

Study and development of various modules for an interactive G- CAPP using a novel approach for a 2.5D prismatic part

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Abstract-- The role of CAPP system in integration of computer aided design and computer aided manufacturing is inevitable. The research work reported in this paper is aimed to develop an interactive G-CAPP system. The extraction of features along with their dimensional information, using 3'CAM technique is the input for the 3'C-CAPP approach. In This a new technique 3'C-CAPP approach has been implemented to generate an efficient machining module preparation, machining strategy, material selection, indispensable cutting tools, power prerequisites and various operations that vital to craft a G-CAPP system for some prismatic part analyzed using 3'C-CAPP to demonstrate their potential for engineering applications. In this paper, a 3'C-CAPP methodology has been introduced and demonstrated for a simple 2.5D part. However, the sophisticated method can be extended for complex models.

Keywords: Computer Aided Process Planning, material selection, machining strategy and G-CAPP system

Abbreviations and Acronyms

---►	A single turn active link
N_s	Revolution per Minute
f	Surface speed per minute [m/min]
D_z	Drill feed per revolution [mm/rev]
P_d	Unit power required for drilling
P_m	Unit power required for milling
E_f	Milling feed
E_s	Milling feed
CD_f	Variable assigned for circum-diameter module
CDM	Circum diameter module
CC_f	Variable assigned for Circumcentre module
CCM	Circumcentre module
DB_f	Variable assigned for Drill bit module
DBM	Drill Bit Module
I	an identity denotes the selected material
@	Address
CMT	Corner Mill Table
C_s	Corner end mill speed [RPM]
C_z	Corner end mill Feed [mm/min]
SDBM	Standard drill bit module
SDB_f	Variable for standard drill bit module
f	operating variable for feature selection [1....f....F]
F	Total number of features (constant)
SF_f	Variable assigned for Scaling factor module
SFM	Scaling factor module
$R\lambda$	Row variable [1..... λF]
$C\beta$	Column variable [1... βF]
DFT	Drill feed table

MIC I Material information chart I
 MDOS Module data operating system
 FET Feature extraction table
 T Thickness of work piece

I. INTRODUCTION

Owing to the global antagonism a demand has been engendered for a standardized, lessen cost, prompt delivery of necessitated product. This scenario has led to a rising hub on expansion of computer integrated manufacturing (CIM) systems. In emergent CIM system, an effectual bridge is vital to fill the gap between computer aided design (CAD) and computer aided manufacturing (CAM). As a result, a sophisticated Computer-Aided Process Planning (CAPP) system has been developed as a bridge to fill this gap. Due to this the importance of CAPP system has been identified by the researches. Thus, a number of research approaches have been proposed by many investigators on CAPP system both in variant and generative categories. Most of the research works have been carried on generative approach due to its vast scope and benefits. Basically, in generative a process plan for each part is created from scratch without human interference.

However, in an interactive type of generative CAPP system the user need to provide required information to the system and then the process plan generates and synthesize process information to develop a process plan for a part. A computer aided process planning presents process selection, machine tool and cutting tool selection, set-up planning, fixture selection, machining parameter selection etc. First of all, an interface between design and process planning using 3rd CAM technique has been implemented for feature recognition and extraction along with their geometrical dimensional information. Further, a unique 3rd C-CAPP approach has been developed to generate CAPP system from outcome information of 3rd CAM technique. In this paper, a 3rd C-CAPP approach has been developed for 2.5D prismatic part. The work presented here on process planning consists of machining plan, machining module preparation, machining strategy, material selection, required cutting tools, power prerequisites and operations. The two approaches are used to create a well-organized interactive G-CAPP system one after another. Tremendous researches have been made to develop generative planning capabilities and incorporate CAPP into a computer-integrated manufacturing architecture in the past. Effective use of CAPP can improve a manufacturer's viable benefit. Several researches have been carried out till the date, a machining operations selection has been automated using mathematical models, decision trees, expert systems and artificial neural network (ANN). An approach has been discussed for operation selection by using a mathematical model for mapping the machinable volumes to feasible machining operations [1].

