CHAPTER II

LITERATURE SURVEY AND THEORETICAL CONSIDERATION

2.1 Literature survey

Ambwani (1997) examined the changes in different flexibility types upon conversion from a job shop layout to a cellular layout. An instrument has been constructed to be measure the change in different flexibility types as a result of the implementation of cellular manufacturing to test the propositions examining these changes. The data for this study was collected through a fax survey of seventeen plants in the electronics and telecommunications industry in Canada. The results reveal that implementation of cellular manufacturing contributed towards improvement in their responsiveness to the following: delivery of productions on time, introduction of new products, introduction of design changes in existing products and respond to fluctuations in product demand.

Cesani (1999) developed an investigation of labor flexibility in cellular manufacturing system. This research consists of an empirical investigation of labor flexibility in cellular manufacturing systems using a multiple exploratory case study approach combined with simulation modeling. The scope has been twofold: first to compare the practice of labor flexibility across and within companies, and second to evaluate the contribution of labor flexibility to system. The practice of labor flexibility in two case study firms is focused in this research.

Chen (1998) presented a two-stage algorithm to schedule the flow line cellular manufacturing system (CMS) considering intercellular parts. The major objective of this research is to obtain the final schedule with minimized make span. In the first stage, the CDS scheduling rule is utilized for each cell to obtain the initial sequences for parts within each cell, and the initial sequence among cells is also assigned in a systematic way. This initial schedule is then improved by the proposed tabu search heuristic in the second stage. Computer programs were developed for the proposed TSH procedure and other critical group scheduling procedures. Performance comparisons were conducted between these procedures and the outcomes demonstrate the proposed TSH performs better than other cellular manufacturing system procedures. Several findings on the final scheduling using the proposed procedure are discussed.

Foulger (1999) focused on cellular manufacturing systems. The research proposed an attempt to group machines into cells, assign tools to the machines, and allocate operations of parts to the machine-tool combinations, simultaneously. In this research, a 0-1 integer programming model is developed. The objective of the model is to reduce operation costs, material handling and refixturing costs, taking into consideration tooling, machine capacity and tool life.

Johnson (1998) formed a basic for answering questions by empirically studying cell adoption and non-adoption decisions in industry. A two-stage research design was deployed. In the first stage, a mail survey was used to identify five plants that were subjected to further analysis using a multiple case study approach. A secondary purpose of this survey was to provide additional information about factors affecting cell adoption and penetration from a broader population of plants than those selected for further analysis. In the second stage, in-depth field studies of the selected plants were performed using a semi-structured interview methodology. A case study was written for each plant and the content and accuracy of each case was verified by the plant. A cross-case analysis of these plants resulted in the development of 19 propositions about factors affecting cell adoption and penetration.

McQuaid (1998) examined the relationship between manufacturing input parameters and factory performance in a cellular manufacturing environment. The independent factors investigated include the process structure and product structure represented by operation capability and work content, respectively. Dependent variables explored include factory throughput and flow time. The research exposed that a relationship exists between the input parameters of the part/operation matrix and the factory performance. Evidence suggested that operation capability, represented by the number of parts each operation processed, had a significant effect on factory performance. In addition, the process structure and product structure significantly affected the throughput performance of the factories. Under the conditions assumed in this research, cellular manufacturing performed competitively with a traditional manufacturing strategy.

Moon (1999) developed a comprehensive computerized methodology to deal with cell formation and layout plan simultaneously. Anew solution technique is introduced to generate initial cell formation. Heuristic algorithms are used to refine the initial cell formation and duplicate machines. The new technique solves a network model using a new similarity coefficient and maximum-flow minimum-cut theorem, and guarantees an optimal solution. A flow line layout is developed to plan intra-cell and inter-cell layout. This flow line layout is constructed with a cut approach and layout patterns. The proposed comprehensive methodology has been applied to five case studies, and the results have been analyzed with several evaluation measures for cell formation or layout plan. The evaluation results for the cell formation stage are at least equivalent, or better, to those in other previous approached.

