Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 69 (2014) 1381 – 1387

Procedia Engineering

www.elsevier.com/locate/procedia

24th DAAAM International Symposium on Intelligent Manufacturing and Automation, 2013

Application of Group Tools in Production of Printed and Laminated Cardboard Packaging for Total In-Process Time Reduction

Djordje Lazarevic*, Ilija Cosic, Milovan Lazarevic,

Aleksandar Rikalovic, Nemanja Sremcev

[a]*Univrsity of Novi Sad, Faculty of Novi Sad, Trg Dositeja Obradovica 6, Novi Sad 21000, Serbia*

Abstract

One of the main issues in production is the share of total in-process time of a product. Over 85% of in-process time is throughput time and machine setup time. Operating tools in setup and throughput time are idle. There are no product value added operations in this period. Group technology brings solution in reduction of setup times and throughput times; it also deals with improvement of material handling operations and storage management, as well as increase in finished goods. Production is arranged in group-type layout, in such a manner that it corresponds to as much product groups as possible. Group technology saves time and effort in throughput setup by doing operations for a group of similar parts instead for each part individually. This paper analyses processes in which it is possible for group of parts to be treated on some operations at the same time. It is noted that the more flexibility in product and production management is achieved, setup, throughput and production time are reduced and the level of plan execution is higher, by making group tools and managing groups of product at the same time instead of individual group or product.

Selection and peer-review under responsibility of DAAAM International Vienna

Keywords: group approach; group tools; setup time; production time; production flow; group criteria

1. Introduction

Group technology is manufacturing technique in which functionally-grouped machines (producing parts or products with similar characteristics) are organized into cells [1]. Each of these cells is specified for a family or group of parts. Because of its organization, the group technology is often called cellular manufacturing.

* Corresponding author. Tel.: +381 63 888 0434; fax: +381 21 459 536.
E-mail address: djordje.s.lazarevic@gmail.com

1877-7058
Selection and peer-review under responsibility of DAAAM International Vienna
doi:10.1016/j.proeng.2014.03.132

In production systems based on group approach, group of parts follow the same procedures of production: same machines, order of operation, require relatively proportional time requirements on operations and share setup time of the machines [2].

The objective of group technology is to form small organizational units (cells) which complete all the set of products/components which they make, through one or a few major processing stages and are equipped with all the machines and other processing equipment they need to do so [3].

The data used in production can be classified into three categories: fixed, historical, and incidental data. Data collection of products, parts, machines, methods is performed. Product data consists of products type, number and name, parts list, assembly, sub-assembly and location of assembly. Collected data will shape the outcome of group making process.

Group is formed based on information about products similarity. Products of similar geometrical shape can be considered for similar. It is also important that those products are made out of same or very alike material. Purpose of product is not a big issue, but some procedures must be followed for products which are of specific usage. Similar techniques can (and have) been applied to products/assemblies also are a part of group making process [4]. At the end, the group of parts will follow the same material flow through the production.

There is no good solution for group making. There are lots of discussions and proposed solutions for group formation issues. Some of those techniques for classification have been used in practice with success. The problem of group making is in coding and classification of products. Coding is nothing more than assignment of symbols to represent information about product structure (shape, material, etc.). Classification is a proceeding that is used to separate a large group of objects into sub groups [5, 6, and 7]. Product flow analysis (PFA) is a relatively simple, well tested, inexpensive and efficient technique for planning the change from traditional process organization to group technology. Product flow analysis will follow the rout cards of products, showing how parts are made and gathering relevant information.

This technique is quite general, and has applications in many areas of manufacturing systems: design, process planning, layout planning and scheduling and routing [8].

The problems of production systems are long production cycles, the share of total in-process time for product and material overconsumption. This paper deals with a new model for tool shaping in group approach which will address these issues. Explanation of model is presented in Section 2. Example of model application is given in Section 3. Brief conclusion of topic and further research is in Section 4.

