COMPUTER AIDED INTERACTIVE PROCESS PLANNING FOR TURNING (CAIPP)

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ABSTRACT

Computer aided process planning plays an important key role in computer integrated manufacturing (AIM).There are three approaches in computer aided process planning-variant, generative and semi- generative. The generative approach is more suitable to CAD/CAM integration because it can synthesize a process plan. The objective of the present work is to introduce a generative computer aided interactive process planning (CAIPP) procedure for the operation sequence planning of turned parts. This system is designed and created using Microsoft Visual Basic 3 under windows. The utility of the developed system is demonstrated by producing Planning sheets for a large number of example parts depicted in working drawings obtained partially from industry. For use in the CAIPP system, mathematical models are developed for the determination of the cutting speeds, and for calculating the power constants for a wide range of practical cases. Finally, the strategy to be used for developing further CAPP systems as a component of CIM is presented.

Keywords: Process planning-CAPP systems-Computer integrated process planning

INTRODUCTION

The preparation of planning sheets for turned parts by conventional means requires a skilled planner. Planning involves tedious calculations of cutting times, reference to tool files, cutting data, standard times and material and machine files. Planning sheets produced manually are frequently inconsistent and incomplete. Computer Aided Process Planning has been recognized as playing a key role in Computer Integrated Manufacturing (CIM). Altig and Zhang [1] presented an overview for computer aided process planning systems. In that work, 156 CAPP systems are listed with general information such as the characteristics of the, systems, the domain of planable workpieces, programming languages, references and developers etc.. A CAPP system was developed by McDonnell Douglas Automation Company [2]. It is a database management system and is developed as a research tool to demonstrate the feasibility of computer assisted process planning, with logic based on group technology methods to classify code parts. SAPPAS (Automated Process Planning and Selection) System is developed by Wysk [3]. It is Known as a generative CAPP system with the description of the detailed technological information of each machined surface by means of special code.

Automatisch Arbeits Planerstellung (AUTAP and AUTAP-NC) systems were developed by Eversheim *et al.* [4]. The only difference between the two is that AUTAP is for generation of a process plan and AUTAP- is for generation of the part program. They are of the most complete generative process planning systems. Totally Integrated Process Planning System was developed by

Cheng *et al.* [5]. This system integrates CAD and generative process planning into a unified system utilizing the AI and decision tree approaches. Experimental Planning System (XPS-1) was developed by UTRC [6]. This system is a prototype advanced generative process planning system. It is designed to provide a basic framework for advanced generative process planning. XPLAN is an expert process planning system that was developed by Joshi [7]. This system is based on DCLASS decision tree logic processing sytsem. It Uses DCLASS tree structures for storage and handling of Knowledge. The knowledge is represented in terms of rule-based approach. TURBO-CAPP is one of the most complex intelligent process planning systems that has been developed by Wang and Wysk [8]. The system consists of five modules: machine surface identification, process selection and sequence, NC code generation, knowledge acquisition, and database management. Know-how and Knowledge Assisted Production Planning System was developed by Iwata and others [9]. It is one of the CAPP systems emphasizing special production know-how and experience. It consists of foursub-systems ; CAD interface and user input sub-system, decision making sub-systuem, Know-how and database, and Know-how acquisition sub-system. A comprehensive CAPP system under the CIM circumstance was developed by Xingling *et al.* [10]. It consists of three sub-systems; retrieval, variant, and expert system. This system can handle new parts or parts that have been machined before. Also, The NC instructions of this part are obtained by assembling each feature macro-NC program in the CAM software. A neural network approach for CAPP to automatically select manufacturing datums for rotational parts on the basis of the shape of the parts and tolerance constraints has been developed by Mei *et al.* [11]. A back-propagation algorithm is used and some experiments are conducted. An effective method that uses fuzzy sets and fuzzy decisions to create optimal process plans for metal cutting manufacture has been presented by Zhao [12]. In that method, a model alternative process plans is proposed and fuzzy decisions are applied to the model to select optimal process plans according to certain criteria and constraints. KOMATSU Ltd. [13] developed a computer based system for assembly process planning. It has some functions, such as estimating assembly work time, making work sheets, and arranging process. In this system, documents can be easily made, maintained and applied to the similar model. Kayacan *et al.* [14] presents an optimized process planning system for rotational parts. The model of a part is drawn by using a CAD module prepared for This purpose. After the feature recognition module, machining operations are determined and the cutting tools are selected by using the knowledge base and machining topology. An expert process planning and filtering system has been developed by Gulesin [15]. The system employs forward planning strategy. After each operation the machined region is removed and a new intermediate is generated. A part model description scheme called face-oriented neighboring graph has been utilized to represent blank, finished, and intermediate models within the database. A graph theoretical approach is proposed by Huang *et al.* [16] to systematically solve the setup planning problem and to be more efficient and effective for achieving tolerance control, high precision in machining processes, and stability during machining. The design specification of a part is represented as a graph. The problem of identifying the optimal setup plan is transformed into a graph search problem. A setup planning algorithm for rotational parts was then developed. Based on the previous survey the objective of The present study is overcome the shortcomings of existing CAPP systems. parts are described in terms of machining features which consists of geometric and non-geometric information linked to design and manufacturing.

