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PROCESS UNIFICATION AND FRAME PREPARATION OF MACHINING PARAMETRES FOR ROTATIONAL PARTS

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ABSTRACT

Any traditional or computerized metal removal process needs a prototype, a technical drawing and a database for production of a part. Design, process planning and manufacturing problems such as modeling, the necessity data extraction from standard data exchange formats, and part programme preparation for machine tools can be solved by the operators or experts as soon as possible while they occurred in the traditonal approach. In circumstances of the production efforts spent by the computer, all experiences of expert can be saved in a database for foresight of the possible problems. This data can be used at any stage in the product cycle. In this paper, it is presented the results of research efforts which aimed to extract information from the defacto industry standard DXF files to determine features existing on rotational parts to be machined on horizontal machining centers. After process extraction and definition, process unifications and frame preparation for machining parameters of the part are introduced.

Key Words : Process planning, Frame preparation, DXF, Process extraction, Process unification

DÖNEL PARÇALARIN İŞLEME PARAMETRELERİ İÇİN İŞLEM BİRLEŞTİRME VE ÇERÇEVE HAZIRLAMA

ÖZET

Geleneksel veya bilgisayarlı tezgahların kullanıldığı her hangi bir metal işleme ünitesi, üretilecek parçanın prototipine, teknik çizimine veya bir veri tabanına ihtiyaç duyar. Geleneksel üretim ünitesindeki tasarım, işlem planlama ve üretimde karşılaşılan modelleme, standart veri yapılarından bilgi çıkarımı ve etzgahlar için parça programı hazırlama gibi problemler operatör veya uzmanlar tarafından problemin oluşması anında çözümlenir. Üretim süresi içindeki uygulamaların bilgisayar desteği ile gerçekleştirildiği ortamlarda ise, muhtemel problemlerin çözümüne yönelik olarak alan uzmanının bilgi birikiminin her hangi bir şekilde bir veri tabanına kaydedilmesi gerekir. Bu bilgiler ürün döngüsünün ihtiyaç duyulan bir aşamasında gerekli oldukça kullanılmaktadır. Bu makalede, yatay işleme merkezlerinde üretilecek silindirik parçalardaki işleme özelliklerinin belirlenmesi için gerekli olan tasarım ve imalat bilgisini DXF veri yapısından çıkarmak için gerçekleştirilen araştırmanın sonuçları sunulmuştur. Ayrıca işlem çıkarımı ve tanımlaması, işlem birleştirme ve parçanın işlenmesi için gerekli olan işleme parametrelerini tanımlamak amacıyla çerçeve oluşumu tanıtılmıştır.

Anahtar Kelimeler : İşlem planlama, Çerçeve hazırlama, DXF, İşlem çıkarımı, İşlem birleştirme

1. INTRODUCTION

Many Computer Aided Process Planning (CAPP) systems are in use in the industrial and academic area. They have maintained modules such as data and feature extraction, calculation for the operations, operation sheets, tool path and part programs for the computerized machine tools. In the last three decade, the development of a wide range of computer programs for Computer Aided Design

(CAD) and Computer Aided Manufacturing (CAM) in order to improve the effectiveness and economics of each function has been considered by Hartley et. al. (Hartley et. al., 1986). Process plans can be categorized into two main groups as variant and generative process plan systems ignoring manual approach. INTELLICAPP (Granville, 1986), PART (Boogert et. al., 1996), TECHTURN (Hinduja and Barrow, 1986), IFPP (Patil and Pande 2002) have been developed as variant CAPP systems. APPAS (Wysk, 1977), AUTAP (Eversheim et al., 1980), CADAM (Chang, 1981), CMPP (Sack, 1982), GAPPS (Kung, 1984), LOCAM (Logan, 1985), PROPLAN (Phillips, 1985), EXCAP (Darbyhire and Davies, 1984) have been developed as generative process planning systems. Alam et al. (2000; 2003), Jain et al. (1995), Jain et al. (2002), and Kumar et al. (2003) have produced generative process plan systems as well.

