

Group Technology in Design of Manufacturing Systems -A Review

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ABSTRACT. From a "Industrial Engineering" standpoint, group technology has been widely explored (layout, workflow, scheduling, etc.), while organisational design has received less attention. This essay has evaluated research on the effects of group technology. It has been noted that five more examples were taken from an archive search to strengthen the validity of conclusions made from the examination of these empirical cases. The coding of components was not used in order to arrange machines and workers into production cells; instead, cluster analysis and product flow analysis were used. Additionally, the findings show that group technology adoption often satisfies changes in performance criteria brought on by competitive pressures, notably flexibility and responsiveness, even though the organisations only explored group technology when under pressure of 'poor' business performance. Group technology does not, however, always address issues that businesses face. An actual instance demonstrates that defunctionalization and scheduling with virtual groups were more advantageous. However, group technology also enables businesses to explore assigning responsibility for production planning and scheduling to lower levels of the hierarchy and semi-autonomous groups as an alternative to "complicated" software programmes where it is practical to do so (a socio-technical approach). While the current study provides some insight into the connection between group technology and organisational structure design, more investigation into the design of these structures and their connection to group technology is required.

Keywords: GT, Manufacturing Cells, Socio-technical Approach.

INTRODUCTION

Group technology is a manufacturing method in which a few machines or processes are used to produce items that are similar in shape, manufacturing process, or functionality. A single solution to a set of problems may be found by grouping comparable problems, which can save time and effort. This is the basic tenet of group technology. Many problems are similar. Part families are collections of related components, while machine cells are collections of machines used to process a single part family. Every machine in the associated machine cell does not have to process every part in a part family. Cellular manufacturing refers to this process in which a machine cell produces a component family. Employing GT often improves manufacturing efficiency since the necessary procedures may be contained within a small cell, eliminating the need to transfer items that are still being processed. Group technology is a strategy that makes use of the commonalities in design and manufacturing

by identifying and grouping together comparable pieces. Part families can be created by grouping parts together based on similarities.

GROUP TECHNOLOGY IN MANUFACTURING

Manufacturing benefits greatly from group technology. The quantity and diversity of pieces are decreased. Planning the procedure for the remaining components is simpler and more reliable. CAPP, or computer-aided process planning, is a crucial instrument for this. It plans consistently, standardised, and precisely estimates expenses using the coded commonalities. It then allocates the component to a GT production line. Cells utilising group technology shorten throughput times and work-in-process. They streamline scheduling, save down on travel, and make oversight easier. Improved setups and tooling costs are some of the more notable and obvious reductions. Lower lot sizes and smaller lines result from reduced setup times, which leads to quicker throughput, shorter lead times, and less inventory. gt can occasionally replace the need for pricey NC machinery. When paired with NC, GT makes programming simpler.

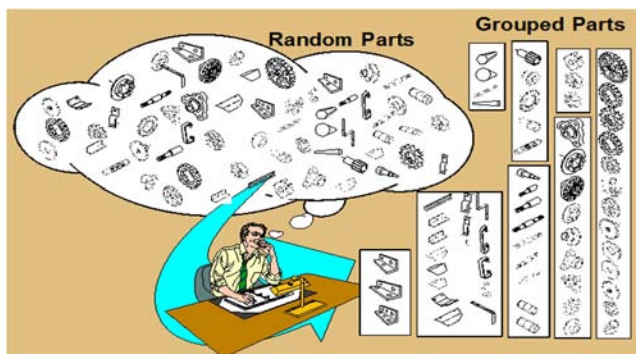


Figure 1 Group Managing System In Group Technology

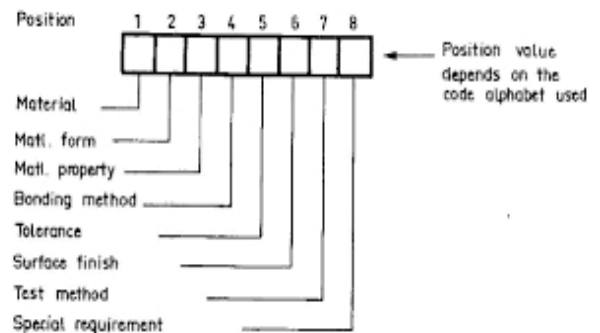


Figure 2 Coding System In Group Technology

WAYS TO IDENTIFY PART FAMILIES

- Visual inspection - based on the components or photographs of the parts, using best judgement to classify the parts into suitable families.
- Production flow analysis - putting things into categories based on the data on route sheets.
- Part classification and coding - using a coding system to relate parts by pointing out their similarities and differences.