SYSTEM FEATURES

In the current work, a computer aided interactive process planning (CAIPP) system is designed for turning. Based upon analyzing the characteristics of the reviewed CAPP systems as well as the approaches used in CAPP and its implementation techniques. It is concluded that the proposed system should have the following features:

1- The system is to be based upon the generative approach to achieve high automation.
2- The part design data input will be interactive to achieve high flexibility of the input operation.
3- The implementation technique should be of the top-down type. The top-down technique, contrary to the bottom-up technique, develops the process planning by means of tracing the task of process planning from top to bottom. This is an automated process planning method oriented towards the generative approach. In this technique, the system works in the sequence determination of overall strategy, analysis of detailed tactics, analysis of the production process for each individual component, ..etc. Hence, it is compatible with the generative approach.
4- The programming language of the system is to be VISUAL BASIC for Windows which is an event-driven language [17,18]. Program instructions are executed only when a particular event calls that section of code into action. VISUAL BASIC automatically executes a subprocedure when an application event occurs. Also, Windows provide a proper environment of interactive programming (simultaneous multitasks, graphics and transforming data-including scanned images, spread sheets, and text from one window to another).

CAIPP SYSTEM DESIGN

The generative approach to process planning implemented in the developed system of the current work utilizes an automatic computerized system consisting of decision logic, formulae, technology algorithms, and geometry based data to uniquely determine the many processing decisions for converting a part from a rough to a finished state. The process planning system essentially consists of two major components. The first component is the part recognition segment. The part recognition segment defines all geometric features and features sizes for all process related surfaces. The second component of the process planning system is the software, comprised of decision logic, formulae, and technological algorithms, to compare the part geometry requirements to characteristics and capabilities of available manufacturing facilities. This involves determining the appropriate processing operations, selecting the machine tool, determining the cutting plan or other operations details, and calculating the machining time and power needs for each operation. CAIPP system has been designed to follow the following sequence: 1) Determination of the blank size, 2) Recognition of the part, 3) Determination of the operation sequence, 4) Selection of the cutting tool, 5) Calculation of the cutting parameters, 6) Selection of the machine tool. Also, because CAIPP system is generative, the built-in decision logic contains the general rules of the manufacturing operations. They can operate on a brief input data describing the geometric features and their related dimensions. The top-down technique utilizing this decision logic is used. Figure 1 depicts CAIPP main menu window. The following sections present CAIPP approach to the determination of all needed information and decisions for producing process plans.