As seen from the efforts about European Community Budget which supports by its 15% of whole budget in 6th Frame Programme, most of the industry nearly 85% consist of the Middle Scaled Companies in any country. Most of the Middle Scaled Companies are in difficult to maintain part programmes and operation sheets for numerically controlled or traditional machine tools in a short time. These difficulties can be sorted out by CAPP software. There are some 3 Dimensional (3D) CAD/CAM systems in order to maintain solutions for these problems. All these flexible programmes mentioned above are highly expensive for Middle Scaled Company. These companies need cheaper and quicker software for shop floor preparation. Main objective in production for Middle Scaled Companies is shorten preparation time between drafting/design stage and product. Part model design, data extraction, process planning, and post-processing are time consuming for any company in a product cycle if proper CAD/CAPP/CAM tool is not used.

Technical drawing, process plan, and frame preparation for part programmes or operation sheet should be evaluated from the point of the Middle Scaled Companies. While data extraction period working with 2 Dimensional (2D) modeling, process unification should be considered and production data should be collected from part model. In this paper, a design and process planning modules of a CAPP system called ASALUS (Aslan, 1995) were introduced. In design stage, part model was prepared by using pre-defined design tools created with AutoLISP in a CAD programme. In process planning stage, data extraction, process unification, and frame preparation were maintained.

2. MATERIALS AND METHOD

In this study, 2D CAD model is designed from symmetrical axis by any commercial or educational software having DXF format. Seven basic geometrical features as cylinder, taper, recess; chamfer, concave fillet, convex fillet and thread are constructed sequentially by answering of system questions from left side of the part to the right (Aslan and Alpdemir, 1996). The software creates DXF with design and production data after completion of the part profile.

In order to design the part profile, user chooses the command related for a feature from screen menu. Feature is drawn with replying the questions for variables (diameter, length, angle etc.). All features were sequentially constructed from left to right on the part. In spite of placement commands according to Figure 1; two different tapers (right and left), twenty seven recesses, two chamfers (right/left), four fillets (right hand concave and left hand convex), four threads (right/left thread equal length with the cylinder and right/left thread shorter than cylinder length) and 1 cylinder can be defined by the system as showed in Figure 2. CAD model from symmetrical axis is saved in DXF for further processing. First in the system, DXF file is processed. All vertex coordinates, which represent part are extracted afterwards they are saved into "Vertex Coordinate Array – VCA". System evaluates the coordinates extracted by comparing two, three or four of them to define features. Whole extracted data for features properties have been saved into Features and Machining Parameters Array (FMPA). Everything for any feature defined by the system has been identified into this array such as blank and machined diameter, depth of cut, length of cut, number of cut, spindle speed, feed rate, and coolant. A right concave arc record is given in Figure 3. The extraction and array preparation processes were discussed in the paper of (Aslan et al., 1999). Neighborhood of the features, priority of the processes and cutting tool for each segment are discussed later. The neighborhood between cylinder and recess, cylinder and concave/convex fillet, cylinder and taper, cylinder and chamfer, face and cylinder, face and fillet should be made clear from the point of manufacturing principles. The confident factors are obtained to define priority of the processes. Another important decision, which should be made, is the definition of process neighborhood. This should be considered as an obligation for maintaining of tools, shortening of tool path and part programme and preventing of tool crashing into the part material. The neighborhoods below have been defined and new processes were established.