HISTORY OF GROUP TECHNOLOGY

R. Flanders from the United States delivered a talk on organising manufacturing at Jones and Lamson Machine Company in 1925, and it was during this presentation that the original concept for GT originally emerged. A. P.

Sokolovski of the USSR proposed in 1937 that components with comparable configurations and features, all other things being equal, should be produced using a standardised technological and manufacturing method. Then, also from the USSR, S.P. Mitrofanov developed this idea and introduced GT. Design uniformity and simplicity, according to Mitrofanov, are essential for a successful GT programme. In 1937, the same year Sokolovski released his article, a firm in the United States disclosed a technology in their manufacturing system. Swedenamed A. Korling gave a presentation in 1949 on "group production," which is a batch manufacturing application of production line principles. In his presentation, he explained how the job was separated into groups, each of which had equipment and tools for specific tasks.

Similar to the implementation at Forges et Ateliers a few years prior, GT was used in 1963 at Hopkinsons Ltd. in Huddersfield, England. In 1963, GT was also deployed at a Springfield, Vermont, facility that made machine tools. In 1966, Mitrofanov's writings were published in both German and Russia. The first ever international conference on classification and coding took place in 1966 in Fort Lauderdale, Florida, in the United States. The Waldorf-Astoria hosted the Second Conference on Classification, Coding, and Group Technology in 1967.

The International Labour Organization held a meeting in Turin, Italy, in 1969, with the major focus of the conference being on the definition of GT. A machine shop that was conventionally organised was converted into "family of part" lines by the Langston Division of Harris-Intertype in New Jersey, USA, also in the same year. The adoption has shortened lead times to days rather than weeks while increasing production by 50%.

The simplification and standardisation processes that emerged at the start of the 20th century form the foundation of the GT idea. It first appeared as a single machine idea designed to speed up setup. This idea was developed further by grouping items with comparable machine specifications and fully processing them within a machine group or cell. Part family creation is the result of a procedure that groups like parts together or divides them based on specified characteristics. Therefore, this procedure should be viewed as a requirement for the effective grouping of components into units and other benefits of production. The design properties of parts, such as component shape, size, surface texture, material type, and raw material estate, may be used to divide them into different categories. According to design characteristics, such as component size, surface texture, material type, and raw material estate, or manufacturing characteristics, such as operations and sequences, batch sizes, processing times, or level of production, parts can be grouped. Design engineers can obtain old drawings using the first method in order to assist new component design standardisation and conduct precise cost estimation. The second one results in setup time reduction, uniform process planning, and enhancements to the control process.

The concept of using part similarities to address the scheduling problem has been adopted by several writers, with the majority of the applications starting in the metal processing industry; nevertheless, there is no reference to the tile business to be discovered. In this instance, setups are not insignificant in these productive systems, and each stage of production has some resource availability. The "hybrid flow shop problem with dependent setup times on the sequence" is what this is known as. An estimation of setup times is required in order to optimize setup times. There aren't many studies on these issues, however one that uses statistical regression is in In order to facilitate the sequencing of jobs in a single machine, the researchers are looking towards minimising total setup time. A method based on the breakdown of setup time in a computer numeric control (CNC) environment is described, however it is not applicable to more complicated systems since it is reliant on the geometry of the components.

Literature review

Andrew Kusiak (1988)[1] This work presents the EXGT-S knowledge-based solution for resolving the generalised group technology challenge. Constraints relating to machine capacity, material handling system capabilities, machine cell dimensions, and technological needs are included in the formulation of the group technology issue. It was created for a production system that is automated. The tandem system design described in Kusiak is the foundation of EXGT-S. (1987). It takes various machines and different designs into account. The advancements in expert systems and optimization are utilised by EXT-S. Two key elements of the knowledge-based system are discussed: the expert system and the heuristic clustering approach. The expert system evaluates each partial solution produced by the clustering algorithm before changing the program's search directions.