Moussa (1997) presented a solution methodology to help solve the cellular manufacturing problem. The method seeks the solution that achieves a good cellular division and minimizes the possibility of bottleneck machines and exceptional parts in order to reduce the need for inter-cellular moves thus reducing the material handling costs. The developed technique solves the cellular manufacturing problem one step before the incidence matrix such as during the part-machine assignment. The solution method developed in this research proves to be more effective. It has the advantage of permitting the person creating the cells the access to information concerning the operations required to produce the parts as well as information regarding the operations which can be performed by the machines. That results in the increase of flexibility in the cell design.

Pham (1998) focused on improvement of material handling and resource utilization in small manufacturer by applying cellular manufacturing system. There are two phases in this research. First, in order to improve production flow and reduce material handling costs, a plant layout is redesigned by utilizing cellular manufacturing principles. In comparison with the original layout, the new layout provides a substantial improvement in the system performance and has since been implemented. In the second phase, a combined algorithm for scheduling jobs is developed. It comprises of two parts. The first part constructs ten job sequences for ten work stations using three dispatching rules: shortest processing time, earliest due date, and minimum setup. The second part applies a modified Simple Genetic Algorithm to generate one optimal job schedule for all ten work stations in the plant.

Srisansanee (1998) examined the cell formation problem under probabilistic and uncertain demand. This research aim to develop a new machine cell formation methodology, which will address the dynamic nature of the production environment, which can be divided into two situations: probabilistic production volume and uncertain production volume. The important factors such as sequence of operation and resource capacity are also considered. The objective of the design methodology is to maximize the total profit.

Szwarc (1997) developed crisp and fuzzy mathematical models to optimally determine machine grouping and parts assignment under fuzzy demand and machine capacity. The objectives of these models are to minimize the processing and the material handling costs. Comparisons between the crisp and fuzzy results are made to show how outcomes differ when the uncertainty is introduced. The example problems are solved using the Hyperlindo software package to illustrate the ability of the model to react under different input parameters.

2.2 Theoretical Consideration

2.2.1 Group Technology (GT)

As the economics grow at the fast pace, the desire of the individual to possess special goods different from those of the other people rises, and the demand for specially ordered products increases, while the product life cycle decreases. The need for multi-product, small lot sized production becomes critical. The most recommended methodology is the Group Technology (GT).

GT is defined by Hyer & Wemmerlov (1984) as a philosophy to capitalize on similarities in recurring tasks in three ways : (1) by performing the similar activities together, thereby avoiding wasteful time in changing from one unconcerned activity to the next; (2) by standardizing closely related activities, thereby focusing on distinct differences and avoiding unnecessary duplication of effort; and (3) by efficiently storing and reducing the search time for the information and eliminating the need to solve the problem again.

GT becomes more significant because of its Classification & Coding system (CCS), which the latter plays the key role of joining the missing link of the Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM).

2.2.2 Type of GT

There are 3 types of Group Technology. Figure 2.1 shows each type of GT.

1. GT Flow line

This is used for the group of parts that pass the same sequence of machine. The time is relatively proportional time requirement for each machine. The GT flow line is suitable for the a product mix line system. The part handling is automated by machine transfer in some cases.

2. GT Cell

This allows parts to move from the machine to machine. The machines are arranged in the close proximity.

3. GT Centre

This is the logical arrangement. It may be located the same as a process layout by its function. Each machine is indicated to producing even material handling increase. GT centre is good for the large machines that have been located and cannot be moved easily.

2.2.3 Classification and Coding System

Generally, part similarities are of two types : design attributes, such as shape and size (figure 2.2 and 2.3) ; and manufacturing attributes, such as technological sequence, production time, tool required. Each type has their advantage depending on the application of users. The 13 parts shown in the figure 2.2 might have the same part family in manufacturing, but their geometry characteristics do not permit them to be grouped as a design part family.