A mathematical-based model method has been introduced to generate various machining routes for producing a part [2]. An inflexible and incapable of automatically acquiring knowledge decision tree for machining operations selection. [3]. A mathematical model has been proposed for selection of hole machining operations that is capable of generating an optimal sequence of operations by minimizing the number of tool changes. [4]. A rule based expert system for hole making process selection [5]. An algorithm using rule based process capability knowledge to generate an operations precedence tree, which are refined further using rules [6]. A rule based approach for operation selection and sequencing for various rotational and prismatic parts [7-9]. A set of knowledge based rules and heuristics to solve the problem of operation selection and sequencing for mill-turn part [10-11]. In recent and since 30 years it has been focused on the knowledge on CAPP and many experimental and commercial systems have been developed. As a result the most researchers have focused on a particular aspect of process planning. However, a small number have addressed about the integration of sub-systems and system architecture. The current CAPP systems are general and other obstacle their closed form approach. Inevitably result in the ineffective realistic execution of CAPP, predominantly in manufacturing milieu. However, the constant change in product design and production resources. In this study, a novel approaches 3rd CAM and 3rd C-CAPP are proposed for rapid development of CAPP systems for 2.5D parts.

II. DATA FLOW OF THE PROPOSED METHODOLOGY

In this approach, the 3CAM technique is initially used to recognize, and extract the features along their geometric and dimensional details. Using these geometric details a 3rd C-CAPP generates an efficient machining module preparation, machining strategy, material selection, indispensable cutting tools, power prerequisites, operations, tool path planning, operation sequencing and scheduling, machine tool specification, machine tool selection, cost estimation and reduction. A 2.5D prismatic part (as shown in Fig 1) has been analysed using 3rd C-CAPP to demonstrate their potential for applications.

