Journal for Technology of Plasticity, Vol. 36 (2011), Number 1
DOI: 10.2478/v10211-011-0005-0

TECHNOLOGY-BASED SHEET METAL CLASSIFICATION AND CODING SYSTEM

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ABSTRACT

Group technology (GT) concept uses design similarity measure to identify the most similar design and retrieve a useful process plan. One of the existing formal methods of machine parts classifying for the group technology applications is the coding and classification. The researchers have developed many different GT coding schemes, which very precisely describe the design characteristics of the parts, but many of them do not explicitly describe the process plan. The paper presents a new approach to the sheet metal part coding and classification with plan-based attributes implementation in accordance with the technical standard STN 226001.
Keywords: *Sheet-metal forming, Group technology, Classification, Coding, CAPP*

1. INTRODUCTION

Group technology (GT) philosophy, used in modern variant computer aided process planning systems (V-CAPP), is a method that improves manufacturing efficiency by classifying similar products into families based on their attributes [1]. Usually, these attributes are based on geometric and/or production process characteristics. A major problem of this approach is the lack of adequate models of technology-based similarity evaluation. Application of GT principle needs a design similarity measure that identifies machine part with similar process plans. The part similarity measure should correspond to the process plan. Two parts should be similar if and only if their process plans are similar. [2],[3],[4].
One of the most popular manners of similar parts group formation is classification and coding. Oftentimes apart from classification based on geometrical properties of the part, the classification process continues in classification according to the non-geometrical attributes such as weight, tolerances, etc. [5]. Although part similarity measure based on group technology code is useful for

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finding generally similar parts, these measures cannot be precise enough for process planning since there is no explicit relation between process plans and GT codes.
The use of GT for machining operations is well established, but a similar approach to forming operations is not so well developed [6]. In the field of sheet metal forming process plan design we cannot see so significant utilization of the automated process planning systems compared to the machining processes planning. Usually these are oriented on specific, separate problem of forming technology (for example: sheet metal bending) and preferably are based on generative approach to the process planning [7,8,9,10,11,12].
To overcome some limitations of variant process planning of sheet metal parts production, a new plan-based part similarity classification and coding system is presented in the article. The system is created in respect to sheet metal technological processes classification mentioned in the [13].

2. THE SHEET METAL CLASSIFICATION AND CODING SYSTEM

Based on the analysis of design-technological features of parts, the five-sign chain (classification code) was created (Table 1 and Table 2).

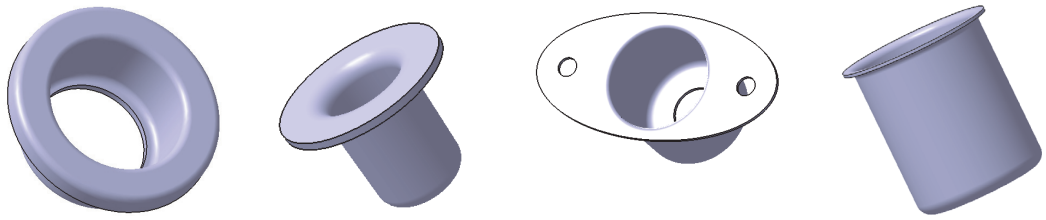
Table 1: The optional values for shape positions of the classification code (Positions 1, 2, 3)

attribute positions				hierarchical position			
Position	meaning	Position options		Position	meaning	Position options	
		Code	meaning			Code	meaning
1	**bottom shape**	0 1 2 3 4 5 6 7	no plane chamfer hemisphere with groove semicircle conical general				
2	**body shape**	1	rotary part	**3**	**wall shape**	0 1 2 3 4	no cylindrical cone ellipse shaped
		2	non-rotary part	**3**	**number of walls**	0 1 2 3 4	no 1 wall 2 walls 3 walls 4 walls

Table 2: The optional values for shape positions of the classification code (Positions 4, 5)

attribute positions				hierarchical position			
Position	meaning	Position options		Position	meaning	Position options	
		Code	meaning			Code	meaning
4	**tilt wall**	0	no				
		1	30°				
		2	45°				
		3	60°				
		4	90°				
		5	120°				
		6	135°				
		7	150°				
5	**flange**	1	with				
		2	without				