Rob Dekkers (2018)[2] From an "industrial engineering" standpoint (layout, scheduling, workflow, etc.), group technology has been widely explored, whereas organisational design has received less attention. In three empirical situations, the technique of applied systems theory for the design of organisational structures was employed as the framework for analysis to examine this consequence of group technology. Five more instances were taken from an archive search to strengthen the validity of the conclusions gained from the examination of these three empirical cases. The coding of components was not used in order to arrange machines and workers into production cells; instead, cluster analysis and product flow analysis were used. Additionally, the findings show that group technology implementation generally satisfies changes in performance requirements brought on by competitive pressures, particularly flexibility and responsiveness, even though companies only gave group technology a second thought when faced with pressure from "poor" business performance. Group technology does not, however, always address issues that businesses face. An actual instance demonstrates that defunctionalization and scheduling with virtual groups were more advantageous. However, group technology also enables businesses to contemplate assigning responsibility for production planning and scheduling to lower levels of the hierarchy and semi-autonomous groups as an alternative to "complicated" software applications when their introduction is practical (a socio-technical approach). While the current study provides some insight into the connection between group technology and organisational structure design, more investigation into the design of these structures and their connection to group technology is required.

Norani Nordin et al. (2010)[3] An exploratory study of the use of lean manufacturing in Malaysia's automotive sectors is presented in this report. To investigate the degree of lean manufacturing application, a questionnaire survey is performed. This essay also looks at the forces and obstacles affecting the adoption of lean manufacturing. Sixty Malaysian companies that manufacture car components participated in the survey. The responders were selected from among people who have direct experience with lean manufacturing techniques, such as members of the production and quality teams. The results demonstrate that the majority of respondent companies are categorised as moving toward lean manufacturing practices. For each of the five areas of lean manufacturing practices, these in-transition companies have mean values that are modest. Additionally, it has been shown that these businesses give internal areas like administration and operation more attention and funding than they do to their exterior interactions with suppliers and clients. These companies contend that the goal to put the customer first and achieve continuous improvement inside the company are the driving forces behind the adoption of lean manufacturing. The results of this study also identified the key obstacles to or bottlenecks in the implementation of lean. The attitude of shop floor personnel and a lack of knowledge of lean ideas are the biggest obstacles to establishing a lean manufacturing system.

Christopher M. McDermott et al. (1998)[4] Using information acquired from a sample of 97 manufacturing facilities, we examine the relationship between organisational culture and results related to the implementation of advanced manufacturing technology (AMT). Many item measures are developed and adapted from a range of literature sources to measure managers' views of organisational culture, AMT benefits, and implementation outcomes like operational benefits, organisational benefits, satisfaction, and competitive success. To examine the correlations between these variables, regression analysis is performed. The findings imply that cultural traits as outlined by the competing values model are strongly associated with the success of AMT adoption. We finish by talking about how these effects may be managed.

Arash Shahin et al. (2010)[5] Although Group Technology (GT) has a significant impact on key aspects of lean production such production wastes, setup times, quality, and inventory management, the literature has not fully explored the link between the two topics. The implementation of Group Technology (GT) in lean production systems has been suggested as a conceptual paradigm for increasing productivity in this study. The model incorporates GT dimensions and how they relate to lean manufacturing objectives. The suggested model's relationships have been investigated using statistical analysis and a questionnaire. Managers from two industrial businesses were included in the statistical population. The findings support the strong association between the model's component parts in both businesses. Additionally, the variance analysis's findings show that, except from two questionnaire items, there is no difference between the two firms' responses to the other questions.

K.Arun Prasath et al. (2015)[6] In order to accomplish a significant improvement in production output, we have intended to present a full evaluation of group technology (GT) and its application concept in the area of cellular manufacturing in this article. The development of a cellular manufacturing system has proven to be a crucial step for batch, job shop, and to some extent process industries. Group technology has been a key element

in this process. With the principle of group technology acting as a traditional concept, it continues to play an important role in new manufacturing concepts like just-in-time manufacturing, total quality management, and technologies like computer integrated manufacturing in manufacturing systems. Group technology helps to reduce setup time, inventory levels, and logistics of goods while also providing effective control of production.

SanJeet Kumar¹ et al. (2013)[7] Finding a group of families of integrated byproducts with commonalities has been one of the key goals in the current manufacturing system optimization of the industries. Production managers would benefit from this categorization by being able to eliminate unnecessary activity on the shop floor, changeover time, production delays, and total cost. The fundamental idea of "exploiting commonalities," which comes from the Group Technology (GT) philosophy, has been utilized to come up with a novel solution to the issue. Implementing the GT technique, which involves forming product and machine groups and streamlining material flows, is one way to do this. This study has already been put to use in the context of a real case, with largely favourable outcomes in terms of setup and production costs, better planning and short-term scheduling, more precise setup time estimations for new items, etc. The synergy between GT and PFA is shown to provide advantages in the article. Eventually, a suggested solution was obtained by combining the use of material flow simplification based on PFA with the application of some good common sense and judgement.

