Systematization of Manufacturing Technologies through the Use of Group Technology

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Abstract: *Manufacturing technology represents a set of processes, activities, methods, procedures, rules, operations, and technical conditions, which happen in order to obtain a certain product (part, machine body, industrial construction or of a different nature). The current literature presents an industrial need for optimization of the manufacturing processes. We designed a detailed study which tackles manufacturing technologies and processes that refer to small series and unique (individual). The diverse requirements within the industrial field, push this type of production to a continuous development. Therefore, the objectives of this study are to establish components families, code, classify, and determine a common manufacturing technology which will reduce resulted variation of the manufacturing process.*

Keywords: *experimental, fabrication, group, process, similarity, technology.*

1 INTRODUCTION

Many international researchers came up with various definitions and classifications of group technology. A definition is that group technology reduces necessary time for designing products and machines for the manufacturing process. A successful implementation of group technologies principles can significantly reduce costs, accelerate, simplify and develop industrial and manufacturing processes. A management theory used in the industrial field, proposes that group technology can be seen as a process of identifying and grouping similar elements, in order to ease the designing and manufacturing stages. In the present paper we will present results of the experimental study, personal contributions, conclusions and future directions of research, in regard to the manufacturing technologies used in the area of auto manufacturing lines for the European market. To elaborate the standard landmarks classification of the component's families, we used the data from the S.C. Ramira S.A., and were searched orders placed in the year 2016, from six contractors who work in the construction lines of welding and automotive assembly. The landmarks were selected though a careful analysis, where we chose the most common types of the components family and classified them based on technical features and functional role in the subassembly. For this research, we used machines of different sizes and configurations, with different functional roles. These differences were given by their purpose, which could be in the welding or the assembly lines. The information we gathered, helped us create a classification of standard landmarks for the most important components families in the manufacturing process, by using the CAM (Modeling-Aided Computer) software. Up to the present moment, we are still using this classification at S.C. Ramira S.A.

2 COMPONENTS FAMILIES

A components family is a collection of similar parts, due their shape and geometrical size or the similar processing stages in their manufacturing. In speciality literature, authors came up with different ways of defining the components family. One way to look at it, suggests that a components family/ group is a collection of related parts that are similar or almost identical. They refer to geometrical shape and/or size, as well as the necessity of carrying out similar processing operations. Alternatively, they can have a different shape, but can still carry out mutual processing operations. A designed component must be manufactured through multiple successive operations. If there is a wide spectrum of parts that will be produced, it will be necessary for the precessed parts to be manufactured on mutual processing equipments. It is advantageous to process the landmarks either by geometrical similarities or by similar manufacturing methods. When the production type, the order and the number of operations are similar, the parts of the component's family will also be similar. This similarity is therefore linked to the basic shape of the parts or the number of elements of the part's shape. The type of operation is determined by the processing method, the attachment method of the semi-finished product, the processing type and the conditions of debiting the material. Moreover, if the parts must be manufactured together, we must take into account their frequency of occurence. The more similarities we see in the production process, the easier it is to define the components family. The key to the group technology concept lays in the grouping of the parts in components families. These components families can be built in two ways. The first type of components family is made out of parts that have a similar shape based on a dimension interval and have in common more processing operations. The second type of components family is made out of parts with different geometrical shapes but have in common a certain number of processing operations; this is mostly a similarity of the production process, rather than a similarity in shape and size.

3 CONDUCTING THE EXPLORATORY STUDY

In the present exploratory studies we decided to focus on the most used components families from the manufacturing process of the private company S.C. Ramira S.A. Thus the components families we chose are: angles, gauges (parts that go in contact with the auto sheet of the device), port-pilot, console, and clamp (bonding element). For each family we designed an individual system of coding and a version of manufacturing technology that meets requirements of all the landmarks. These landmarks are part of sub assemblies, that are found in machines which serve to the assembly or welding lines of machines manufacturing. The standard time of the manufacturing technologies is made out of preparation time – closing + basic time. This time frame was established by using the experimental method – statistically through operations carried out on the machines, without numerical command – and through simulation – carried out in the CAM (assisted manufacturing) software for machines with numerical command.

3.1 Angles

The similarity critera we employed, was based on the number of holes and the drilling method reported to the part's functionality. In the landmarks of angle type we can observe a grouping by the number of holes of one side: 3, 4, 6 holes, and a second grouping based on the drilling method: first method is reaming hole – clearance hole, the second method is reaming hole – metric hole. Refer to these criteria, we elaborated a coding model, which contains necessary elements that we need for identification in the classification, plus the associated technology to the landmark in talk.