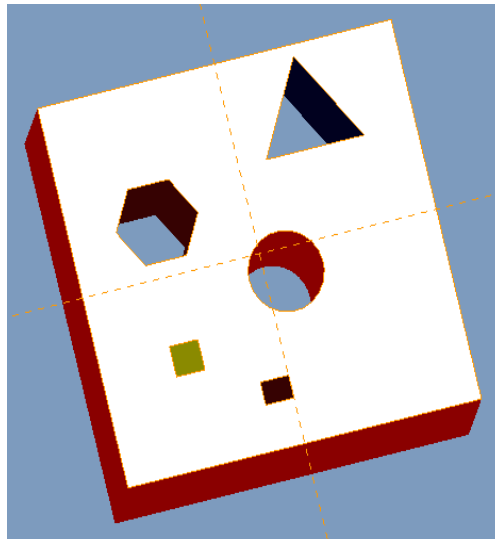


Fig. 1 Isometric view of prismatic part model

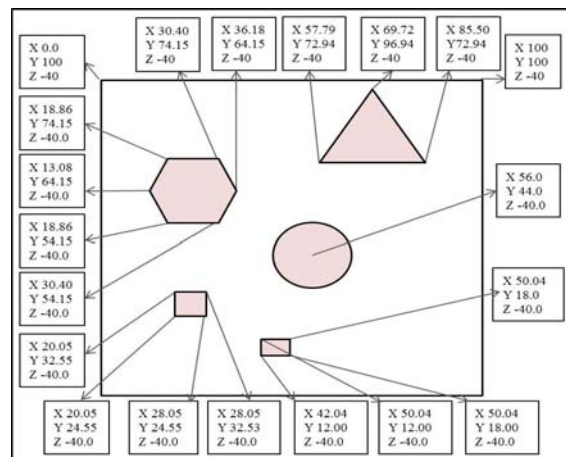


Fig.2 Nodes Edge-rep