Orchida Dianita et al. (2019)[8] The Indonesian furniture market is expanding quickly, with an average annual growth rate of US\$1.627 trillion in 2017. Given Indonesia's huge potential for the furniture business, a strategy to boost production and efficiency is essential. To attain its prior goal, group technology in cell manufacturing is employed as a method to enhance the production layout. The Hollier technique and Rank Order Clustering (ROC) are used to categorise the equipment and procedures in the production layouts. The layout change is effectively lowering the overall journey time by up to 24.6% and the total travel distance by up to 16.1%, according to the Discrete Event Simulation (DES) used as a validation tool.

Christopher Risandy Anak Rimes (2009)[9] The project is an investigation of the use of group technology in regional manufacturing. Group Technology (GT) is a manufacturing concept that holds that if several issues are similar, they may be grouped together to find a single solution, saving time and effort. The GT idea stresses minimising the scope of the circumstance that has to be managed. The factory is separated into smaller cells instead of being functionally built out, with each cell having all the tools and machinery required to finish a certain family of components. In order to accomplish the project's goals, 48 samples received a postal survey. Only 8 of the 48 firms responded. For this study, a single business was chosen as the case study. The business is situated in the Demak Laut Industrial Park and is active in food processing. During the visit to the firm, observations and interviews were conducted to determine whether the GT idea could be implemented and integrated in terms of production procedures and plant architecture. Based on the observations made during the factory inspection and interview, a new plant layout was created to be presented to the corporation. The research's and the proposal's goals have been met. Recommendations Due to the need for more study, the project's area of focus will be expanded.

D Ernawati et al. (2012)[10] One of the design issues is the facility layout problem, which involves placing facilities (such as machines or departments) in a planar area (such as a plant) in order to achieve goals like minimising the cost of anticipated interactions between facilities or maximising closeness ratings, among others. The effectiveness of production systems is significantly affected by layout. The layout design issue in this study is resolved using the cellular manufacturing system. The choice of this technique was made possible by the flexible option provided by cellular manufacturing tools, which are sophisticated and automated production equipment. The overall distance and component movement can be minimised. Similar components are recognised and grouped in cellular manufacturing systems to capitalise on similarity, according to their ideology. Manufacturing cell grouping minimises overall distance, according to the study's findings. Similar components are recognised and grouped in cellular manufacturing systems in order to capitalise on commonality. According to study findings, combining production cells decreases overall distance from 411.51 m to 335.14 m.

U Tarigan et al. (2018)[11] ABC is a woodworking business that uses rubber wood as its primary raw material to create home items including chairs, tables, waggons, shelves, and laundry hangers. According to the findings of the observations performed on the firm, it was known that the production process in the company still contained a lot of non-value added activities, such as delays and long distance transportation activities, which caused the production process' lead time to increase. By employing Value Stream Mapping to identify operations

that add value and those that don't, the lean manufacturing technique is used to eliminate non-value contributed activities as a result of challenges that the organisation is experiencing. It uses the 5W and 1H concepts. Following the reduction of non-value-added operations, the Group Technology Layout technique is used to create three different layouts with the goal of reducing the distance between stations. Through manufacturing process simplification and layout redesign to save production time, this research seeks to minimise non-value added operations. According to the study's findings, this strategy reduced the manufacturing lead time from 19237.4 seconds in the beginning to 14340.3 seconds.

Emad Rabiei Hosseinabad et al. (2020)[12] Over the past two decades, lean manufacturing applications have significantly influenced both academic and industry contexts. However, case studies have been the extent of the use of lean techniques in cellular manufacturing. A summary of the lean evolution in cellular manufacturing was required, as were critical remarks on strategies that addressed some of the early deficiencies in the lean application in cellular manufacturing. This project will create a distinctive framework for scholars, academics, and professionals by connecting the lean trends in cellular manufacturing and connected lean research partnerships. They are anticipated to get a better understanding of how lean has evolved in cellular manufacturing, both conceptually and in terms of how it is used inside an organization, as well as identify potential future study areas.