One of the manufacturing advantages of grouping work parts into families can be described in the figure 2.4 and figure 2.5 to show the process-type layout for batch production in a machine shop. The various machine tools are arranged by function. There are several sections such as a lathe section, milling section, and drill press section. During the machining of a given part, the work piece must be flowed between sections and somehow, the same section being visited many times. This results in a big material handling, a lot of work in process, much setups time, long throughput time, and high cost. Figure 2.5 shows the production line with the same capacity, but the machines are

M: Milling
B: Boring
T: Turning
G: Grinding
D: Drilling

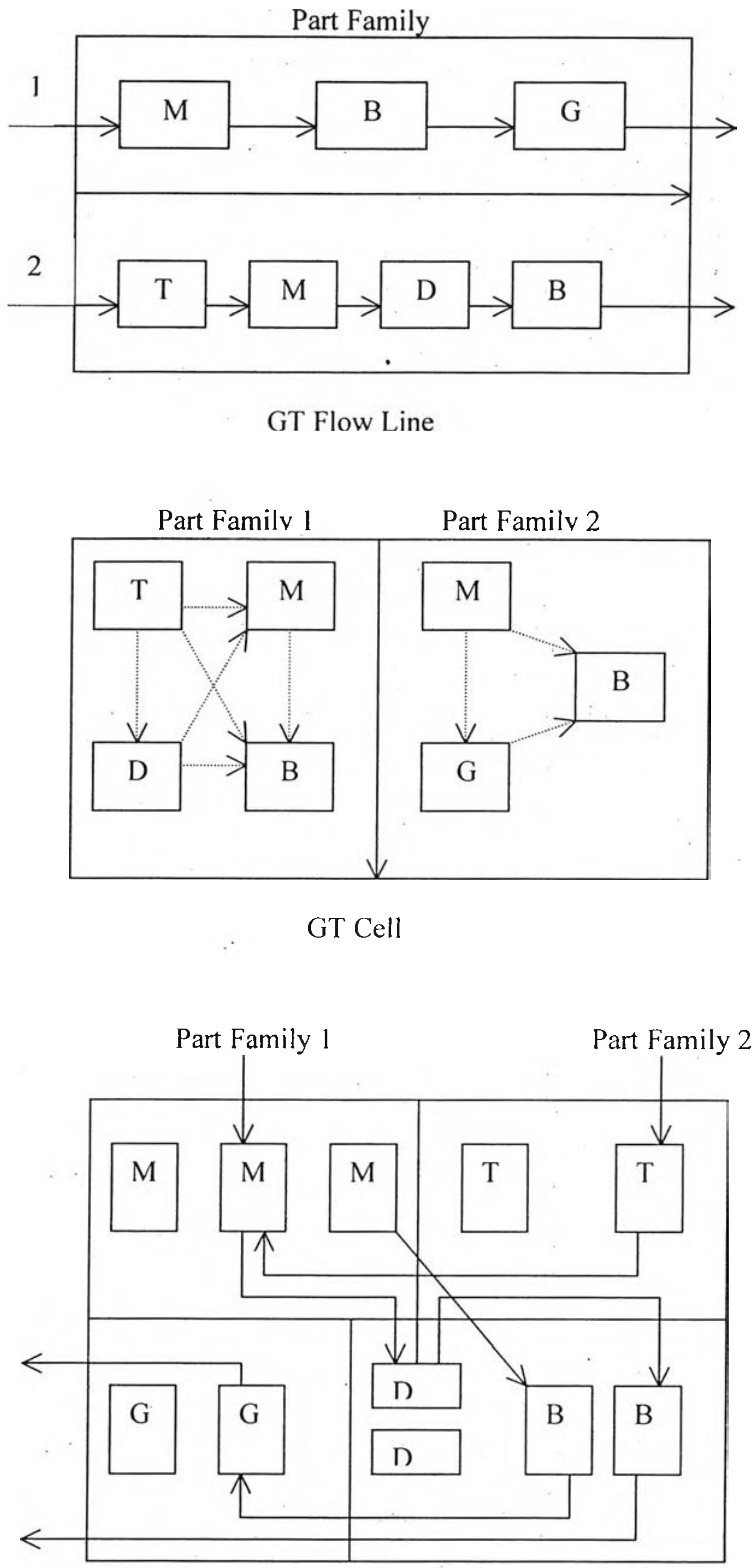

Figure 2.1 : Type of Group technology[1]

[1] A Framework for Production Planning and Control of cellular Manufacturing(Decision Science Institute, 1982)p.167

arranged into cells. Each cell handles a specific part family so the advantages gained in terms of handling reduction, lower setups times, less work in process, and shorter throughput time. As a result, the cost is decreased. Some of manufacturing cells can be designed form production flow lines, with conveyors used to transport work piece between machines in the cell.