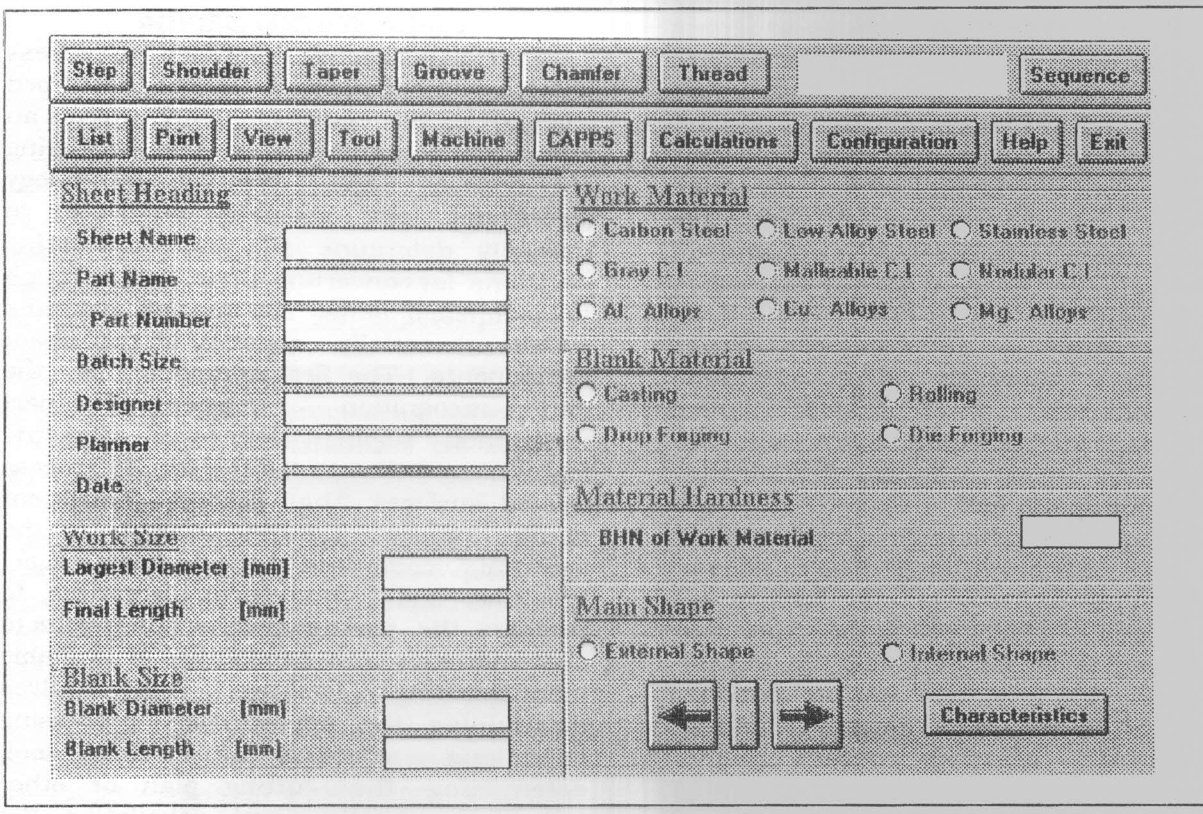


Figure 1 Main menu of CAIPP system.

DETERMINATION OF BLANK SIZE

The proper blank size for parts to be machined by turning is determined by the blank length L_b and blank diameter D_b . The blank diameter is considered to be of cylindrical shape, and it is assumed that the blank is for producing one piece only. Thus the parting off operation is not considered. Thus; the blank size is expressed as

$$L_b=L_f+2a \quad (1)$$

$$D_b = a+d_L \quad (2)$$

$$a=a_d+a_e+a_t+a_{op} \quad (3)$$

Where, a : total allowance (mm)

a_d : thickness of defective layer (mm).

a_e : error of geometric form (mm).

a_t : tolerance of the blank (mm).

a_{op} : allowances of the next operation (mm).

L_f : final part length (mm).

d_l : largest machined diameter (mm).

The recommended values for the allowances of different blank material sources [19] are considered for CAIPP system. Although the calculated blank diameter is not a standard diameter, standard diameter should be used. This can be done by selecting the diameter just greater than or equal to the calculated blank diameter according to the standards.

RECOGNITION OF THE PART

The part recognition in CAIPP system considers the parts as objects composed of various types of adjoining shapes having a given dimensional size. Table 1 shows cylindrical type shapes and a scheme for defining the parts in terms of five external shapes and ten internal shapes. A shape modifier is a feature that may be found on a cylindrical surface. Table 2 presents twenty two features universally found on internal or external surfaces of cylindrical type shape.

The CAIPP considers machining of the shapes and features on the left side of the part first, and then followed by machining on the right side of the part.

DETERMINATION OF OPERATION SEQUENCE

In industry, much of the lathe work is held in a chuck. It is important to follow the correct machining sequence of operations in order to prevent spoiling work, which so often happens when incorrect procedures are followed [20]. The general machining scheme applied in CAIPP is to perform machining operations on the external features, followed by drilling operations to remove the bulk internal stock, and finally machining operations on the internal features [21]. Turning, facing, grooving, chamfering, drilling, boring, and threading are the basic operations that have been implemented in CAIPP system. They are further divided into external and internal operations, involving two types of machining (rough cut and finish cut). Also, CAIPP is capable of selecting multiple passes and processes for the desired machined surfaces.

The guidelines considered for selection of sequence of operations in CAIPP system are: 1) apply roughing operation to the external profile by facing and turning operations, 2) apply finishing operation to the external profile, 3) perform external grooving operations, 4) produce the external threads, 5) perform chamfering operations on the external surfaces, 6) prepare for the internal profile, if any, by removing as much internal stock as possible by a drilling operation, 7) apply rough boring to internal profile, 8) apply finishing operation to the internal profile, 9) perform internal grooving operations, 10) produce the internal threads, and 11) perform chamfering operations on the internal surfaces. Moreover, CAIPP system applies the top-down and decision logic to select the processes and their sequence and parameters. The decision logic is divided into a condition and an action. Fourteen decision logic blocks have been built in CAIPP system for the relevant machining operations. These decision logic blocks are used for determining final diameter, machined length, maximum depth to be cut and tool label for all operations.

Table 1 Cylindrical type shapes

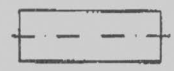
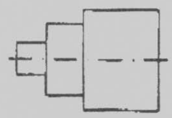
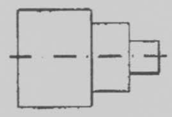
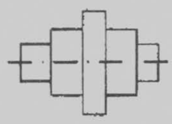
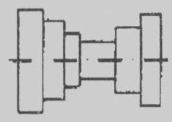
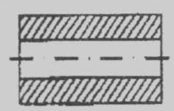
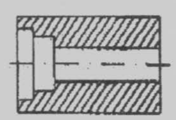
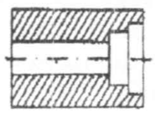
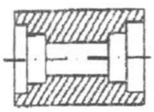
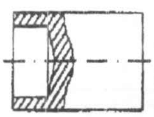
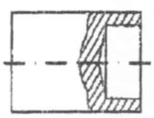
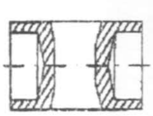
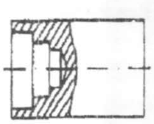
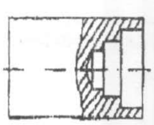
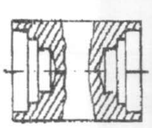
Shape	Definition
	external, no steps
	external steps decrease to left end
	external steps decrease to right end
	external steps decrease to left and right ends
	external steps decrease from left and right ends
	through hole no internal steps
	through hole internal steps at left end