2. Model formulation

It is noted that Group approach, when applied in production, reduces setup and throughput times, optimizes material, information and energy flows, reduces stock and increases level of plan execution [9]. To group machines, part routings must be known [10]. By scheduling parts of the same family on the same (or similar) machine tool, much of the setup and positioning time can be cut.

In a batch production system level of setup time is significant. Items are produced in lots. For each lot, machines (technological systems) must be prepared. Preparation of machine is measured in setup time. Setup time includes: cleaning of machines, warming of machines and fluids, tools adjusting, material preparation, etc. Operating tools are not in use in this stage of production. Product value added operations in this period are almost none existing. Setup and holding costs do not depend on the lot size.

By introducing group tools, which enable to work on a group of parts at the same time on the same machine, repeating of setup time is reduced. Specialized group tools can be considered as a substitute for parallel working operations in production. It can be also referred as branched groups [11], but in this case, conducted on one machine, see Fig. 1.

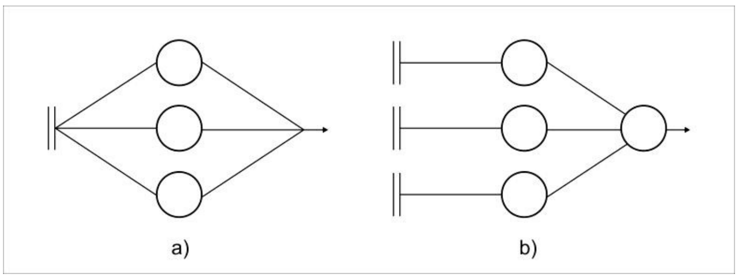

Fig. 1. Forms of assembly groups - a) parallel b) branched.

The first step will be assignment of machines and parts to groups. Parts made out of the same material can be considered to be in one group, and parts which are similar in shape can be made by the same set of machines. Group criteria for part selection, in this particular case, must be the material of which parts are made of. This would mean that, at one point, parts will have to be treated on the same machine. And on that particular machine specialized group tools can be applied.

The output of product flow analysis is a list of groups, list of the machines and other facilities to be installed in each group (cell), and lists of the parts to be made in each group. The main details needed about each part in the part list are the name and identification number (code) which must be unique. Analysing those products characteristic, one will came across processes which can be done parallel for more than one part in a group. Those parts that can be processed on the same machine at the same time will form a sub-group.

In addition, it is necessary to know how materials are held on a machine for each operation. Code for material holding will provide such information. Each machining technology must be supported by selection of the relevant cutting tools and cutting materials, design and use of plant and machinery suitable for innovative machining technology, which benefits must always be continuous reduction in production time and mechanical machining time in each operation, subject to the quality and accuracy of the product [12]. List of all tools used on each machine for each operation on each part is needed to find tooling families of parts which can be made using the same tools at the same set-up, and also to help in tool rationalization and the overall planning.

Production management must consider the right order of releasing products in production, it must be product oriented rather than process oriented [13]. Group of products will be released at the same time, by the nature of production organization, but sub-groups of product will be released parallel in the production process and will be treated at the same time on several machines. Process planning and scheduling are two most important tasks in a manufacturing company. Both functions play an important role in order to deliver the products on time and optimum utilization of resources as well as profitability of manufacturing a product [14].

The model examines product flows through production where conventional tools are replaced with specialized group tools, thus shaping more than one part/product of the group at the time. Group tools are not applicable for all processes. There are some types of uncertainty with this approach which affect the production process and this in turn impacts on the overall cost efficiency. Production process itself is speeded and machine usage is more efficient in production where product quantity is sufficient and product process making is eligible for this kind of process management. Areas where it is possible to apply specialized group tools are machine metal processing, printing, textile industry, wood processing, confectionery industry, casting of plastics and glass, disassembly [15] and similar.

Now, that group for products, parts, processes, machines and tools are defined, the decision making process can be conducted. Inside the limitations imposed by product organization, the engineer has considerable freedom to choose the form of organization which he prefers.