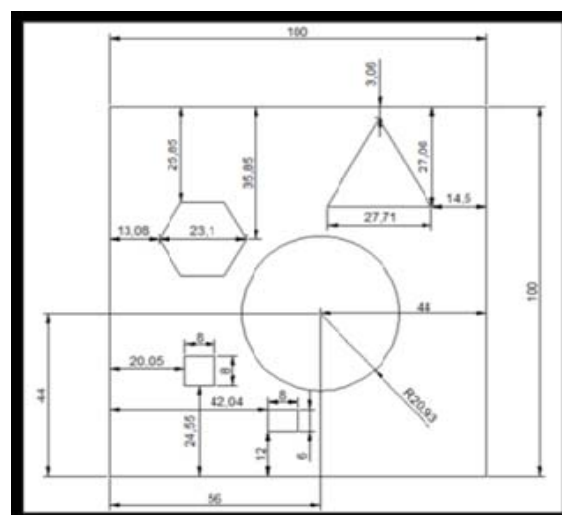


Fig.3 2D view of the Part

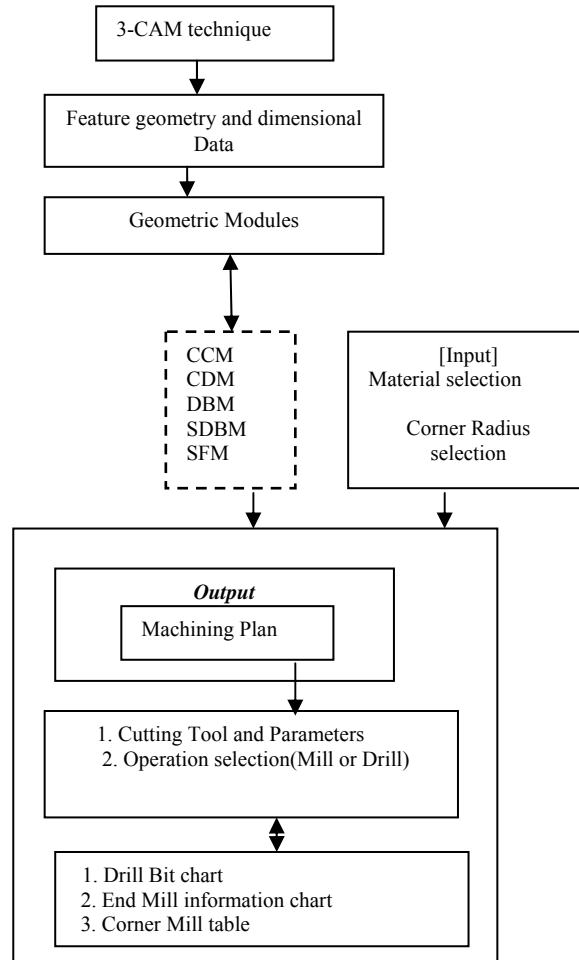
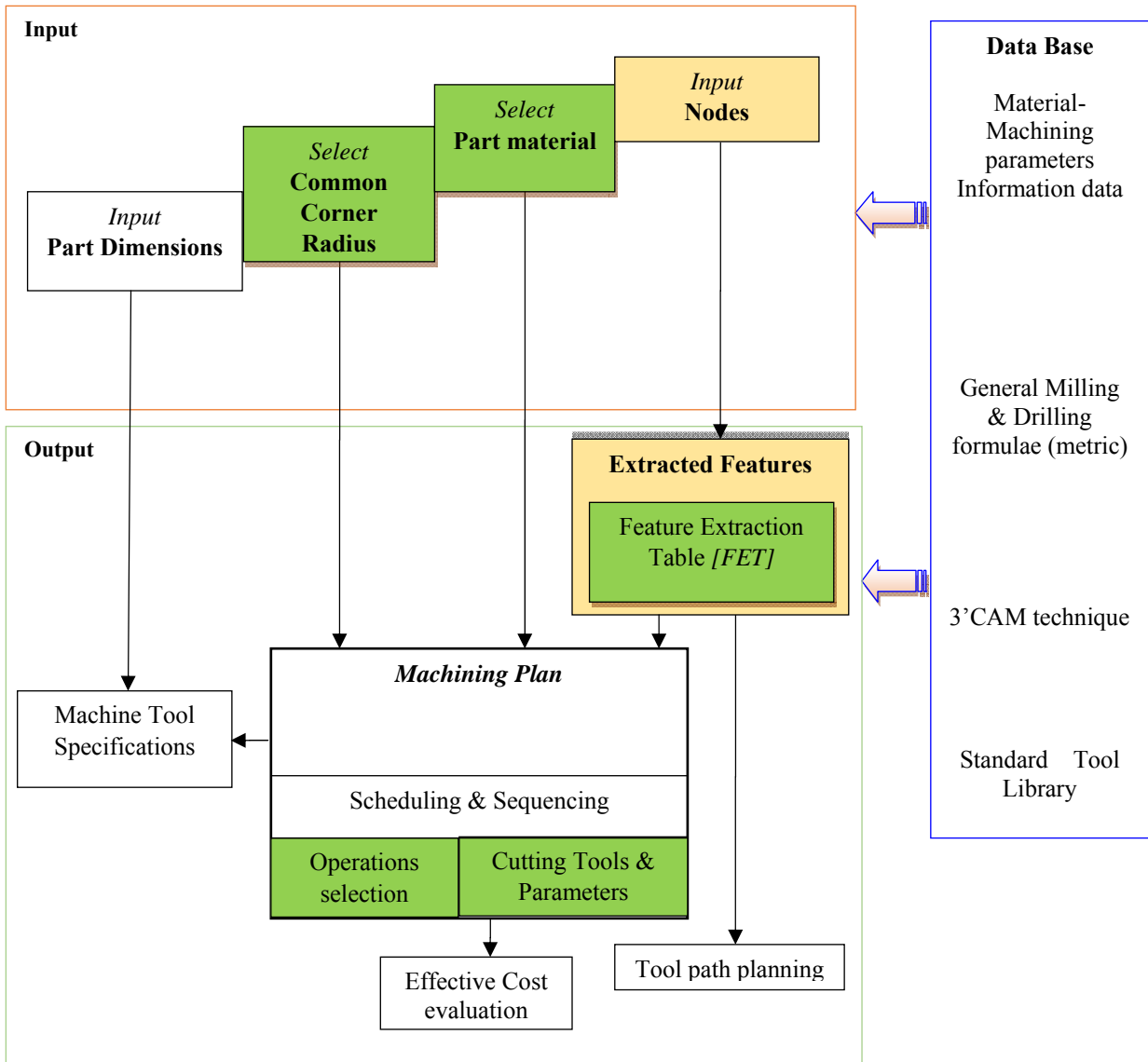