Table 1. Coding Elements

Code	*Description*
A 431	Angle 4 axis with 3 reaming holes–pass hole
A 432	Angle 4 axis with 3 reaming holes- metric
A 441	pass hole
A 442	Angle 4 axis with 4 reaming holes- metric
A 531	pass hole
A 532	Angle 5 axis with 3 reaming holes- metric
A 541	Angle 5 axis with 4 reaming holes pass hole
A 542	Angle5 axis with 4 reaming holes– metric
A 461	Angle 4 axis with 6 reaming holes–pass hole
A 462	Angle 4 axis with 6 reaming holes– metric

Coding Example:
A = angle; 4 / 5 = machine type (CNC 4 axis) or (CNC 5 axis); 3 / 4 / 6 = number of holes; 1 / 2 = drilling method(1 – reaming hole– clearance hole) or (2 – reaming hole–metric hole). In the following figure we can observe a representation of the landmark previously mentioned.

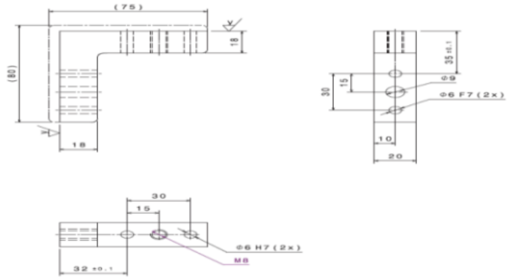

Fig 1. Angle

For the landmarks of the component's family of angle type, we established the following manufacturing technology that can facilitate and support mechanisms of the manufacturing process. Tp = preparation time – closing, Tb = basic time.

Table 2. Manufacturing Technology

Tp [min]	*Tb [min]*	*Operations/machine*
	5	Debiting
	3	Sanding
5	10	Milling interior surfaces + milling thickness
5	15	Exterior milling + drilling + chamfering holes + reaming
	1	Technical control of quality
	5	Chamfering edges + marking + threading case
	2	Black finish

3.2 Gauges

These landmarks shave an important functional role for the subassembly in which they belong to, as they come in contact with the auto sheet and have the role of supporting or buffering. When discussing the landmarks of gauge type we can observe the first grouping based on the number of holes of the sett element base: 3 or 4 holes. The second grouping is based on the drilling method: the first method is reaming hole – pass hole, and the second one is reaming hole – metric hole. Following these two criteria we developed a coding model which contains all the necessary elements to simply identify them in the classification, as well as the associated technology to the discussed landmark, that should technically correspond to all the landmarks of this family.

Table 3. Coding Elements

Code	*Description*
G 331	Gauges 3 axis with 3 reaming holes–pass hole
G 332	Gauges 3 axis with 3 reaming holes - metric
G 341	Gauges 3 axis with 4 reaming holes – pass hole
G 342	Gauges 3 axis with 4 reaming holes - metric
G 531	Gauges 5 axis with 3 reaming holes – pass hole
G 532	Gauges 5 axis with 3 reaming holes - metric
G 541	Gauges 5 axis with 4 reaming holes - pass hole
G 542	Gauges 5 axis with 4 reaming holes - metric

Coding Example:

G = gauges; 3 / 5 = machine type (CNC 3 axis) or (CNC 5 axis); 3 / 4 = number of holes; 1 / 2 = drilling method (1 – reaming hole– clearance hole) or (2 – reaming hole – metric hole). In the following figure we can see a representation of the landmark previously mentioned.

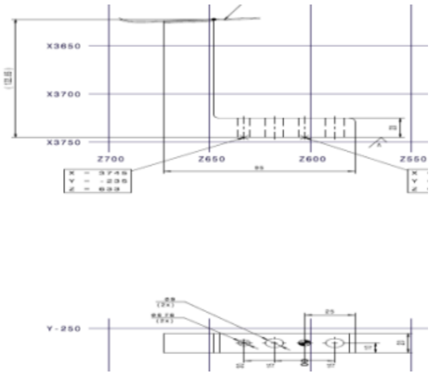

Fig 2. Gauge (contact part)

For the landmarks of the components family of gauges type (contact part with auto sheet) we established the following manufacturing technology meant to facilitate and supportthe manufacturing processmechanisms. Tp = preparation time – closing, Tb = basic time.