Table 1 Cylindrical type shapes (*Cont*)

Shape	Definition
	through hole internal steps at right end
	through hole internal steps at left and right ends
	blind hole no internal steps at left end
	blind hole no internal steps at right end
	blind hole no internal steps at left and right ends
	blind hole internal steps at left end
	blind hole internal steps at right end
	blind hole internal steps at left and right ends

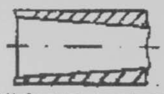
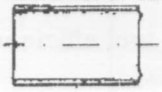
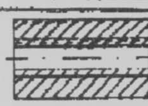
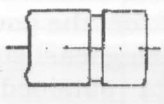
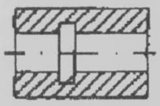
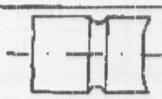
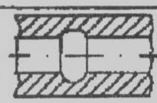
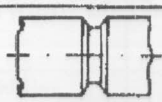
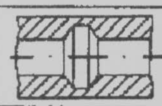
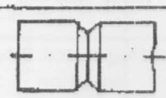
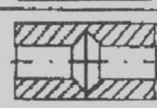
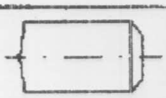
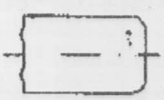
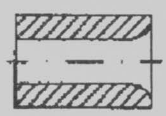
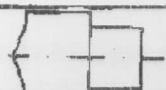
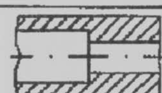
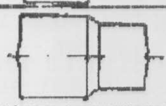
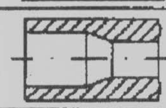
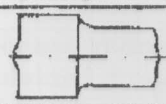
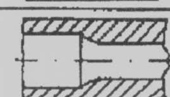
SELECTION OF CUTTING TOOL

The CAIPP system is planned for high speed steel and carbide cutting tools. Work materials considered are carbon steel, low alloy steel, stainless steel, maleable cast iron, nodular cast iron, gray cast iron, aluminum alloys, copper alloys, and magnesium alloys. The selection of the cutting tool material is determined by the planner through the cutting tool window. In case of a null selection is detected, the high speed steel tool will be used as the default cutting tool. During the selection and sequencing of the machining process, an appropriate cutting tool label is assigned for each machining process depending upon the shape to be machined. According to the primary tool label and tool material, a tool code will be selected. For drilling operations, standard twist drills are selected.

CUTTING PARAMETERS AND MACHINING CONDITIONS

The machining parameters in turning are cutting speed, feed rate and depth of cut. The setting of these parameters determines the surface finish, metal removal rate, production time and The power needed. The CAIPP system uses a data retrieval method for determining the cutting speed, feed rate and depth of cut. The concept of establishing machining data retrieval is to use a computer to look up table values for cutting conditions. Machining data for different combinations of materials, tools and operations are ordered in a computer. These data are compiled through different metals machining textbooks [20,22-24]. Tables 3 and 4 present a sample of machining data for rough and finishing cuts with carbide tools for the considered materials. The equations presented by these tables are developed through the current work by using least-squares fitting for mid-point value of each range. The values of R (which measure the goodness of fit) for all fitted equations are very much acceptable where the minimum value is 0.90. Similar tables were developed for other operations and tools.

Table 2 Shape modifier.

Shape	Definition	Shape	Definition
	external taper		internal taper
	external thread		internal thread
	external square groove		internal square groove
	external round groove		internal round groove
	external taper groove		internal taper groove
	external sharp groove		internal sharp groove
	external chamfer		internal chamfer
	external round corner		internal round corner
	external square shoulder		internal square shoulder
	external beveled shoulder		internal beveled shoulder
	external fillet shoulder		internal fillet shoulder

PRODUCTION TIMES

Three times are considered in CAIPP system. These times are set-up times for batches, tool change time and part time. The set-up time occurs once per part. Tool change time t_{ct} , is the time to change a tool. The value of both set-up time and tool change are controlled from the limitation window of the configuration task in the CAIPP main menu window.

PART TIME

In the present CAIPP system, three elements of time are related to parts. These elements of time are machining time (t_m), approach (t_t) time attributed to advance and withdraw the tool and non- productive time due to loading and unloading the part (t_u). The approach time is dependent on the operation selected [8]. The total production time can be expressed as the sum of $t_m + t_t + t_u + t_{ct}$.