Fig.4 Data flow in proposed approach



III. EXTRACTED FEATURES USING 3’CAM TECHNIQUE

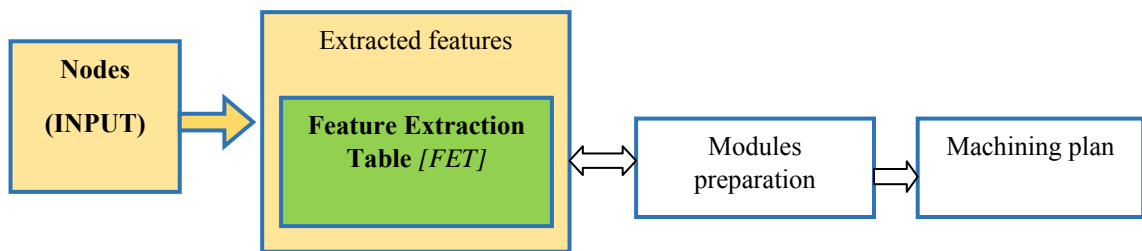


Fig.6 Data flow from nodes to machining plan

Consider the nodes (vertices and centroids of the features) as input to the 3’CAM technique, result extraction of feature along with their geometric and dimensional structures in the form of FET. The instruction obtained as an output is the input to the machining plan and tool path generation for the CAPP system. Further, generates modules for drilling, machining area and machine tool specification. The modules are represented by serial numbering, along with an operating variable ‘**f**’ and functions up to total number of terms ‘**F**’.

IV. CONSTRAINTS OF PROPOSED METHODOLOGY

1. Corner radius and part material must be selected from pre- defined charts.
2. HSS and Carbide as cutting tool material
3. Suitable for drilling and milling operations
4. Appropriate 2.5D part

V. EXPLANATION OF MODULES

Circum Diameter Module (CDM):

Circum diameters are the diameters of the circum-circles of the features. The Circumdiameter are computed and stored as a group in the database as Circum Diameter Module.

Circum Centre Module (CCM):

Circumcenters of all the features are collected in ascending order of distance from origin and stored in the database as Circum-Centre Module

Drill Bit Module (DBM):

The in-circle diameters of all features are computed and stored as a group in the data base as Drill Bit dia Module using 3'CAM technique.