3. Examples

PFA analyses the production flow, and the result is a clear image of how product production is done. Products travel from operation to operation in defined order. Overall time of production is shown as setup time and production time, throughput time is not a value of interest in this case. When parts processing time is finished, setup time is in place for preparation of process for next group of parts. Figure 2 shows time consumption in process for making of several groups of products.

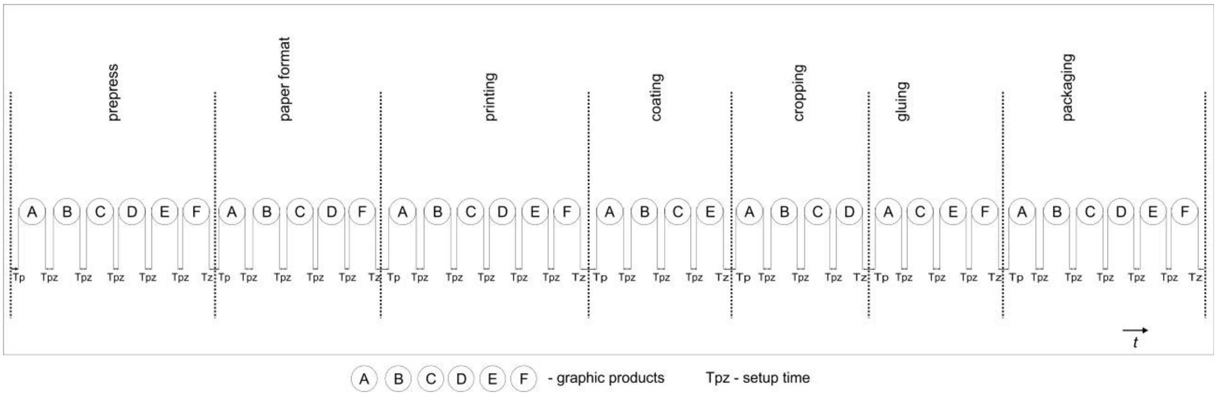

Fig. 2. Process of products making.

When it is possible on operation to make a group tool for some parts, significant time cut can be achieved, shown on Fig. 3.

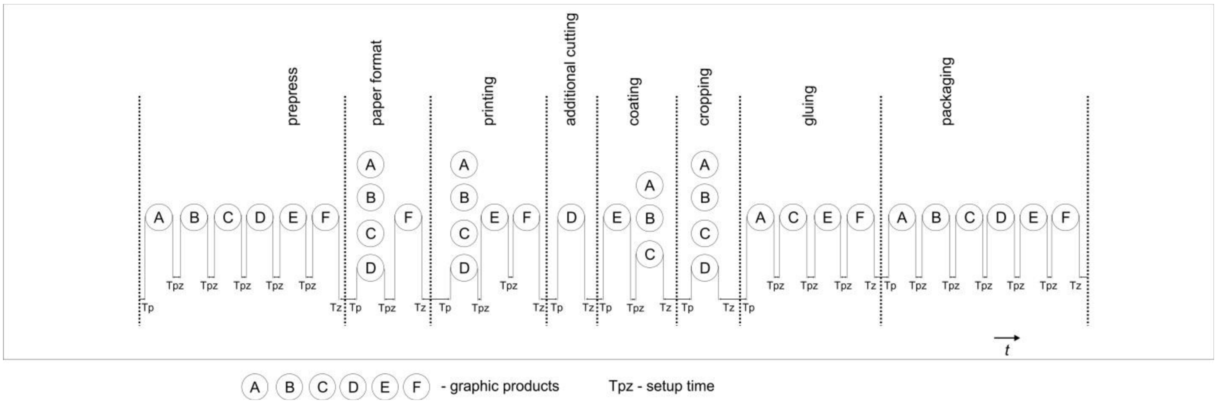

Fig. 3. Process of products making when using group tools.

In shown case, when it is possible to treat a group of parts at the same time, setup time is reduced from 35 setup times for 6 groups which is processed on 8 operations to 25 setup times for same groups of products and on 9 operations.

By analysing product flow for the same groups of products, conclusion is that the complexity of Fig. 4. a. is much higher than solution on Fig. 4. b.