MACHINING POWER

The available power on any machine tool places a limit on the size of the cut that it can perform. The conditions in different workshops may vary and machine tools are not all designed alike, hence some variations between the estimated results and those obtained on the job are expected. However, by using the method provided in this section reasonable estimates of the power required can be made. The power required to perform a machining operation is given by [25]:

$$P_c = K_P C Q W \quad (4)$$

where P_c : power required (kW).
K_p : power constant.
C : feed factor for power constant.
Q : metal removal rate in cm^3/s.
W : tool wear factor.

The power of the motor, P_m is given by

$$P_m = P_c/E \quad (5)$$

where E : machine tool efficiency factor.

Feed Factor for Power Constant

Feed factors for the power constant are calculated, by using least squares fitting technique and data obtained from [18], through the following equation developed in this work.

$$C = 0.785 * f^{-0.1975} \quad (6)$$

where f = feed rate (mm/rev)

Table 3 Cutting Conditions for rough turning with carbide tools

Material	BHN	Cutting speed m/min	Feed rate mm/r	Depth of cut mm	cutting speed fitted equation	R^2
Carbon and Low Alloy Steels	85 - 125 125 - 175 175 - 225 225 - 275 275 - 325 325 - 375 375 - 425	140 116 102 95 82 69 53	0.381	3.81	V=161.5-0.27*BHN	0.97
Stainless Steel	135 - 185 185 - 240 275 - 325 375 - 425	152 137 98 51	0.381	3.81	V= 224.2-0.43*BHN	0.99
Meallable Cast Iron	110 - 160 160 - 200 200 - 240 200 - 255 240 - 280	213 91 69 61 46	0.381	3.81	V=361.91-1.3 *BHN	0.90
Nodular Cast Iron	140 - 190 190 - 225 225 - 260 240 - 300 270 - 330	140 99 76 61 37	0.381	3.81	V=258.76-0.74*BHN	0.98
Gray Cast Iron	110 - 140 150 - 190 190 - 220 220 - 260 250 - 320	140 107 85 69 35	0.381	3.81	V=218.2-0.64*BHN	0.99
Al Alloys	-	335	0.381	3.81	-	-
CU Alloys	-	182	0.381	3.81	-	-
Mg Alloys	-	305	0.381	3.81	-	-

Table 4 Cutting Conditions for finish turning with carbide tools

Material	BHN	Cutting speed m/min	Feed rate mm/r	Depth of cut mm	cutting speed fitted equation	R^2
Carbon and Low Alloy Steels	85 -125 125 - 175 175 - 225 225 - 275 275 - 325 325 - 375 375 - 425	165 137 128 119 107 88 69	0.177	0.635	V=189.6-0.29 *BHN	0.97
Stainless Steel	135 - 185 185 - 240 275 - 325 375 - 425	170 152 114 60	0.177	0.635	V=247-0.46 *BHN	0.98
Meallable Cast Iron	110 - 160 160-200 200-240 200-255 240-280	274 122 99 - 76	0.177	0.635	V=442.7-1.5 *BHN	0.90
Nodular Cast Iron	140-190 190-225 225-260 240-300 270-330	175 122 91 76 49	0.177	0.635	V=318-0.9 *BHN	0.98
Gray Cast Iron	110-140 150-190 190-220 220-260	175 140 107 84	0.177	0.635	V=276.4-0.81 *BHN	0.99
Al Alloys	-	365	0.177	0.635	-	-
CU Alloys	-	228	0.177	0.635	-	-
Mg Alloys	-	450	0.177	0.635	-	-

Machine Tool Efficiency Factor

The machine tool transmits the power from the driving motor to the work piece using different power transmission systems. The machine tool efficiency factor for power depends on the transmission system. Average values of these factors are used as obtained from [25]. Also, average values for the tool wear factors are used.

Power Constant

The power constant Kp depends mainly on the hardness of the material to be cut. In this aspect, formulae for determining power constants are developed (R^2 from 0.97 to 0.99) for different materials based on the obtained values from [18]. Table 5 lists these equations for different materials.

SURFACE FINISH

In CAIPP system, the surface finish requirement for each defined shape should be given as an input. If the surface finish is ignored during data input, a recommended value for the nose radius and feed rate will be assigned. In case of a given surface finish, the CAIPP system will compute a proper nose radius or select the most suitable standard size that the desired finish will be obtained. However, for single point tools, the arithmetic mean value of surface finish (R_a in μm) can be expressed as a function of nose radius (r) and feed rate (f) [3].

$$R_a = 0.0321\, f^2 / r \qquad (7)$$

WORK SUPPORTING METHOD

CAIPP system supports machining of parts in a 3-jaw chuck and or tail stock constrained by L/D ratio which is the ratio of the extended length to the diameter.

SELECTION OF THE MACHINE TOOL

The method of selection of machine tool in the CAIPP system depends on the two dimensions that indicate the diameter and length of the largest work piece that can be machined on a lathe. CAIPP system can support 90 different lathes. It is also capable of selecting the lathe that needs less power input to produce a given part within the size specification limits of the lathe. The machine tool data file format is an ASCII file. The format in this file is :

- Machine tool data file name.
- Machine tool number.
- Machine tool name.
- Available power.
- Swing.
- Span.
- Number of available spindle speeds.
- Available spindle speeds.
- Number of available feeds.,
- Available feeds.