Table 4. Manufacturing Technology

Tp [min]	*Tb [min]*	*Operations/machine*
	5	Debiting
	1	Improvement 22 – 26 HRC
	3	Sanding
	12	Grinding thickness dimension
5	10	Millings sett element base
5	40	Drilling + chamferingholes + reaming + gauges
	10	Milling chamfer / expulsions
	1	Technical control of quality
	8	Adjusting edged + marking + threading case
	5	Size control
	2	CIF (active surface) + r - HRC
	1	Strength control andverification
	2	Black finish

3.3 Port pilots

The port pilot landmarks have the role of sustaining the pilot/pin (which has the role of centring the auto sheet of the machine) to be able to carry out its role constructively. There are different shapes and configurations, depending on the shape of the seet, design and dimensions of the pilot. The port pilot landmarks are also grouped based on the number of holes of the settlement base: 3 or 4 holes, and a second grouping based on the drilling method: the first method is reaming hole – clearance hole, the second method is reaming hole – metric hole. Building up on these two criteria we developed a coding model which contains necessary elements to identify it in the classification, plus the associated technology to the landmark discussed.

Table 5. Coding Elements

Cod	*Description*
PP 431	Port pilot 4 axis with 3 reaming holes–pass hole
PP 432	Port pilot 4 axis with 3 reaming holes - metric
PP 441	Port pilot 4 axis with 4 reaming holes - pass hole
PP 442	Port pilot 4 axis with 4 reaming holes - metric
PP 531	Port pilot 5 axis with 3 reaming holes - pass hole
PP 532	Port pilot 5 axis with 3 reaming holes - metric
PP 541	Port pilot 5 axis with 4 reaming holes - pass hole
PP 542	Port pilot 5 axis with 4 reaming holes - metric
PP 631	Port pilot WKV cu 3 reaming holes - pass hole
PP 632	Port pilot WKV cu 3 reaming holes - metric
PP 641	Port pilot WKV cu 4 reaming holes - pass hole
PP 642	Port pilot WKV cu 3 reaming holes - metric

Coding Example:

PP = port pilot; 4 / 5 / 6 = machine type (4 axis), (5 axis), (6 WKV); 3 / 4 = holes number;1 / 2 = drilling method (1 – reaming hole – clearance hole) or (2 – reaming hole – metric hole). In the following figure, we present a landmark of port pilot type.

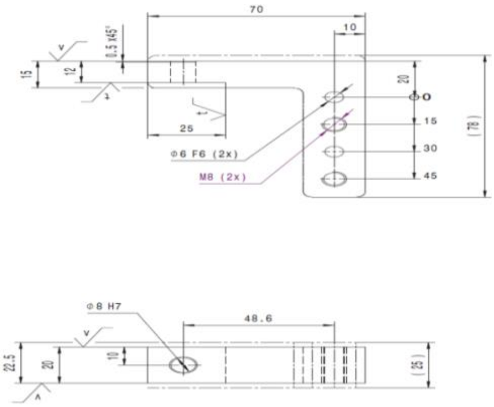

Fig 3. Port pilot

For the landmarks of the component's family of port pilot type, we established the following manufacturing technology meant to facilitate and support the manufacturing process mechanisms. Tp = preparation time – closing, Tb = basic time.

Table 6. Manufacturing Technology

Tp [min]	***Tb [min]***	***Operations/ Machine***
	5	Debiting
	3	Sanding
5	10	Milling surface of sett element (thickness)
5	15	Drilling + chamfering holes + reaming) sett element surface + (milling + drilling + chamfering holes + reaming) pilot grip surface
	8	Milled seating surfaces for the nut and chamfered
	1	Technical quality control
	8	Adjusting edges + marking + threading case
	2	Black finish

3.4 Consoles

These elements are important for the machines they are a part of, as they are the support elements on which we build the rest of the subassembly parts. This is normally found in larger sizes and it provides physical support to the whole subassembly. The typologies and configurations are extensive, because they vary in regard to machine type and functional role. When discussing consoles, we can observe a group by height and number of milling surfaces. Based on these criteria we developed a coding model which contains all the necessary elements we need to identify in the classification, plus the manufacturing technology of the landmark. We present this nformation in the following table.