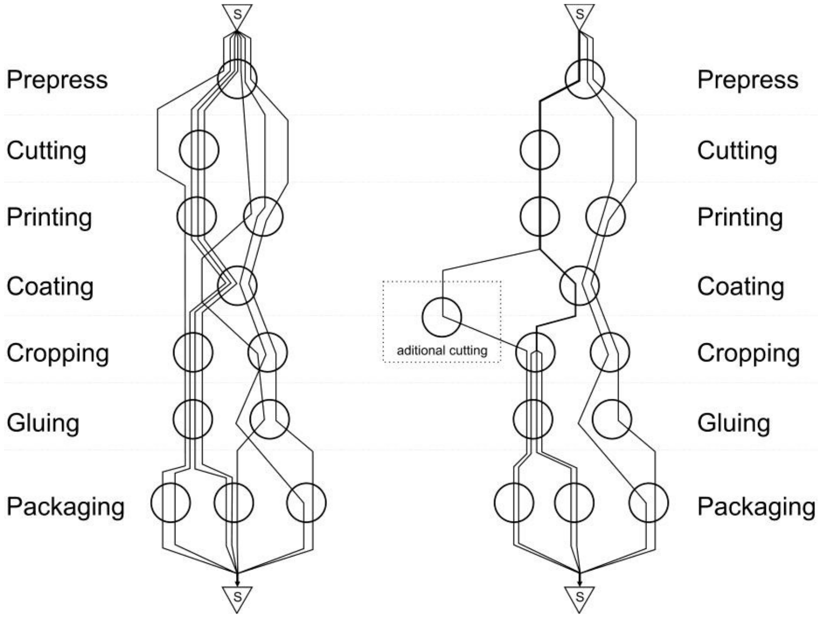

Fig. 4. Material flow a) current way of production b) proposed solution.

Process organization, where similar processes are divided into process cells, is outdated. Production should be product oriented, divided into cells of product organization, by line flow.

To make it possible for production to work in a described manner, specialized tools must be made for certain processes. It is not always possible to implement these measures, process must be eligible and group of parts must be made in accordance with model planning. First criteria for part selection must be the material of which parts are made of. Code for material holding will provide such information.

Group tools, used in graphic industry for printing and cropping (printing plate and cropping plate) are good example for proposed model where different groups of parts are treated on a machine at the same time. On the left side of the Fig. 5 layouts of 4 parts (of 5 in totals) on separate printing plates is shown. In this case, considering that each of those 5 parts are printed in 4 standard colours (CMYK) and special colours (pantone colour), there is a need of 30 printing plates for printing those products. On the right side of the Fig. 5 layout of 5 parts on a 4 printing plates is shown. In this layout, only 7 printing plates will be needed for printing of those products. Number of product patterns on a tool is proportional to their lot size. Beside of tool budget savings, this manner of producing will save time (setup time, as shown on Fig. 4 and Fig. 5) and increase efficiency of printing machines and overall plan execution.