The allotment of feature numbering is defined in ascending order with respect to distance from the origin. The closest feature is denoted as first ($f=1$) and to bordering feature within the work piece is denoted as last ($f=F$), this reckon from the origin. On the other hand, the first term of all module denotes the information about first feature ($f=1$) similarly the last term of all modules are represents the last feature. In this approach, the circum centre dia, circum centre location and circum circle dia, basically the outcome values of the 3'CAM technique result the CDM, CCM and DBM respectively. Then, the operating variable is assigned as ' f ', a total number of terms ' F ' and serial number specified to features ($1...f.....F$). The entire data and logic flow as shown in fig 7.

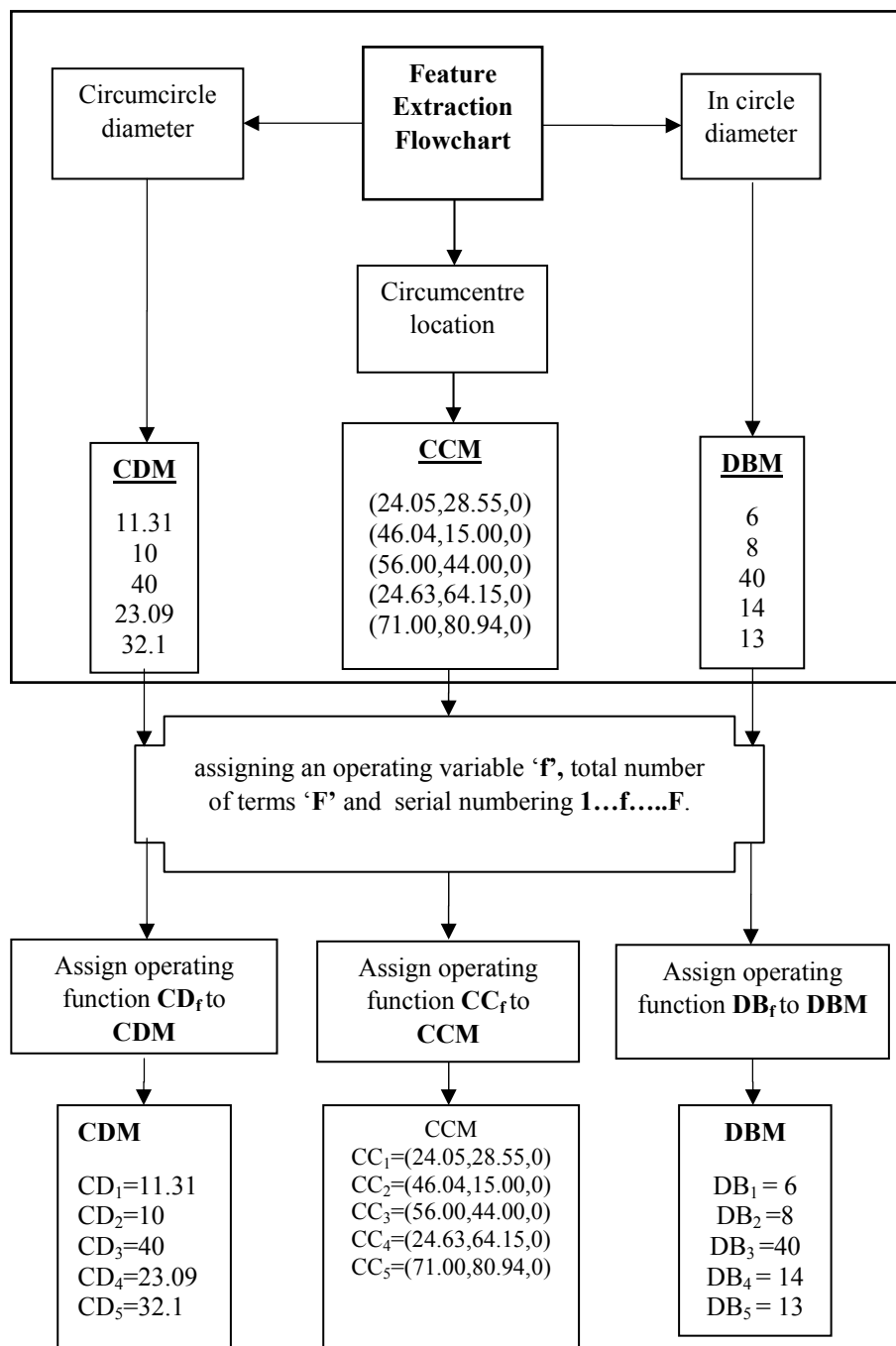


Fig.7 Modules preparation

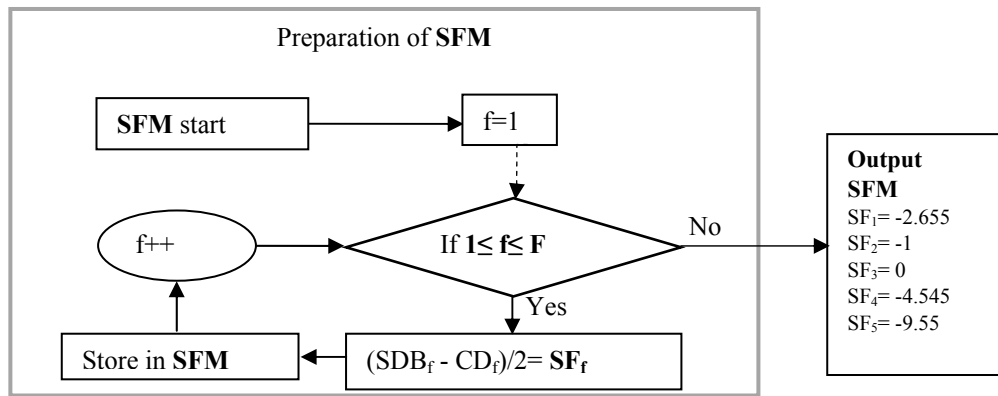


Fig.8 Preparation of scaling factor module

VII. MODULE DATA OPERATING SYSTEM [MDOS]

STEP #1

Retrieve modules

{Circum-circle diameter}

{In-circle diameter}

{Circum-centre}

Data from “feature extraction algorithm”,

Assign with an operating variable ‘**f**’

Restraining to total number of terms = ‘**F**’

STEP #2

Assign Operating functions

{**CD_f** to **CDM**}, (i.e., **CD₁**, for **f=1** is the circum diameter of first feature) {**CC_f** to **CCM**},

{**DB_f** to **DBM**},

{Numbering specified to features **1 ...f.....F**}.

1. Scaling Factor

It is the measure of variation flanked by Circumcircle (**CD_f**) & in-circle diameter (**DB_f**).

Decision: (milling or no milling)

Scaling Factor Module algorithm (SFM)

f=1 (first feature information)

Step#1:

If $1 \leq f \leq F$, then $[(SDB_f - CD_f)/2] = SF_f$

Go to Step#2

Step#2:

Store **SF_f** in scaling factor module [**SFM**],

Go for **f** increment, (**f++**);

Go to Step#1.

Else; output SFM is stored in database,

2. Validation checking:

The obtained diameters in CDM may or may not be standard in magnitude leads to the need for standardization. As per the algorithm below, standard Drill bit diameters are selected from Tool library.

f=1 (Information of first feature is selected)

Step#1:

If $1 \leq f \leq F$, then

Go to Step#2

Step#2:

If $DB_f = CD_f$

Go to Step#3

Step#3:

Assign SDB_f to DB_f & Store in **SDBM**

Go for **f** increment, (f++);

Go to Step#1

Else;

If [DB_{f-2}] is a standard value

Go to Step#3

Else;

Replace [DB_{f-2}] with nearest smaller standard drill size value

Go to Step#3

Else; output SDBM is stored in database,

End.