A part family or group can be identified by both geometric shape or size and processing steps in manufacturing as above mentioned. There are 3 general methods of grouping parts into families, all of them are time-consuming and involve the analysis of much data by properly trained personnel. They are : (1) visual inspection, (2) classification and coding by examination of design and production data, and (3) production flow analysis (PFA).

The second method, classification and coding by examination of design and production data, is the most difficult and complicated. There is a long list of coding system shown in the figure 2.6 that is from the textbook written by Burbidge, Edwards, Hitomi, Ham & Yoshida, Jackson. In practical work, there is no international coding system. One system is suitable for one company but it is not necessary to fit another company.

The parts coding system covers many forms. It may be alphabetical, alphamnemonic numerical, mixed alphanumerical, serial number, product block, class block, descriptive numerical, or descriptive serial. Coding system can be of two basic structures :

1. Hierarchical structure

In this code, the interpretation of each succeeding symbol depends on the value of the preceding symbols. The strong point of this code is that it can hold a lot of information with a short code. Anyway, this code is not so compatible with a computerized system.

2. **Chain-type structure**

In this code type, the interpretation of each symbol in the sequence is fixed. It does not depend on the value of the preceding symbol.

There are 2 examples discussed to show how this code works. They consist of a sequence of numerical digits or alphabets devised to identify the part's design and manufacturing attributes. These are the Optiz System and MICLASS System.

- Optiz System : this system was developed by Professor H. Optiz at the Tecynische Hochshule, Aachen, West Germany (Grayson, 1968). This part classification and coding system represents one of the pioneering efforts in the group technology area and is probably the best known of classification and coding systems. The use of digits in this system is shown as following.

12345 6789 ABCD

The first nine digits are intended to convey both design and manufacturing data. The first five digits, 12345, are so called the "Form Code" and describe the primary design attributes of the part. The next four digits, 6789, constitute of the "Supplementary code". It indicates some of the attributes that would be of use to manufacturing dimensions, work material. starting raw work piece shape and accuracy. The extra 4 digits, ABCD, are referred as the "Second Code" and are intended to identify the production operation type and sequence. The secondary code can be designed by the firm to serve its own needs.

The digits are assigned from left to right, the part classified in increasing detail with higher value digits denoting that the part is more complex such as difficulty in manufacturing. The sequence of code places is compatible to the sequence in which the part is designed and then produced. As a result, it helps the use of existing designs and ease of production planning.

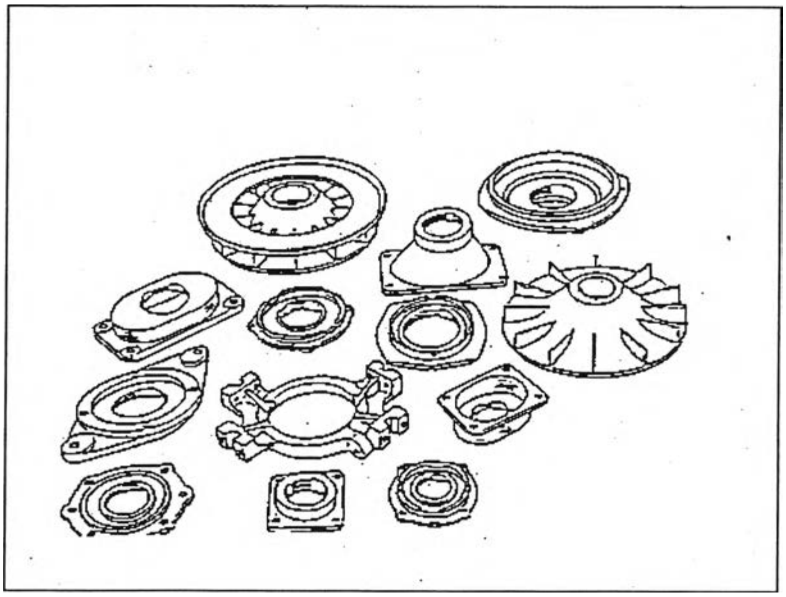

Figure 2.2 : Thirteen parts with similar manufacturing process requirement but different design attributes