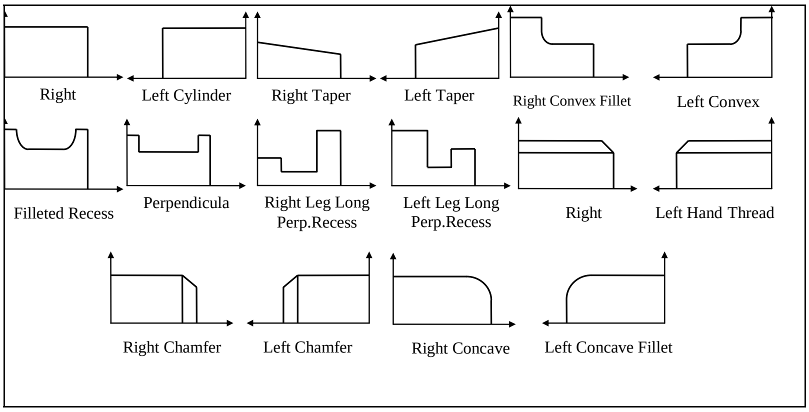

Figure 1. Basic geometrical features defined in the system

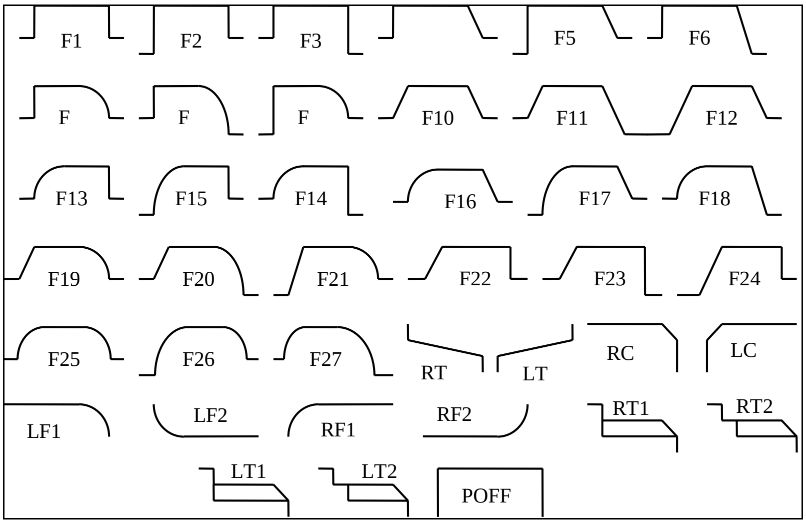

Figure 2. Types of Recesses and Other Features

RIGHT CONCAVE ARC	Blank diameter	Machined diameter	Arc radius	Arc start point	Arc end point	Start angle

End angle	Arc angle	I	K	Spindle speed	Feed	Coolant	Surface roughness

Figure 3. An array record for right concave arc

2. 1. Neighborhood of Cylinders and Recesses

System evaluates cylinders and recesses from right of the part to the left. If the feature extracted is first cylinder, second recess and last cylinder, then from the point of manufacturing rules applied by experts in the real manufacturing environment, first cylinder should be machined if a special condition is valid and later on the other feature such as recess in this example can be machined. So cylinder-recess-cylinder trio should be unificate to establish new features for optimum cutting conditions as shown in Figure 4. Otherwise two cylinders having same diameter will machine sequentially which causes long tool path and tool crashing into blank diameter of the recess. A new cylinder necessity containing blank diameter of recess occurs. This causes to update cylinder record in the static array. The diameter is the same with first big cylinder and the length of new cylinder can be calculated as below:

Length of new cylinder = (length of 1st cylinder + length of 2nd cylinder+ .....+ length of nth cylinder) + (length of 1st recess + length of 2nd recess+ .....+ Length of nth recess)

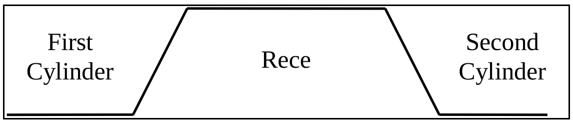

Figure 4. Neighborhood of Cylinder and Recess

2. 2. Neighborhood of Cylinder and Concave or Convex Fillet

In the conditions which found neighborhood between cylinder and fillet (concave or convex) as shown in Figure 5, new calculation for length of cylinder is obtained as below while the other records have being kept as before:

Length of new cylinder = Length of old cylinder + Fillet radius

RULE: Neighborhood Definition of Cylinder and Fillet

IF There is concave or convex fillet after cylinder

THEN Calculate length of new cylinder

AND Define new cylinder start point

AND Create new cylinder record

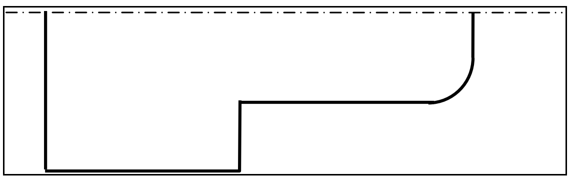

Figure 5. Neighborhood of Cylinder and Fillet

2.3. Neighborhood of Cylinder and Taper

The procedure for this neighborhood shown in Figure 6 is the same as cylinder-fillet relations. While any neighborhood is occurred between cylinder and taper, the production rule is fired for creation of new record containing a new cylinder length. The other record, which will be changed, is the start of new cylinder according to the part face.

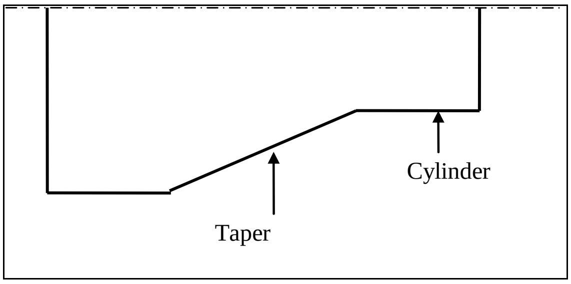

Figure 6. Neighborhood of cylinder and taper

2. 4. Neighborhood of Cylinder and Chamfer

This neighborhood given in Figure 7 shows same characteristics with cylinder and taper relations. The difference is on creating new cylinder record from chamfer's. The chamfer start point becomes new cylinder start and cylinder length is bigger by chamfer distance. A new cylinder and its record are created as mentioned above by production rules.

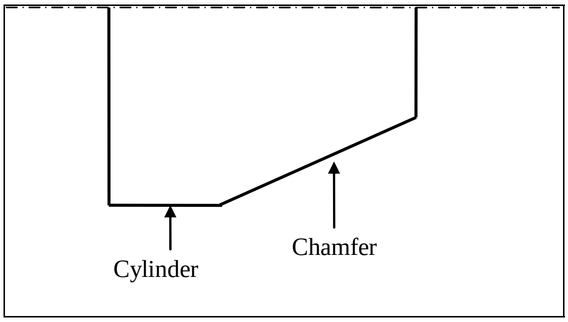

Figure 7. Neighborhood of Cylinder and Chamfer

2. 5. Neighborhood of Face and Cylinder

The procedure for this relation shown in Figure 8 is more different than last three neighborhoods. Face, even if it is an identical process, is correlated with the process before/after itself, but faces at start and end of the part are the exceptions. When a neighborhood is defined, the cylinder diameter is recalculated according to the face afterwards face is erased. For this purpose the production rule is fired as below:

RULE: Neighborhood Definition of Face and Cylinder

IF There is face after cylinder

THEN Face big diameter becomes cylinder un-machined diameter

AND Make small diameter of the face equal to the diameter of new cylinder to be machined

AND Erase face

AND Create new cylinder record

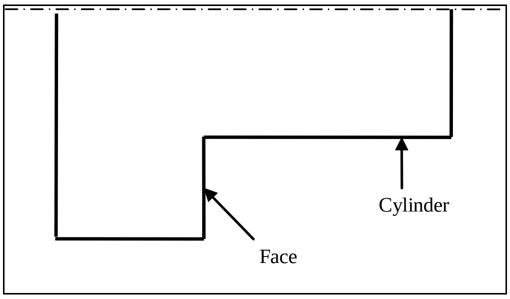

Figure 8. Neighborhood of Face and Cylinder

2. 6. Neighborhood of Face and Fillet

This relation creates a new cylinder by the length of fillet radius and face depth (see Figure 9). The big diameter of face becomes blank diameter for new cylinder and the big diameter of the fillet becomes the diameter of new cylinder to be machined.