Andrew Kusiak et al. (1988)[13] One of the most important elements to increase the productivity of production systems is group technology, or GT. The fundamental concept behind GT is to put together components that call for comparable actions and the machines that perform these processes. See Fazakerley (1974), Ham et al. (1985), and Gallagher and Knight for a thorough analysis of GT and its benefits (1986). A machine-part incidence matrix $[a_{ij}]$ with "1" (empty) entries that signals that machine i is employed (not used) to process the part j is one of the often used representations of the GT issue. Clusters of machines and parts are often invisible when a machine-part incidence matrix $[a_{ij}]$ is built. The original incidence matrix can be transformed into a structured (perhaps block diagonal) form using a clustering technique. Take a look at the machine-part incidence matrix to demonstrate the clustering technique to GT.

G. Harhalakis et al. (1987)[14] The challenge of identifying a useful breakdown of the production system into manufacturing cells that may be assigned to part families is dealt with in this work. Presented is a straightforward two-step heuristic approach that can solve industrial applications with plausible dimensions while limiting the inter-cell material flow. The bottom-up aggregation technique is the first phase of the suggested heuristic, which aims to reduce "Normalized Inter-Class Traffic". The second stage is an improvement-seeking process where the value of a machine to a cell is verified.

Kamal Khanna et al. (2014)[15] One of the biggest changes in the global economy over the last few decades has been the transfer of control over defining market demand from producers to consumers. Manufacturers must continually adjust to market changes given the intense competition they face to stay in business. The focus on flexibility and responsiveness in manufacturing system design has changed as a result of the pressure of competitive price, quick delivery times, and high customisation. It has made outdated concepts of technical and managerial advancements to the point where traditional production processes are no longer optimal. To address these contemporary manufacturing issues, a variety of more recent production system paradigms have arisen over time. Group Technology, the management tenet of solving issues collectively, has taken centre stage in most of these paradigms. The goal of the current study is to give a three-part, concise assessment of the literature on this subject. The first section reviews the flaws in several traditional production system paradigms. The development of numerous contemporary manufacturing system paradigms is historically explored in the second section in the context of the shortcomings of traditional paradigms. The second section will also make an effort to demonstrate how Group Technology has come to serve as the foundation for each of these paradigms. An extensive assessment of the research on component categorization (and/or machine group formation) utilised in various current production systems is offered in the third section of the study. Literature is categorised both chronologically and in accordance with different methodologies, including coding and classification, clustering, knowledge-based systems, heuristics, soft computing, simulation, and others. The study also makes an effort to categorise the literature according to the criteria employed, the aims taken into account, and the emphasis orientation. It concludes with a vision for further study in this field. Group technology and manufacturing systems are key words.

Nancy Lea Hyer et al. (1989)[16] 53 US users of group technology were surveyed for this paper's findings (GT). Medium-sized to big metalworking and electronics businesses made up the respondent installations. They produced a lot of finished goods and/or component parts mostly through fabrication operations. These companies used GT in the following areas: design, process planning (including NC programming), sales, purchasing, cost assessment, tooling, scheduling, new equipment size, and tool selection. Most of the time, businesses applied GT using categorization and coding systems as tools. Although users noted technical and management challenges that must be solved for GT to be applied successfully, considerable and diversified operational and strategic advantages have been realised. The majority also believed that GT will play a crucial role in future CAD/CAM operations at their facility. The experiences of the respondents support the utility of GT, which is extremely wide. They also imply that by failing to comprehend GT as a universal concept and instead viewing it as a tool or equating it with a particular usage, possibilities to increase manufacturing efficiency may be lost. The experiences these manufacturers have had with cellular manufacturing are described in a second article that is based on the same survey data.

CONCLUSION

The majority of the research has focused on the machine and parts into cells with component families, so this study draws attention to the necessity of building the cellular manufacturing system with GT for maximum performance. In order to succeed in group technology, it is urgently necessary to design models that identify the ideal number of groups and the ideal production mix, taking into account technological and logistical limitations. The development of more effective tools that allow manufacturing system designers to achieve optimal solutions in reasonable processing times is necessary. We have also produced a better productive system with the help of the group technology principle. The application of GT in advanced manufacturing systems improves the design and operational efficiency of a system. We have also incorporated lot sizing and some flexible manufacturing systems with the production activities of a system. And the primary motivation for this paper's creation was to demonstrate GT's excellence in cellular manufacturing to both the small- and large-scale process industries.

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