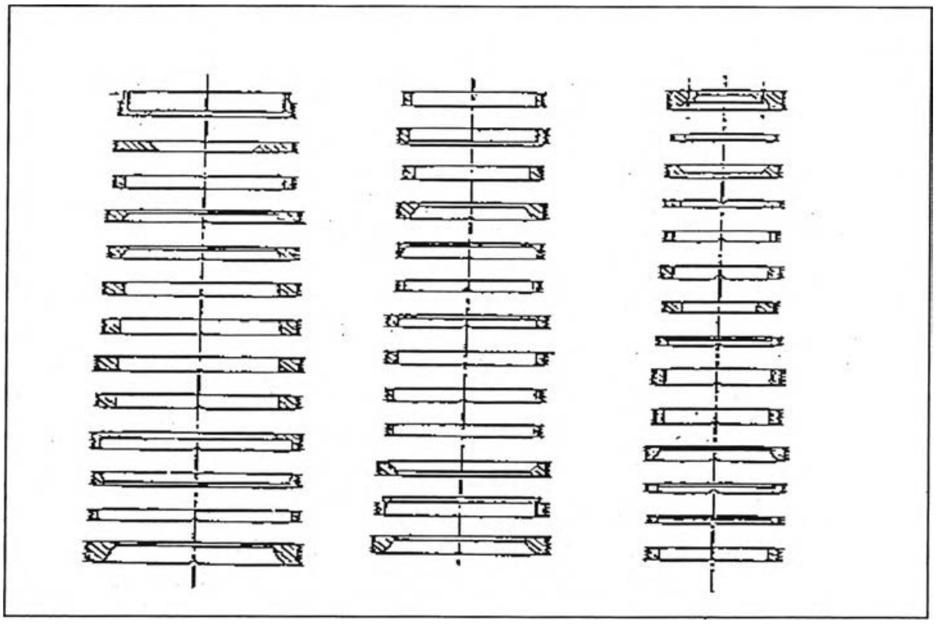

Figure 2.3 : Parts of Similar Shape

• MICLASS System

TNO, The Netherlands Organization for Applied Scientific Research, has developed both MICLASS and MISCHEDULE. Metal Institute Classification System or MICLASS in a short name, was developed to help automate and standardize various design, production processes, and planning. According to Nee's paper on Group Technology, MICLASS includes the following functions;

- Standardization of engineering drawings

- Retrieval of drawings according to classification number

- Standardization of process routing

- Automated process planning

- Selection of parts for processing on particular group of machine tools

- Machine tools investment analysis

The MICLASS Classification number can range from 12 to 30 digits. There are a universal code in the first 12 numbers that can be applied to any part. Up to 18 additional digits can be used to code data that are specufic to the particular company or industry. MISCHEDULE (Furth and Roubos, 1983) also applies the MICLASS Classification for their analysis. The MICLASS Classification and Coding System numbers indicates the meaning as follows:

1^{st} digit	main shape
2^{nd} and 3^{rd} digits	shape element
4^{th} digit	position of shape element