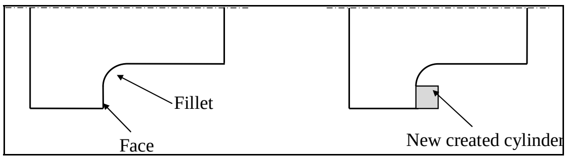

Figure 9. Neighborhood of face and cylinder

2. 7. The Definition Of Process Priorities

The production environment is either traditional or computerized; an operator, part programmer or process planner should evaluate and make decisions on two conditions in metal removal processes of any machine part. These decisions should be made at design stage of the part. These are given below:

1. The production of the part by small number of tools
2. The production of the part by single clamping if possible or applying as much as operation at one clamping.

The extracted processes by data extraction are in incorrect order from the point of production rules. The processes are put into order according to metal removal principles, becoming prior and secondary and usability of the tool for many processes as given in Table 1. On the other hand, the processes above have got confident factors to put them in order. The number of factors starts with 100, which belongs to facing. The bigger confident factor describes the first process to be machined.

Table 1. Process Names and Confident Factors

Process Name	Confident Factor	Process Name	Confident Factor
Face	100	Angled reces	50
Cylinder	90	Filleted recess	40
Taper	80	Perpendicular recess	30
Chamfer	70	Thread	20
Concave and convex fillet	60	Parting off	10

2. 8. Frame Preparation

Frames are one of data representation techniques, which are used widely in Artificial Intelligence applications (Minsky, 1975). Minsky described a frame in the following fashion “when one encounters a new situation one selects from memory a structure called a “frame”. This is a remembered framework to be adapted to fit reality by changing details as necessary” (Durkin, 1994). The record as Minsky pointed out has got fields and values which corresponding to the slots and slot fillers of a frame. Data enhanced from data extraction module has been saved into Feature and Machining Parameters Array (FMPA) according to the process. This record contains geometrical such as placement of the process on the part and manufacturing data such as spindle speed estimated machining time etc. In spite of occurrence all data in the array for a process, frames contains limited and necessary data for manufacturing.

3. DISCUSSION AND RESULTS

In order to recognize the results of the study, node coordinate and dimensions array and frame preparations are given at Table 3 and 4a, b, c for Figure 10. Answering commands in the design stage as seen in Figure 10 created out-diameter features. Depth of cut, feed rate, surface roughness, cutting fluid, cutting tool and holders were defined according to pre-defined material twin (cutting tool and workpiece) database in the design stage. New processes were defined after unification. Frame preparation was maintained according to unification and databases.

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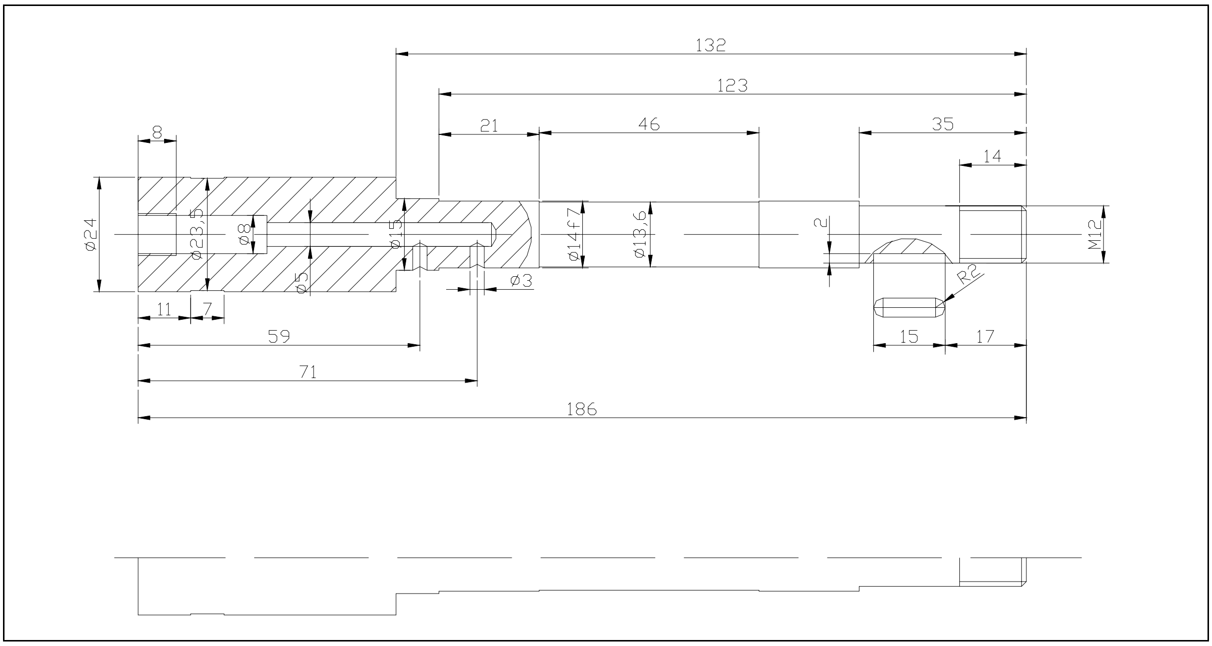