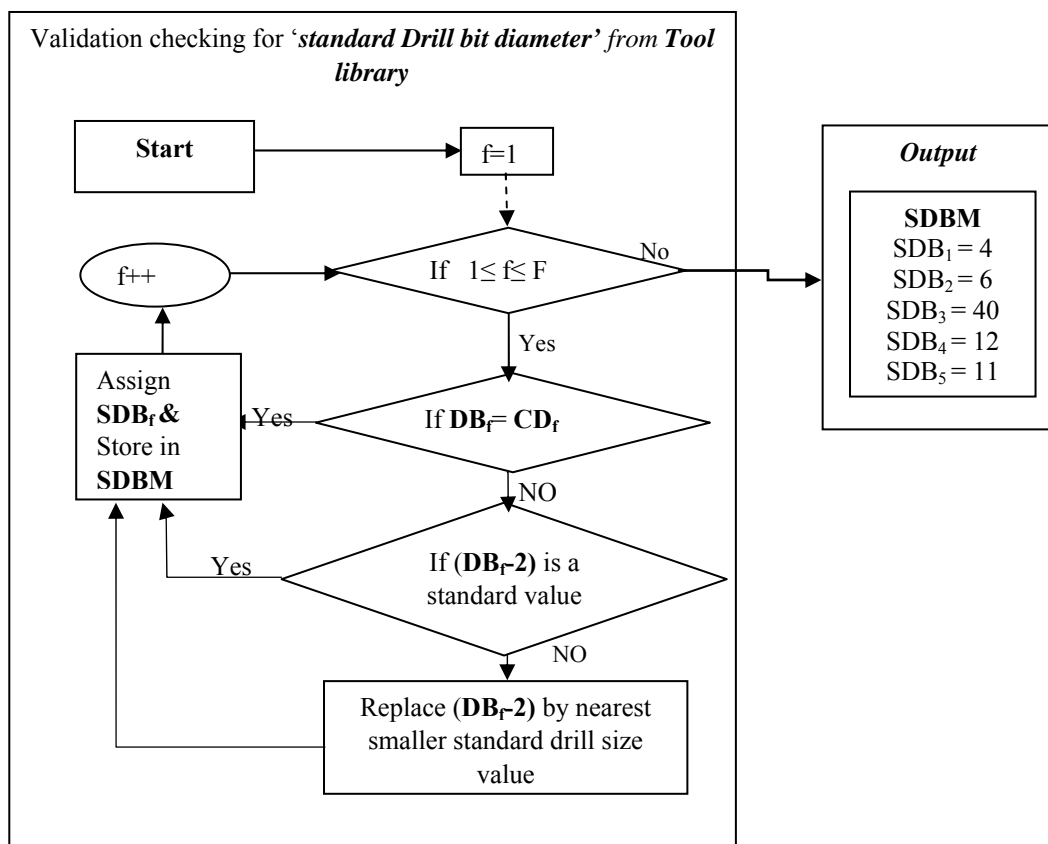







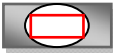












Fig: 9 Validation checking Flowchart

**VIII.MACHINING STRATEGY & OPERATION SELECTION FOR MACHINING OF WORK
PIECE**

Table1: Machining Strategy

Sr.No	Master feature	Drilling or milling feature (In-circle)	Milling feature	Milling initiation boundary (Corner end mill)
1				
2				
3				
4				
5				