EXAMPLES

Figure 2 and Figure 3 exhibit working drawings for the two examples presented in this work. Figure 2 is for a shaft of steel 1045 having a hardness of 210 BHN. Figure 3 is for a nipple of steel 1020 having a hardness of 250 BHN. Tables 6. and7. present the operation sheets produced by CAIPP system for these examples.

CONCLUSIONS

Computer interactive process planning system for turning (CAIPP)offers substantial cost, speed and consistency advantages for operations sequence planning of turned parts.

It can be implemented on a microcomputer and it greatly reduces the range of skills required for planning. The input of CAIPP system data should be learned without difficulty by shop floor personnel.

Also, the output is usable on the shop floor with little or no special training. The software is user friendly and written for an interaction between the process planner/production engineer and the computer. CAIPP software will help process planners increasing their productivity. The sequence of information input through the designed 23 windows of CAIPP system is a flexible input order. The developed process sheets are consistent and provide the necessary information for shop floor in few seconds.

Table 5 Power constant K_p

Material	BHN	K_p	Fitted equation	R^2
Carbon Steel	80 - 100	1.72		
	100 - 120	1.80		
	120 - 140	1.88		
	140 - 160	2.02	K_p=1.25+0.005*BHN	0.97
	160 - 180	2.13		
	180 - 200	2.24		
	200 - 220	2.32		
	220 - 240	2.43		
Alloy Steel	140 - 160	1.69		
	160 - 180	1.77		
	180 - 200	1.88		
	200 - 220	1.97	K_p=0.925+0.005*BHN	0.99
	220 - 240	2.07		
	240 - 260	2.18		
	260 - 280	2.29		
	280 - 300	2.38		
Stainless steel	150 - 175	1.64		
	175 - 200	1.97	K_p=0.0105*BHN	0.98
	200 - 250	2.4		
Cast Iron	100 - 120	0.76		
	120 - 140	0.96		
	140 - 160	1.04		
	160 - 180	1.42	K_p=0.0005*BHN1.567	0.97
	180 - 200	1.64		
	200 - 220	1.94		
	220 - 240	2.48		
Al Alloys	-	0.68	-	-
Cu Alloys	-	1.36	-	-
Mg Alloys	-	0.27	-	-