Table 7. Coding Elements

Code	***Description***
C 511	Console 5 axis with H = 200 – 400 mm and 2 milling surfaces
C 512	Console 5 axis with H = 200 – 400 mm and 3 milling surfaces
C 513	Console 5 axis with H = 200 – 400 mm and 4 milling surfaces
C 521	Console 5 axis with H = 400 – 600 mm and 2 milling surfaces
C 522	Console 5 axis with H = 400 – 600 mm and 3 milling surfaces
C 523	Console 5 axis with H = 400 – 600 mm and 4 milling surfaces
C 531	Console 5 axis with H = 600 – 800 mm si 2 milling surfaces
C 532	Console 5 axis with H = 600 – 800 mm and 3 milling surfaces
C 533	Console 5 axis with H = 600 – 800 mm and 4 milling surfaces
C 51	Welded console 5 axis with H = 200 - 400 mm
C 52	Welded console 5 axis with H = 400 - 600 mm
C 53	Welded console 5 axis with H = 600-800 mm

Coding example:

C = console; 5 = machine type, CNC 5 axis; 1 / 2 / 3 = work piece height; 1 = H 200 – 400 mm; 2 = H 400 – 600 mm; 3 = H 600 – 800 mm; 1 / 2 / 3 = number of milling surfaces; 1 = 2 milling surfaces; 2 = 3 milling surfaces; 3 = 4 milling surfaces.In the following figure, we present a console type landmark.

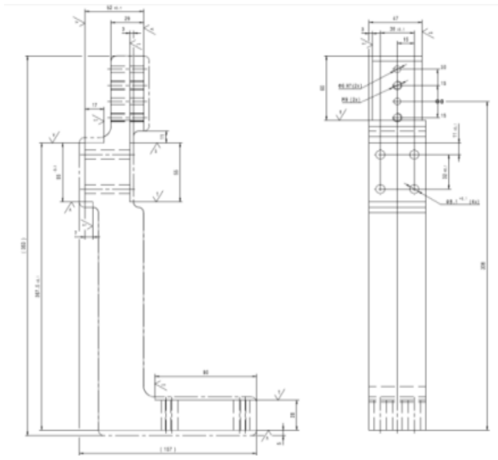

Fig 4. Consoles

For the landmarks of the components family of consoles type we established the following manufacturing technology meant to facilitate and support the manufacturing process mechanisms. Tp = preparation time – closing, Tb = basic time.

Table 8. Manufacturing technology

Tp [min]	***Tb [min]***	***Operations / machines***
	5	Debiting
	5	Stress relief
	5	Sanding
5	15	Milling thickness
15	50	Aligning + establishing origin + prepare tools + prepare method + milling+ drilling + chamfering holes + reaming
	18	Milling seating surfaces for screw-head
	1	Technical quality control
	15	Polishing edged + threading + marking
	15	Surface protection + priming + painting

3.5 Clamps

These are the bonding parts between the land marks of the sub assembly, they are often called „connecting element". Their role is to facilitate the process of positioning and supporting the subassembly it is part of.

Table 9. Coding Elements

Code	***Description***
C 311	Clamp 3 axis with 2 groups of holes and milling thickness
C 312	Clamp 3 axis with 2 groups of holes and inclined milling
C 313	Clamp 3 axis with 2 groups of holes and milling expulsions + thickness
C 321	Clamp 3 axis with 3 groups of holes and milling thickness
C 322	Clamp 3 axis with 3 groups of holes and inclined milling
C 323	Clamp 3 axis with 3 groups of holes and milling expulsions + thickness
C 333	Clamp 3 axis with 4 groups of holes and milling expulsions + thickness
C 511	Clamp 5 axis with 2 groups of holes and milling thickness
C 512	Clamp 5 axis with 2 groups of holes and inclined milling
C 513	Clamp 5 axis with 2 groups of holes and milling expulsions + thickness
C 521	Clamp 5 axis with 3 groups of holes and milling thickness
C 522	Clamp 5 axis with 3 groups of holes and inclined milling
C 523	Clamp 5 axis with 4 groups of holes and milling expulsions + thickness
C 531	Clamp 5 axis with 4 groups of holes and millingt hickness
C 532	Clamp 5 axis with 4 groups of holes and inclined milling
C 533	Clamp 5 axis with 4 groups of holes and milling expulsions + thickness

Coding Example :
C = clamp; 3 / 5 = machine type, CNC 3 axis, CNC 5 axis; 1 / 2 / 3 = number of groups of holes; 1 = 2 groups of holes; 2 = 3 groups of holes; 3 = 4 groups of holes; 1 / 2 / 3 = milling type; 1 = millingt hickness; 2 = inclined milling; 3 = milling expulsions + thickness. In the following picture we can see a landmark of clamp type.