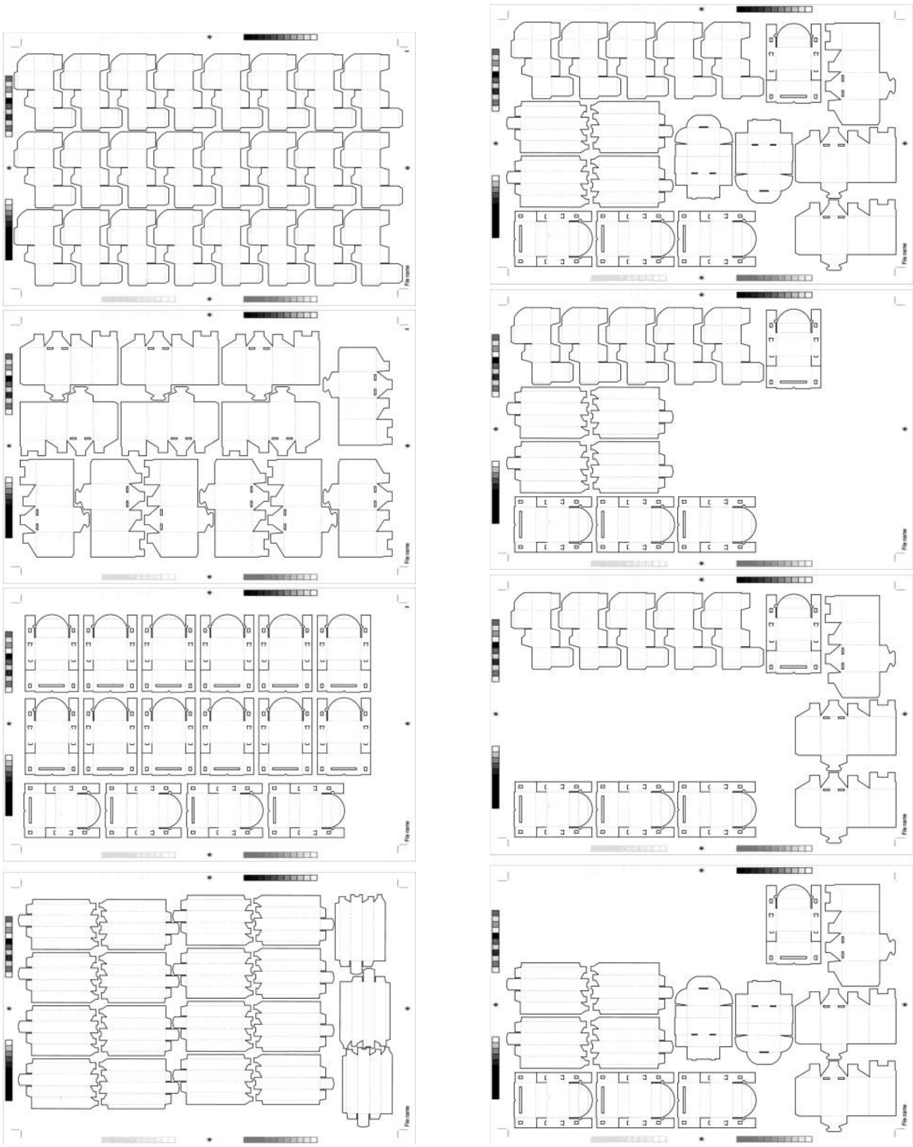

Fig. 5. Layout of printing plates, tools used in graphic industry
(on the left are conventional layouts and on the right is proposed solution for plate layouts).

Patterns from Fig. 5 are used for making tools for cropping. Contours are places where cutting edges are placed for parts removal from paper/cardboard. If used as cropping plate, instead of 5 different cropping plates of which 4 are shown on left side of Fig. 5, for separation of 5 different products/parts, it is possible to use only one, on the top of the right side of Fig. 5. Result is elimination of 4 setup times in production process and reduction of cropping tool number needed from five to only one. In this case, it is also of importance that a number of parts/products on a cropping tool are in proportion with their lot sizes.

4. Summary and topics for future studies

In this paper, a model has been developed to show the relationship of group tools and outcomes of production system. Its application will reduce setup, throughput and production time, increase level of plan execution, and increase flexibility in product and production management.

Coding, classification and PFA will give directions for constituting groups of products, parts, and machines. Knowing what is made, in which quantity, how it is made, and from which resources, the proposed model analyses potential processes in a production to develop specialized group tools. Purpose of these tools is to process the groups of parts/product at the same time. Time of production cycle is shorter and machine setup times for each individual part/product are avoided.

Based on the results from given example, other studies and developed and learned theoretical knowledge, model's economy contribution must be examined. Contribution in time saving and reducing number of specialized tools used in production is significant. Nevertheless, level of material waste and cost of making specialized group tools as well as possibility of their application has to be analysed. From those analyses will emerge recommendations for optimal lot size where group tools are applicable to minimize the total cost per produced item. The optimal lot size will minimize the total cost but only if it is paired up with optimal number of products/parts treated by designed group tool on available operations. It is of essential matter to calculate minimum production requirements for economical usage of group approach and group tools.