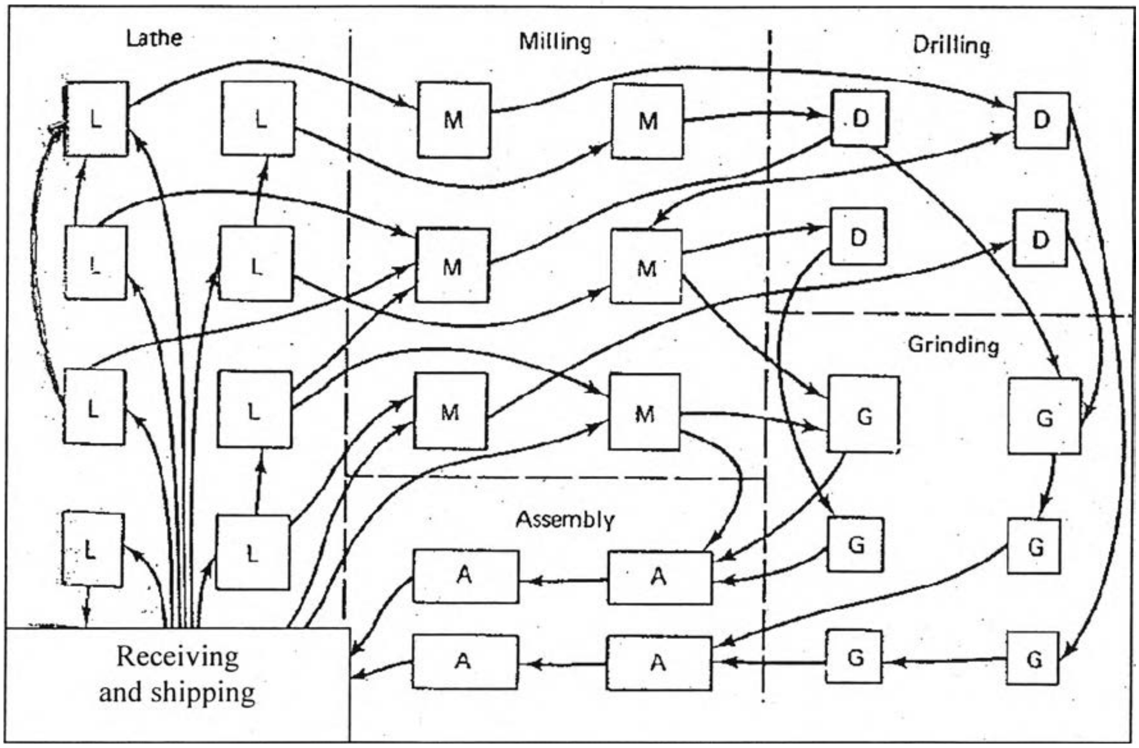

Figure 2.4 : Process-Type Layout

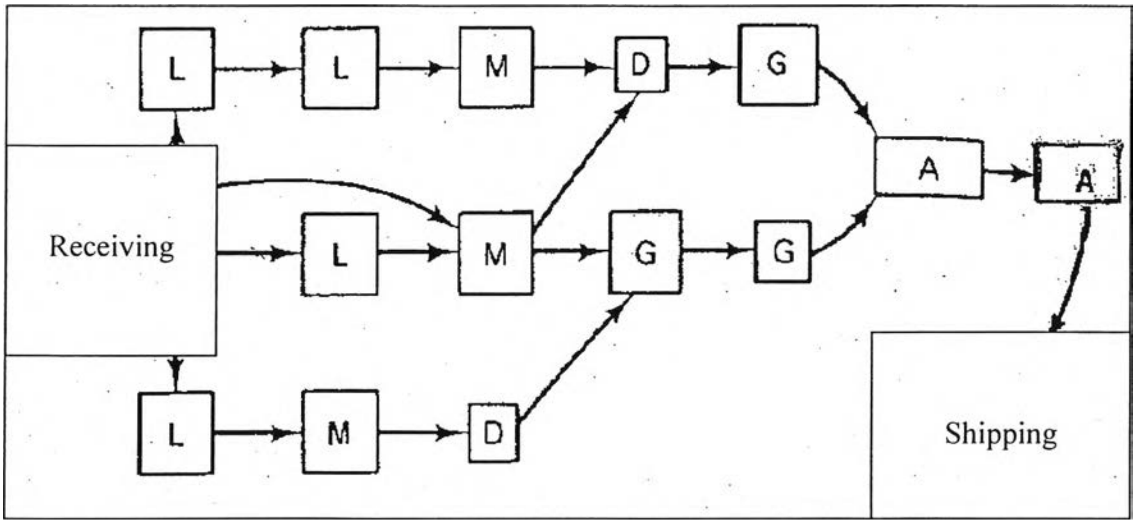

Figure 2.5 : GT Layout

System	Organization and Country
OPITZ	Aachen Tech. Univ. (W. Germany)
OPITZ's SHEET METAL	Aachen Tech. Univ. (W. Germany)
STUTTGART	Univ. of Stuttgart (W.Gemany)
PITTLER	Pittler Mach. Tool (W. Germany)
GILDEMEISTER	Gildemeister Co. (W. Germany)
ZAFO	(W. Germany)
SPIES	(W. Germany)
PUSCHMAN	(W. Germany)
DDR	DDR Standard (E. Germany)
WALTER	(E. Germany)
AUERSWALD	(E. Germany)
MITROFANOV	(USSR)
LITMO	Leningrad Inst. For Pre & Optics (USSR)
NIITMASH	(USSR)
VPTI	(USSR)
GUREVICH	(USSR)
VUOSO	Prague M/T Res. Inst.(Czechoslovakia)
VUSTE	Res. Inst. Eng. Tech. & Econ. (Czech.)
MALEK	(Czechoslovakia)
IAMA	IAMA (Yugoslavia)
PERA	Prod. Engr. Res. Assn. (U.K.)
SALFORD	(U.K.)
PGM	PGM, Ltd. (Sweden)
KC-1	(Japan)
KC-2	(Japan)
KK-1	(Japan)
KK-2	(Japan)
KK-3	(Japan)
SHEET METAL SYSTEM	(Japan)
CASTING SYSTEM	(Japan)
HITACHI	Hitachi Co. (Japan)
TOYODA	Toyoda, Ltd. (Japan)
TOSHIBA	Toshiba Machine Co., Ltd. (Japan)
BRISCH	Brisch-Birn, Inc. (U.K. and U.S.A.)
MICLASS	TNO (Holland and U.S.A.)
CODE	Mfg. Data Systems, Inc. (U.S.A.)
PART ANALOG	Lovelace, Lawrence & Co., Inc. (U.S.A.)
ALLIS CHALMERS	Allis Chalmers (U.S.A.)
SAGT	Purdue Univ. (U.S.A.)
BUCCS	Boeing Co., (U.S.A.)
ASSEMBLY PART CODE	Univ. of Massachusetts (U.S.A.)
HOLE CODE	Purdue University (U.S.A.)
DTH/DCLASS	Brigham Young Univ. (U.S.A.)
CINCLASS	Cincinnati Milacron Co. (U.S.A.)

Figure 2.6 : Selected Examples of Worldwide Classification and Coding Systems

5^{th} and	6^{th} digits	main dimensions
7^{th} digit		dimension ratio
8^{th} digit		auxiliary dimension
9^{th} and	10^{th} digits	tolerance codes
11^{th} and	12^{th} digits	material codes

MICLASS has an unique features, that it can work with computer interactively. To classify a given part design, the user responds to a series of questions asked by the computer. After that, the computer obtains the sufficient input to help the user to code the part items.

2.2.4 Cellular manufacturing

The Group Technology can be implemented through the Cellular Manufacturing effectively. The type of Cells can be classified according to its activity as follows:

- Component Manufacturing Cells.
- Assembly Cell.
- Process Cells.

Component manufacturing cells