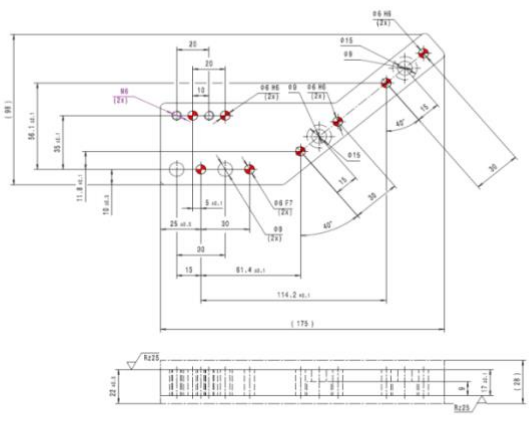

Fig 5. Clamp

For the landmarks of the components family of clamp type we established the following manufacturing technology meant to facilitate and support the manufacturing process mechanisms. Tp = preparation time – closing, Tb = basic time

Table 10. Manufacturing Technology

Tp [min]	***Tb [min]***	***Operations / machine***
	5	Debiting
	5	Stress relief
	5	Sanding
5	15	Thickness milling
5	20	Aligning + establishing origin + tools preparation + way preparation + drilling + chamfering holes + reaming
	1	Technical quality control
	10	Polishing edges + threading + marking
	2	Black finish

Based on the drilling method we choose, it will be mentioned at the adjusting stage to decide whet herth reading is needed or not. This code (reaming hole – clearance hole, reaming hole – metric hole) will be extremely useful in the future even for the computer science field. In the future I wish to standard the processing software CAM (Modeling-Aided Computer) using the same criteria. Establishing tools will be influenced by the typology of the processed landmark. If the landmarks coding were carried out by a different criterion than the above mentioned, the technology will be adapted based on the specificity of mutual elements of the components family from which the landmark is part of. We mention that the time frame resulted for these landmarks are not for guidance. They were found as a result of simulations in the CAM software. For each landmark, the cutting parameters and tools were adapted to the machines and their technical capacity.

4 PERSONAL CONTRIBUTIONS

1. The research, the theoretical and practical analysis of the chosen documentation used to select the most used landmarks that contribute to components families formation;
2. Creating the components families as a result of the technical analysis in 2D and 3D format;
3. Establishing the coding criteria reported to the specificity of each components family and choosing an optimal model that could include more landmarks of a family;
4. Creating coding elements for each family of components of this study;
5. Establishing optimal technological flow of the presented components families, using the already existing flow model;
6. Establishing time frame (preparation time – closing + processing time) option for the landmarks presented in the study.

5 CONCLUSIONS AND RESULTS

1. The research carried out on the existing technological solutions, paved the path of choosing

the optimal model of the technological flow for the family of components used;

6 Detailed analys of specificity of the components' families led to creating and acceptable coding model, by establishing coding criteria for each family of components;

7 The proposed models in speciality literature that refer to group technological processes in the production of small series and unique show little experimental support;

8 Establishing a general technology for all landmarks of a family of components could not happen without bringing change to the time frame, because the landmarks are obviously different;

9 The theoretical research and analysis of the factors which determine the time frame require completation and rigorous analysis. The research up to now followed individual influence of the parameters for each landmark; however, it is necessary to identify similarities for each family of components.

10 As a result of the manufacturing complexity through cuttine, the analysis of the processing is addressed in a limited manner in this study;

11 Most of the research on the uniformization of the manufacturing technologies based on group technology refers to analysis of manufacturing processes through a general perspective, without touching the key points of optimizing this type of technology.

12 The results of this exploratory study were successfully implemented in the manufacturing process of the private company SC. Ramira. SA;

13 To establish evolution of the optimal model of group technology, we observed that the starting point is represented by detailed analysis of the similarities of the landmarks.

6 FUTURE RESEARCH DIRECTIONS

1. Analysis of differences in time spent after using one of the two introductory methods of data by the technological engineers in the moments of launching the landmarks into work:
   - Systematic introduction of each manufacturing technology operation;
   - Manufactuing technology introduction from a classification of technologies with established coding.
2. Analysing the average costs and costs differences resulted by initial planning (initial planned norm) and final planning (effectively scanned norm by an operator /employee), occurring influences after the process of offering and planning of the company, the cost resulted after analysis;
3. Analysis of the necessary time spent on running a CAM programme;
4. Choosing a standard landmark of the ones studied at the first point and checking for the following aspects:
   - Analysis of the manufacturing technology and existing time frame for the landmark mentioned;
   - Analysis of the costs for each operation, following the costs of the planned launching stage and those resulted after effective manufacturing.
5. Coming up with an observatory analysis for all the results up to the present moment, to understand the real differences between what is being planned and what happens after the manufacturing process;
6. Experimental research, physical analysis of the process, physical calculation of determining time frame for preparation + closing;
7. Optimisation of manufacturing technologies and the time frame in order to improve the manufacturing / production processes.

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