The first five positions of the classification code determine the shape of a part, based on the fact, that if it is possible, always one of the walls of the part is considered to be the bottom. Then the first position we might call "bottom shape". Furthermore, it is necessary to determine whether a part is rotational or not, so there is a position "body shape". In contrast to the first two positions, the third will be hierarchical, even its meaning will be changing in dependence on the previous position. So, if a part is rotational, the third position in the code is "shape of the wall", if the part is non-rotational, the third position in the code is named "number of walls". Between the wall and the bottom may be arbitrary angle and so another position in the code is "tilt wall". Finally, the fifth attribute position called "flange" determines whether a part has flange or not.
However, the shapes of the machine part are just one part of the classification system. It is necessary to define manufacturing attributes and incorporate them into the classification and coding system. The simplest way to define manufacturing technology is to determine a few coding positions for "basic technological method" and also a few positions for "basic technological operations". Meaning of these two terms is defined in [13].
The example of rotational parts classification (Parts A to D; Figure 1) is shown in Table 3.



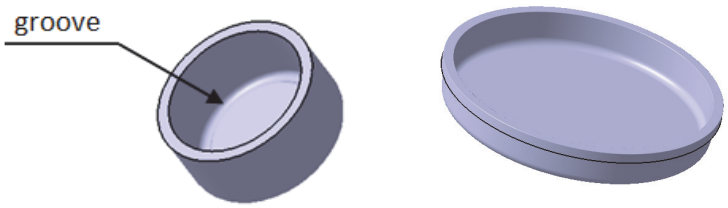
Part A Part B Part C Part D

Figure 1 – Sheet metal parts with identical shape section of the classification code

Table 3: Shape section of the classification code for parts A to D

Part	Name and number of position				
	1. Bottom shape	2. Body shape	3. Wall shape	4. Tilt wall	5. Flange
A	1	1	1	4	1
B	1	1	1	4	1
C	1	1	1	4	1
D	1	1	1	4	1

We can see that parts A, B, C, D have an identical shape section of the classification code, so based on GT principle, we can create family called, e.g., "rotating parts". Now all parts with the same classification code can be included into this family. We can lay down the rule, that this family can contain the parts which do not match all positions in the classification code, and so this family can contain the other parts, e.g. E and F (Figure 2).



Part E Part F

Figure 2 – Sheet metal parts with different bottom shape
(Part E: bottom with groove, Part F: plane bottom)

Shape section of the classification code for these two parts is referred in Table 4.

Table. 4: Shape section of the classification code for parts E and F

Part	Name and number of position				
	1. Bottom shape	2. Body shape	3. Wall shape	4. Tilt wall	5. Flange
E	4	1	1	4	2
F	1	1	1	4	2

The shapes of part are however just one part of the classification system. It is necessary to define manufacture technology for make process plan into the classification system. The simplest way to define manufacturing technology into classification system is to determine a few positions for so called "basic method" and also a few positions for so called "basic operations". For simple sheet metal parts as in Figures 1and 2, three attribute positions are sufficient for basic methods and three hierarchical positions for basic operations. Together it is 12 positions to determine the technology; their available values are presented in Table 5.

Table 5: Optional values for technological positions of classification code

attribute positions				hierarchical position			
Position	meaning	Position options		Position	meaning	Position options	
		Code	meaning			Code	meaning
6 10 14	basic method	0	no				
		1	shearing	7,8 9 11 12 13 15 16 17	basic operations	0	no
						1	blanking
						2	punching / notching
						3	lancing / slitting
						4	trimming
						5	shaving
						6	parting
						7	fine shearing
		2	drawing	7,8 9 11 12 13 15 16 17	basic operations	0	no
						1	deep drawing
						2	reverse drawing
						3	ironing
						4	spreading
						5	necking
						6	grooving / doming
		3	bending	7,8 9 11 12 13 15 16 17	basic operations	0	no
						1	air bending
						2	offset
						3	straightening
						4	roll bending
						5	hemming
						6	beading
						7	shouldering
						8	setting-out
						9	seaming
		4	metal spinning	7,8 9 11 12 13 15 16 17	basic operations	0	no
						1	without wall thickness reduction
						2	with wall thickness reduction
						3	beading
						4	flanging
						5	spreading
						6	necking
						7	grooving

In the following table (Table 6) technological section of the classification code for parts A to F is recorded. We can see here that the classification code is identical, especially in basic forming method (e.g. position 10), so we can name this family as rotation deep drawing parts.