This cell is to manufacture a family of geometrically related components or process related components by a single unit of machine or equipment. Its output is a family of the finished components so the various machines or equipment are obtained in one cell such as machining, drilling, milling etc. The assembly business is the customer of this component cell. They shall have to understand their customer and be able to supply their products in timely manner.

Assembly cells

This cell is organized to cover the production of assembled products family rather than a family of components. It depends on the complexity of the products that it may need both a sub-assembly cell and a final assembly cell. The sub-assembly cell pulls the parts from the components cells that are external suppliers. The best cells shall be designed to be the team-base manufacturer that enhances the productivity, quality and cycle time.

Process cells

These cells are set according to the function of the processes such as heat treatment, surface treatment. They are formed around a core process, which provides the service to the other manufacturing area. They have to serve the other team leaders' need in the business. The team leaders shall understand the concept of cells work in order to form the working relationship within the cells, the own working pattern with the aim of achieving the customer need.

2.2.5 Advantages of Group Technology Applications

It is clearly stated in the recent publication of Hyer and Wemmerlov (1988) on a survey of GT users. It is reported that GT is the most powerful tool when it is applied as a view of general philosophy. It is shown in the table 2.7 a & b that a reduction of time to create a new design at an average of 24%, time required to retrieve an existing design is 32.5%, reduction of time to create process plans from scratch is 43.5%, as examples. The economics balance sheet of employing GT that the input & output are calculated in monetary terms has not been established yet. However, there is information from one geographical source-USSR. It was reported that the investment of GT introduction in one Soviet economic region cost 7000 rubles with the gain of 10,000 rubles in return at the first year. The substantial gain has been from the productivity increase by 45% in average and approximately 30% up in set-up time reduction. One of the major improvements in the production is the reduction of documentation level by 40 or 60 % and the level of scrap by 40%.