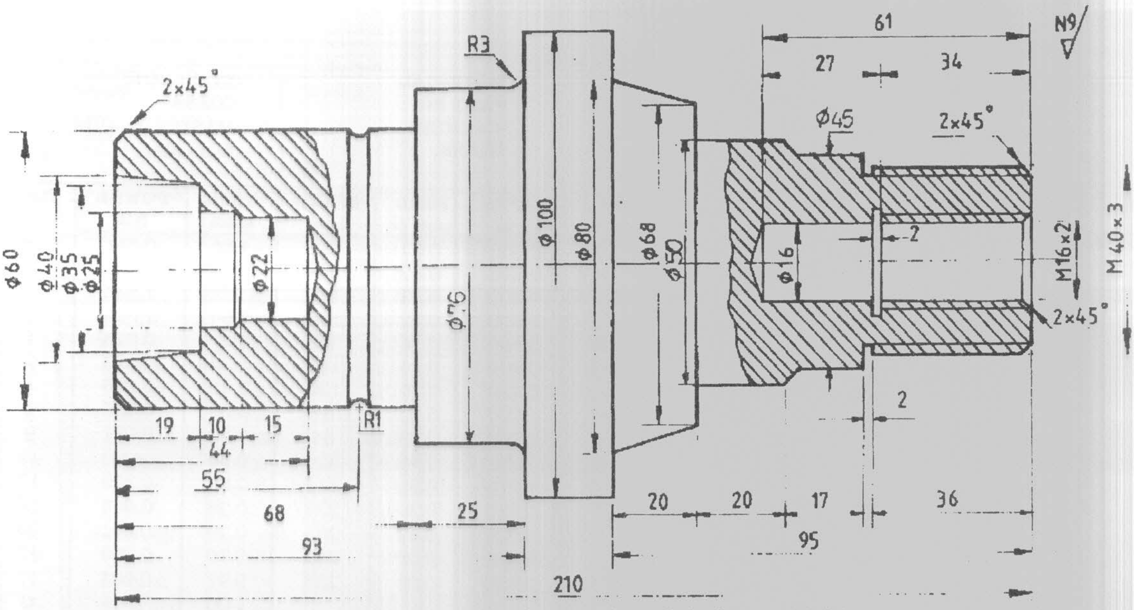


Figure 2 Working drawing of shaft no. 002.94

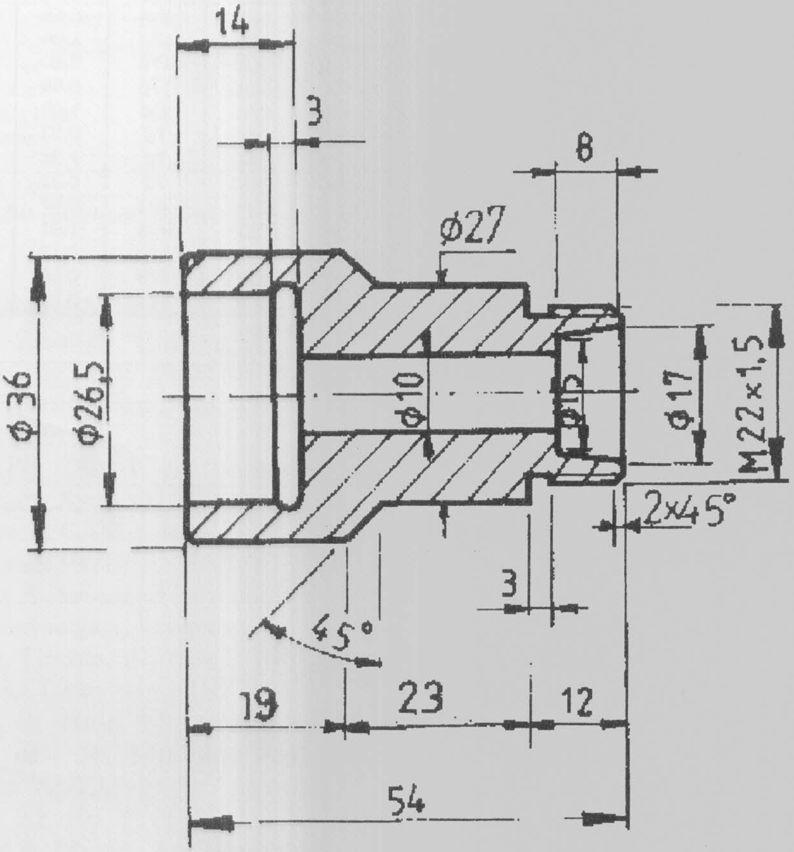


Figure 3 Working drawing of nipple no. 008.94.

Table 6 Operation Sheet for shaft no. 00294

PROCESS SHEET

SHEET NAME	:SHEET2	**MATERIAL**	:STEEL 1045
PART NAME	:SHAFT	**PART NO.**	:002.94
BATCH SIZE	:1	**MACHINE**	:MASTER 2500/N0.4
BLANK SIZE	:110x218 mm	**BLANK**	:ROLLED
BHN	:210		

NO.	OPERATION	LENGTH m m	DIAMETER m m	PASSES	DEPTH m m	FEED mm /r	SPEED rpm	TIME mim	POWER KW	TOOL
1	Face	55	110	2	2.000	0.32	72	4.86	0.511	16
2	R. Turn	115	100.8	2	2.300	0.32	72	10.60	0.588	1
3	R. Turn	93	76.8	4	3.000	0.32	98	12.56	1.534	2
4	R. Turn	68	60.8	4	2.000	0.32	130	6.94	1.023	1
5	F. Turn	22	100	1	0.400	0.16	98	1.57	0.023	1
6	F. Turn	25	76	1	0.400	0.16	130	1.33	0.023	2
7	F. Turn	68	60	1	0.400	0.16	130	3.45	0.023	1
8	Groove	2	60	1	1.000	0.25	54	0.30	0.035	6
9	Chamfer	2	60	1	2.000	0.25	54	0.30	0.071	9
10	Drill	44	21.5	1	n/a	0.40	320	0.36	n/a	13
11	R. Bore	19	34.2	5	1.270	0.20	175	2.89	0.322	17
12	R. Bore	10	24.2	1	1.350	0.20	235	0.28	0.069	17
13	Taper	19	40 7.5	1	2.900	0.32	235	0.29	0.371	33
14	F. Bore	10	25	1	0.250	0.08	235	0.70	0.005	17
15	F. Bore	15	22	1	0.250	0.08	235	0.97	0.005	17
16	Rechuck	-	-	-	-	-	-	1.00	-	0
17	Face	55	110	2	2.000	0.32	72	4.86	0.511	16
18	R. Turn	95	80.8	4	3.650	0.32	98	12.83	1.866	1
19	R. Turn	75	50.8	4	3.750	0.32	175	5.68	1.918	1
20	R. Turn	55	45.8	1	2.500	0.32	175	1.07	0.320	2
21	R. Turn	38	40.8	1	2.500	0.32	235	0.56	0.320	1
22	Taper	20	68 16.7	2	3.200	0.32	130	1.06	0.818	32
23	F. Turn	20	50	1	0.400	0.16	175	0.80	0.023	1
24	F. Turn	17	45	1	0.400	0.16	175	0.69	0.023	2
25	F. Turn	38	40	1	0.400	0.16	235	1.09	0.023	1
26	Groove	2	40	1	2.000	0.25	72	0.23	0.071	5
27	Thread	36	40	5	0.520	3.00	72	1.26	1.102	13
28	Chamfer	2	40	1	2.000	0.25	72	0.23	0.071	9
29	Drill	61	15.75	1	n/a	0.40	425	0.37	n/a	0
30	F. Bore	61	16	1	0.120	0.08	425	1.91	0.002	17
31	Groove	2	20	1	2.000	0.25	130	0.13	0.071	21
32	Thread	34	16	2	0.870	2.00	175	0.26	0.492	29
33	Chamfer	2	16	1	2.000	0.25	175	0.09	0.071	25