Figure 10. Work holding spindle for a paint spraying machine

Table 3. Node Coordinate Array (NCA) and Dimensions Array

X COORD	Y COORD	LENGTH	DIA.	RADIUS
42.71	141.84	11.00	24.00	12.00
42.71	129.84	7.00	24.00	12.00
53.71	129.84	36.00	23.50	11.75
53.71	130.09	9.00	23.50	11.75
60.71	130.09	21.00	24.00	12.00
60.71	129.84	46.00	24.00	12.00
96.71	129.84	21.00	15.00	7.50
96.71	134.34	33.86	15.00	7.50
105.71	134.34	1.14	14.00	7.00
105.71	134.84	14.00	14.00	7.00
126.71	134.84	14.00	13.60	6.80
126.71	135.05		13.60	6.80
116.20	135.05		14.00	7.00
172.71	134.84		14.00	7.00
172.71	134.84		12.00	6.00
193.71	135.84		12.00	6.00
193.71	135.84		9.72	4.86
227.57	136.98		12.00	6.00
228.71	141.84		9.72	4.86
214.71	135.84		9.72	4.86
214.71	136.98			
228.71	136.98			

Table 4a. Face and Cylinder Frames for the Part given Figure 10

Process_Name	FACE	Process_Name	CYLINDER
Confident_coef	100	Confident_coef	95
Blank_dia	25.000	Blank_dia	25.000
Depth_cut	1.000	Machined_dia	12.000
Rpm	1145.917	Length_of_cylinder	35.000
Feed_rate	0.200	Rpm	1548.536
Surface_roughness	6.500	Feed_rate	0.200
Cutting_fluid	KS/MY/C	Surface_roughness	6.500
Estimated_time	0.055	Cutting_fluid	KS/MY/C
Tool_code	CNMM	Estimated_time	0.109
Tool_no	190624	Tool_code	CNMM
Holder_class_code	P	Tool_no	190624
Holder_no	PCLNR	Holder_class_code	P
		Holder_no	PCLNR
		D_CSPF	0.000
		D_CSPF	35.000
		Depth_cut	6.500
		Number_of_cut	4