There were other proven advantages in another survey of 20 companies in the U.S.A. by Hyer in an earlier date are; tooling and fixture expenses reduction, material handling cost reduction, floor space reduction, lead times reduction, work in process reduction, quality improvement, employee satisfaction increase and better cost estimation accuracy. (Hyer & Wemmerlov, 1984).

Let's discuss about the advantages specifically in the manufacturing cell. The implementation of the cellular manufacturing in the traditional factory needs reorganization of the plant and the product flow lines. The machine/equipment may be re-arranged in U shape, L shape, a loop or along the line. The U-shape line is easy for operators to reach several machines in terms of a group of machines requirement. The material handling by mechanized method is better for the linear arrangement of the layout. The best machine and material handling equipment arrangement depend on many factors such as the nature of products; shape, size, weight, scale of production.

The crucial feature of cellular manufacturing is the economics of work-in-process reduction, space reduction causing less movement & more utilization, the quality issues that are detected at real time. Furthermore, the operators are needed to get involved with many machines and functions. The operators become multi-skilled that enhance the flexibility of the operation. Those result cause productivity improvement as a whole.

Benefits From GT Design Applications				
BENEFIT	NUMBER OF PLANTS REPORTING THIS BENEFIT	NUMBER OF PLANTS REPORTING A SPECIFIC PERCENTAGE REDUCTION	AVERAGE PERCENTAGE REDUCTION	MAXIMUM PERCENTAGE REDUCTION
REDUCTIONS IN :				
TIME TO CREATE A NEW DESIGN................................	7	5	24.00	75.00
NUMBER OF UNNECESSARY ITEMS DESIGNS.........................	7	5	22.00	80.00
NUMBER OF PART NUMBERS...	7	5	9.00	20.00
NUMBER OF STORED DESIGNS.	6	4	7.50	10.00
NUMBER OF NEW DESIGNS PER YEAR..........................	6	4	9.50	20.00
NUMBER OF ITEMS THAT MUST BE DESIGNED FROM SCRATCH............................	6	3	6.67	10.00
TIME REQUIRED TO RETRIEVE AN EXISTING DESIGN..............	5	4	32.50	50.00
NUMBER OF DESIGN ERRORS...	3	2	30.00	50.00
COST TO CTREATE A DESIGN...	3	2	7.50	10.00
NUMBER OF DESIGNERS NEEDED.................................	2	1	10.00	10.00
COST TO STORE AND RETREIVE A PART DESIGN......	2	1	5.00	5.00

Figure 2.7 a : Benefit From GT Design Application

Benefits From the Application of GT in Process Planning*				
BENEFIT	NUMBER OF PLANTS REPORTING THIS BENEFIT	NUMBER OF PLANTS REPORTING A SPECIFIC PERCENTAGE REDUCTION	AVERAGE PERCENTAGE REDUCTION	MAXIMUM PERCENTAGE REDUCTION
REDUCTION IN TIME REQUIRED TO CREATE A NEW PROCESS PLANT....................	25	23	37.17	80.00
INCREASE IN NUMBER OF PROCESS PLANTS THAT ACCURATELY REFLECT THE USE OF PERFORMED MANUFACTURING METHODS...	24	19	41.18	90.00
REDUCTION IN NUMBER OF PROCESS PLANS CREATED FROM SCRATCH....................	21	20	43.50	95.00
REDUCTION IN NUMBER OF PROCESS PLANNERS...............	8	8	27.00	80.00
REDUCTION IN NUMBER OF PROCESS PLANS.....................	7	5	38.50	80.00
* ALTHOUGH THE RESPONDENTS WERE ASKED TO REPORT BENEFITS FROM GT PRINCIPLES IN PROCESS PLANNING AS DISTINCT FROM ADVANTAGES GAINED THROUGH THE USE OF THE COMPUTER FOR PROCESS PLAN STORAGE AND RETRIEVAL, THE DEGREE TO WHICH RESPONDENTS WERE ABLE TO SEPARATE THE TWO IS UNKNOWN.				

Figure 2.7 b : Benefit From the Application of GT in Process Planning