FIRST CLAMPING :clamped diameter =110mm and extended length = 124 mm
SECOND CLAMPING: clamped diameter =100mm and extended length = 104 mm

Total machining time	= 79.18 mim
Total approach time	= 2.36 mim
Total tool changing time	= 42 mim
Non-productive time	= 4 mim
Setup time	= 25 mim
Total production time	= 152.53 mim

ALL OPERATIONS ARE SUPPORTED IN 3-JAW CHUCK

Table 7 Operation sheet for nipple no. 008.94

PROCESS SHEET

SHEET NAME	:SHEET 7	**MATERIAL**	:STEEL 1020
PART NAME	:NIPPLE	**PART NO.**	:008.94
BATCH SIZE	:1	**MACHINE**	:Harrison M 300/No.1
BLANK SIZE	:40 x 62 mm	**BLANK**	:ROLLED
BHN	:250		

NO.	**OPERATION**	**LENGTH mm**	**DIAMETER mm**	**PASSES**	**DEPTH mm**	**FEED mm /r**	**SPEED rpm**	**TIME mim**	**POWER KW**	**TOOL**
1	Face	20	40	2	2.000	0.36	125	1.12	0.420	16
2	R. Turn	35	27.8	2	2.050	0.30	180	1.40	0.641	2
3	R. Turn	12	22.8	1	2.500	0.30	260	0.19	0.263	1
4	F. Turn	23	27	1	0.400	0.16	180	0.89	0.019	2
5	F. Turn	12	22	1	0.400	0.16	260	0.34	0.019	1
6	Groove	3	22	1	2.000	0.25	85	0.24	0.057	5
7	Thread	8	22	5	0.260	1.50	85	0.41	0.222	13
8	Chamfer	2	22	1	2.000	0.25	85	0.19	0.057	9
9	Drill	58	9.8	1	n/a	0.40	540	0.28	n/a	0
10	R. Bore	8	14.2	1	2.200	0.20	260	0.22	0.090	17
11	Taper	8	17 7.5	1	1.400	0.30	370	0.09	0.147	33
12	F. Bore	32	10	1	0.100	0.08	370	1.20	0.002	17
13	Rechuck	-	-	-	-	-	-	1.00	-	-
14	Face	20	40	2	2.000	0.30	125	1.12	0.420	16
15	R. turn	19	36.8	1	1.600	0.30	180	0.41	0.168	1
16	R. Turn	19	36	1	0.400	0.16	180	0.75	0.019	1
17	R. Bore	14	25.2	2	2.300	0.20	125	1.28	0.188	17
18	F. Bore	14	26.5	1	.250	0.08	125	1.72	0.004	17
19	Grove	3	29.5	1	1.500	0.25	58	0.35	0.043	22

FIRST CLAMPING :clamped diameter = 40 mm and extended length = 44 mm
SECOND CLAMPING : clamped diameter =27 mm and extended length = 28 mm

Total machining time	= 11.85 mim
Total approach time	= 1.34 mim
Total tool changing time	= 24 mim
Non-productive time	= 4 mim
Setup time	= 20 mim
Total production time	= 61.19 mim

ALL OPERATIONS ARE SUPPORTED IN 3-JAW CHUCK

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معاونة الحاسوب التفاعلية لتخطيط عمليات الخراطة

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ملخص البحث

إن استخدام الحاسوب لتخطيط العمليات يعتبر من الأدوار الهامة الفاعلة فى عمليات التصنيع المتكاملة بإستخدام الحاسوب . يقدم هذا البحث أسلوبا تخليقيا متفاعلا لتحديد تتابع عمليات التخطيط للأجزاء المصنعة على المخرطة. وقد تم تصميم وتخليق هذا النظام بإستخدام Microsoft Visual Basic 3 Under windows. ومن فوائد النظام مقدرتة على تحديد صفحات التخطيط بكل ما تحتاجة من معلومات وبيانات وذلك لعدد كبير جدا من المشغولات الصناعية والتى تم الحصول عليها من الصناعة بالفعل بالاضافة إلى سهولة استخدامة والتدريب علية وأمكانية تطبيقة على الحواسب الصغيرة. كما انه يقلل من المهارات اللازمة والتى تستخدم فى عمليات التخطيط. فى هذا النظام تم إستحداث العديد من النماذج الرياضية لتحديد سرعات القطع وكذا القدرة لكل من الماكينة المستخدمة وعملية القطع . فى نهاية البحث تم ذكر النتائج والتوصيات التى تم الحصول عليها وكذلك مدى امكانية تطوير النظام المقترح مع ذكر بعض الاتجاهات المستقبلية فى هذا المجال.