Table 6: Technological section of classification code for parts A to F

	Number of position											
Part	**6**	7	8	9	**10**	11	12	13	**14**	15	16	17
A	**1**	1	2	4	**2**	1	3	0	**0**	0	0	0
B	**1**	1	4	0	**2**	2	0	0	**0**	0	0	0
C	**1**	1	0	0	**2**	2	7	0	**0**	0	0	0
D	**1**	1	0	0	**2**	1	0	0	**3**	5	0	0
E	**1**	1	2	4	**2**	4	0	0	**0**	0	0	0
F	**1**	1	4	0	**2**	2	0	0	**0**	0	0	0

The visualization of organization and hierarchy of the classification code can be seen in following figure (Figure 3).

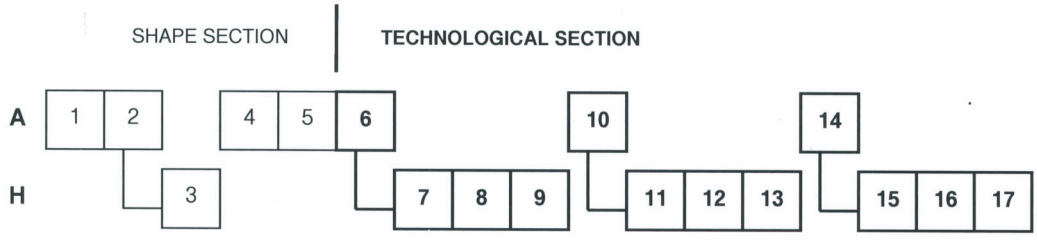


Figure 3 – Organization and hierarchy of classification code
A – attribute positions; H – hierarchical positions

3. CONCLUSION

The systems of computer aided engineering activities have important role in the design of process plans, because e. g., a designer or a technologist is relieved from routine activities, thus the time for creative or innovative work increases. Knowledge and skills, which are deposited in the technological documentation indirectly, constitute hidden value of the company and therefore it is preferred to have a sophisticated tool, which allows its use for designing new process plans. One of the tools for system use of technology documentation in company is the group technology, which by own principle creates a spontaneous pressure on simplicity and standardization of constructional and technological design of production.
An important element of the group technology is the coding and classification system based on the application of similarities of products, resp. similarities of process plans. This paper is a contribution to the creation of more precise sheet metal technology-based classification system suitable for variant process planning.

ACKNOWLEDGEMENT

The authors would like to thank the Ministry of Education Science, Research and Sport of the Slovak Republic for financial support of the research project "Multivariate optimization of the metal spinning processes – research and development" (project MANUNET-2008-SK-001).

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KLASIFIKACIJA I SISTEM KODIRANJA TEHNOLOGIJE OBRADE LIMA PLASTIČNIM DEFORMISANJEM

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REZIME

Koncept grupnih tehnologija koristi sličnosti u geometriji i obliku delova kako bi se unapredio proces proizvodnje, odnosno ona povećava efikasnost proizvodnje na usnovu grupisanja sličnih delova u familije. U grupnim tehnologijama, dva dela su slična samo ako su njihove geometrije, ali i procesi obrade slični. Jedne od formalnih metoda grupnih tehnologija su i kodiranje i klasifikacija. Pored geometrije i oblika, kriterijumi za klasifikaciju mogu biti i drugi parametri, kao što su težina, tolerancije i sl.

Istraživači su razvili različite kodne šeme, koje precizno opisuju geometrijske karakteristike delova, ali mnoge od njih ne opisuju plan procesa. Jedan od alata za sistematsku upotrebu dokumentacije u određenoj kompaniji je grupna tehnologija, koja po svom principu stvara spontani pritisak ka pojednostavljenu i standardizaciji konstrukcionog i tehnološkog dizajna proizvodnje. U literaturi se mogu naći brojni radovi na temu grupni tehnologija u oblasti tehnologije rezanja, ali ne i u oblasti obrade lima deformisanjem. Ovaj rad predstavlja nov pristup kodiranju i klasifikaciji tehnologije obrade lima koji je u skladu sa standardom STN226001. Prema tome, ovaj rad predstavlja doprinos razvoju preciznije klasifikacije obrade lima pogodne za različite planove procesa.

Ključne reči: *Odrada lima, Grupne tehnologije, Klasifikacija, Kodiranje, CAPP*