⍰							
10b								⍰	⍰	⍰				G2				
6								⍰	⍰									
8b								⍰		⍰								
9										⍰	⍰	⍰	⍰					
1c														⍰	⍰	⍰	⍰	⍰
3c														⍰	⍰	⍰	⍰	
10c														⍰	⍰	⍰		
5c												G3		⍰	⍰			⍰
2c														⍰	⍰			
7														⍰	⍰			
8c														⍰		⍰	⍰	
4																⍰	⍰	⍰

Fig. 4 *Resulting incidence matrix* **-** *Division into machine group*

3.4 CELL FORMATION

In this initial setting part groups are assigned to machines according to routing criteria. However, some machines are capable of processing other part groups. Cells are created with no additional costs. Material flow diagram for these two cells is shown in Fig. 5

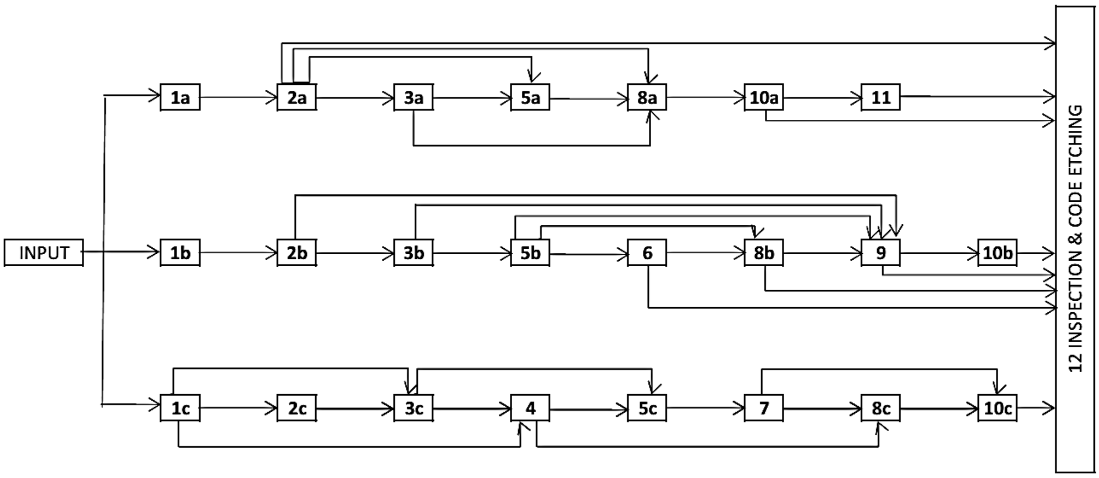

Fig. 5 *Material flow diagram for cell*

The FROM/TO matrices for two cells are shown in Fig. 6. The matrices show that there are no returning flows in the production system organized this way.

(a)

FROM \ TO	1a	2a	3a	5a	8a	10a	11a
1a		●					
2a			●	●	●		
3a				●	●		
5a					●	●	
8a						●	
10a							●
11							

(b)

FROM \ TO	1b	2b	3b	5b	6	8b	9	10b
1b		●						
2b			●				●	
3b				●			●	
5b					●	●	●	
6						●		
8b							●	
9								●
10b								

(c)

FROM \ TO	1c	2c	3c	4	5c	7	8c	10c
1c		•	•	•				
2c			•					
3c				•	•			
4					•		•	
5c						•		
7							•	
8c								•
10c								

Fig.6 *FROM/TO matrices of manufacturing cells*

4. CONCLUSION

In this paper, the presented research, theoretical as well as that conducted in the industry, showed that MC is possible to achieve by implementing GT philosophy in mass production industry. Also Implementation of GT principles through analysis of the system decrease the setup times, simplifying the material flows in the system, shorten the lead times in the system, shortening transport ways and with it the transport times in the systemhave and led to a new layout can be presented. However, full transformation from mass production to MC system cannot only rely on GT and does not end with shop floor transformation. Manufacturing cells are only the first step, and they enable better organization of production system. Having that in mind, in conclusion we propose the development of several systems (mainly software oriented) for MC:

Adaptation of Enterprise Resource Planning (ERP) and product data management system (PDM) for easier understanding of customer needs and product data management processes, information sharing and collaboration, unified analysis and corrective action[16].

Different manufacturing process execution scenarios simulation [17] and [18], for the prediction of possible problems and the evaluation of solutions.

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