Table 4b. Cylinder Frames For The Part Given in Figure 10

Process_name	CYLINDER	Process_name	CYLINDER	Process_name	CYLINDER
Confident_coef	95	Confident_coef	95	Confident_coef	95
Blank_dia	25.000	Blank_dia	25.000	Blank_dia	25.000
Machined_dia	14.000	Machined_dia	15.000	Machined_dia	24.000
Length_of_cylinder	88.000	Length.of_cylinder	9.000	Length_of_cylinder	54.000
Rpm	1469.124	Rpm	1432.396	Rpm	1169.303
Feed_rate	0.200	Feed_rate	0.200	Feed_rate	0.200
Surface_roughness	6.500	Surface_roughness	6.500	Surface_roughness	6.500
Cutting_fluid	KS/MY/C	Cutting_fluid	KS/MY/C	Cutting_fluid	KS/MY/C
Estimated_time	0.299	Estimated_time	0.031	Estimated_time	0.231
Tool_code	CNMM	Tool_code	CNMM	Tool_code	CNMM
Tool_no	190624	Tool_no	190624	Tool_no	190624
Holder_class_code	P	Holder_class_code	P	Holder_class_code	P
Holder_no	PCLNR	Holder_no	PCLNR	Holder_no	PCLNR
D_cspf	35.000	D_CSPF	123.000	D_CSPF	132.000
D_cspf	123.000	D_CSPF	132.000	D_CSPF	186.000
Depth_cut	5.500	Depth_cut	5.000	Depth_cut	0.500
Number_of_cut	3	Number_of_cut	3	Number_of_cut	1

Table 4c. Chamfer and Perpendicular Recess Frames For The Part given in Figure 10.

Process_name	CHAMF.	Process_name	PERP.REC	Process_name	PERP. REC.
Confident_coef	80	Confident_coef	50	Confident_coef	50
Blank_dia	12.000	Blank_dia	24.000	Blank_dia	14.000
Machined_dia	9.720	Machined_dia	23.500	Machined_dia	13.600
Chamfer_length	1.140	D_PRSPF	168.000	D_PRSPF	56.000
Rpm	2637.929	D_PREPF	175.000	D_PREPF	102.000
Feed_rate	0.200	depth_of_recess	0.250	Depth_of_recess	0.200
Surf._roughness	6.500	Rpm	1206.228	Rpm	2075.936
Cutting_fluid	KS/MY/C	Feed_rate	0.200	Feed_rate	0.200
Estimated_time	0.002	Surface_roughness	6.500	Surf._roughness	6.500
Tool_code	CNMM	Cutting_fluid	KS/MY/C	Cutting_fluid	KS/MY/C
Tool_no	190624	Estimated_time	0.029	Estimated_time	0.111
Hold_class_code	P	Tool_code	20ER	Tool_code	26ER
Holder_no	PCLNR	Tool_no	6.35FG	Tool_no	10.0FG
D_CHSPF	0.000	Holder_class_code	snaptab	Hold_class_code	snaptab
D_CHEPF	1.140	Holder_no	CER/L	Holder_no	CER/L
Depth_cut	1.1400	Width_of_recess	7.000	Width_of_recess	46.000
		End_of_recess	175.000	End_of_recess	102.000
		Number_of_cut	2	number_of_cut	5

Table 4d. Thread and Parting-off Frames for the Part Given Figure 10

Process_Name	Thread	Process_Name	Parting off
Confident_coef	45	Confident_coef	45
Blank_dia	12.000	Depth_of_cut	12.000
D_rtspf	0.000	Blank_dia	0.000
D_rtepf	14.000	Machined_dia	14.000
Depth_of_cut	1.140	Part_length	186.000
Rpm	2637.929	Rpm	2291.833
Feed_rate	1.500	Feed_rate	0.200
Surface_roughness	6.500	Surf._roughness	6.500
Cutting_fluid	ks/my/c	Cutting_fluid	KS/MY/C
Estimated_time	0.004	Estimated_time	0.027
Tool_code	16er	Tool_code	150.15
Tool_no	1.5iso	Tool_no	1580
Holder_class_code	snaptab	Holder_class_code	G
Holder_no	cer/l	Holder_no	R150.15
Number_of_cut	6.000		
Thread_length	14.000		

4. CONCLUSIONS

The results of present investigation on process unification and frame preparation can be summarized as follows:

- Quick and cheap data management for Middle Scaled Companies were obtained.
- On the basis of operation sheet or part programmes, frame preparation was established for either traditional and numerically controlled production environment.
- Neighbourhood between various features on rotational parts was constructed and new features were re-created.
- Process priorities were obtained with confident factors according to manufacturing rules.

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