Acknowledgements

This work was partially supported by the Ministry of Education, Science and Technology Development of the Republic Serbia under Grant number 035050.

References

[1] Dragutin M. Zelenovic, The design of production systems, Edicija "Tehnicke nauke – udzbenici" broj 362, Faculty of Technical Sciences of Novi Sad, Novi Sad, 2012, ISBN: 978-86-7892-458-3.
[2] Irani, Shahrukh, Handbook of Cellular Manufacturing Systems, New York, NY: John Wiley & Sons, Inc., 1999.
[3] John L. Burbidge, Production flow analysis for planning group technology, Oxford series on advanced manufacturing, Clarendon press, Oxford, 1997, ISBN – 10: 0198564597.
[4] Department of Industrial Engineering & Logistics Management, The Hong Kong University of Science and Technology, 2013, address: http://www.ielm.ust.hk/dfaculty/ajay/courses/ieem513/GT/GT.html
[5] R.G. Askin, C.R. Standridge, Modeling & Analysis of Manufacturing Systems, John Wiley & Sons, 1993.
[6] Ignacio Castillo, Jeffrey S. Smith, Formal modeling methodologies for control of manufacturing cells: Survey and comparison, Journal of Manufacturing Systems, Volume 21, Issue 1, 2002, Pages 40-57, ISSN: 0278-6125.
[7] Mahdavi, M.M. Paydar, M. Solimanpur, A. Heidarzade, Genetic algorithm approach for solving a cell formation problem in cellular manufacturing, Expert Systems with Applications: An International Journal, Volume 36, 2009, ISSN: 0957-4174.
[8] D. Zelenovic, I. Cosic, D. Sormaz, Z. Sisarica, An approach to the design of more effective production systems, International Journal of Production Research, 1987, Vol. 25, No 1, pp. 3-15, ISSN: 0020-7543.
[9] N. Suzic, B. Stevanov, I. Cosic, Z. Anisic, N. Sremcev, Costumizing Products through Application of Group Technology: A Case Study of Furniture Manufacturing, Strojniski vesnik = Journal of Mechanical Engineering, 2012, Vol. 58, No 12, pp. 724-731, ISSN: 0039-2480.
[10] Chin-Chai Wu, Wen-Chiung Lee, Single-machine group-scheduling problems with deteriorating setup times and job-processing times, International Journal of Production Economics, Volume 115, Issue 1, 2008, Pages 128-133, ISSN: 0925-5273.
[11] J. Burbidge, D. Zelenovic, I. Cosic, R. Maksimovic, B. Kamberovic, PRILOG RAZVOJU POSTUPAKA GRUPISANJA U USLOVIMA REALNOG PROIZVODNOG SISTEMA, Casopis PROIZVODNJA, 1981, pp. 7-11.
[12] J. Jambor, Quality of Production Process with CAD/CAM System Support, Chapter 24 in DAAAM International Scientific Book 2012, pp. 277-286, B. Katalinic (Ed.), Published by DAAAM International, 2012, ISBN 978-3-901509-86-5, ISSN 1726-9687, Vienna, Austria, DOI: 10.2507/daaam.scibook.2012.24.
[13] D. Zelenovic, D. Sormaz, I. Cosic, N. Radakovic, The structure of the procedure of modeling of the process of production systems, Zbornik radova Fakulteta tehnickih nauka, 1987, Vol. 18, pp. 72-83, ISSN: 0350-428X.
[14] R. Phanden,A. Jain, R.Verma, Review on integration of process planning and scheduling, Chapter 49 in DAAAM International Scientific Book 2011, pp. 593-618, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-901509-84-1, ISSN 1726-9687, Vienna, Austria, DOI: 10.2507/daaam.scibook.2011.49.
[15] M. Lazarevic, I. Cosic, Z. Anisic: RFID Tehnologies In Product Disassembly Process, 17. DAAAM International Symposium, Vienna, DAAAM International Vienna, 8-11 November, 2006, pp. 129-137.