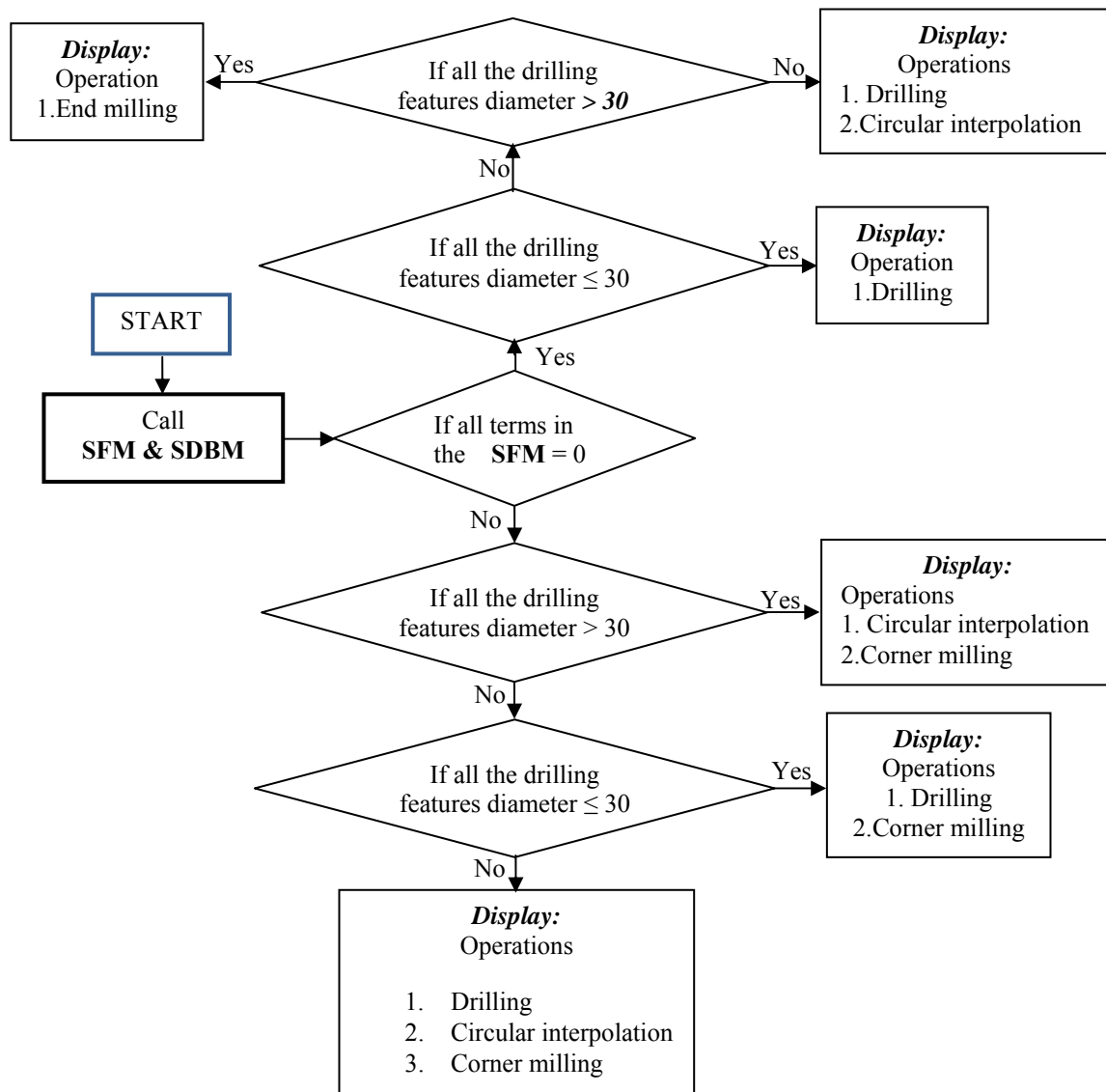


Fig.10 operation selection

The machining strategy presents the best and cost effective operation sequence for machining of each and every feature in the designed model. The given feature is machined in an integrated environment of drilling and milling operations. In the first stage, the in-circle diameter is measured each feature. According to the specified in-circle diameter the features are drilled for those areas, up to the specified limit.

However, the larger diameters that are more than specified limit can be machined using circular-interpolation with an End mill cutter. The circular interpolation applied for larger diameters with relatively smaller size end mill from which machining of total inscribed volume can be avoided to a larger extent.

In the second stage corners of the geometric features is measured and corner milling operation for machining of selected corner radius. However, the corner radius can be specified by the user for all features.

1. Algorithm for Operation Selection

Call SFM & SDBM

Step#1:

If all terms in the SFM = 0, then Go to Step#2

Else; Go to Step#3

Step#2:

If all the drilling features diameter ≤ 30 , then **Display:** Operation 1. Drilling

Else; Go to Step#4

Step#4:

If all the drilling features diameter > 30 , then **Display:** Operation 1.End milling

Else; Display: Operations 1. Drilling 2.Circular interpolation

End.

Step#3:

If all the drilling features diameter > 30 , then **Display:** Operations 1. Circular interpolation 2.Corner milling

Else; go to Step#5

Step#5:

If all the drilling features diameter ≤ 30 , then **Display:** Operations 1. Drilling 2.Corner milling

Else; go to Step#6

Step#6:

Display: Operations 1. Drilling 2. Circular interpolation 3.Corner milling

End.

IX. PART MATERIAL SELECTION

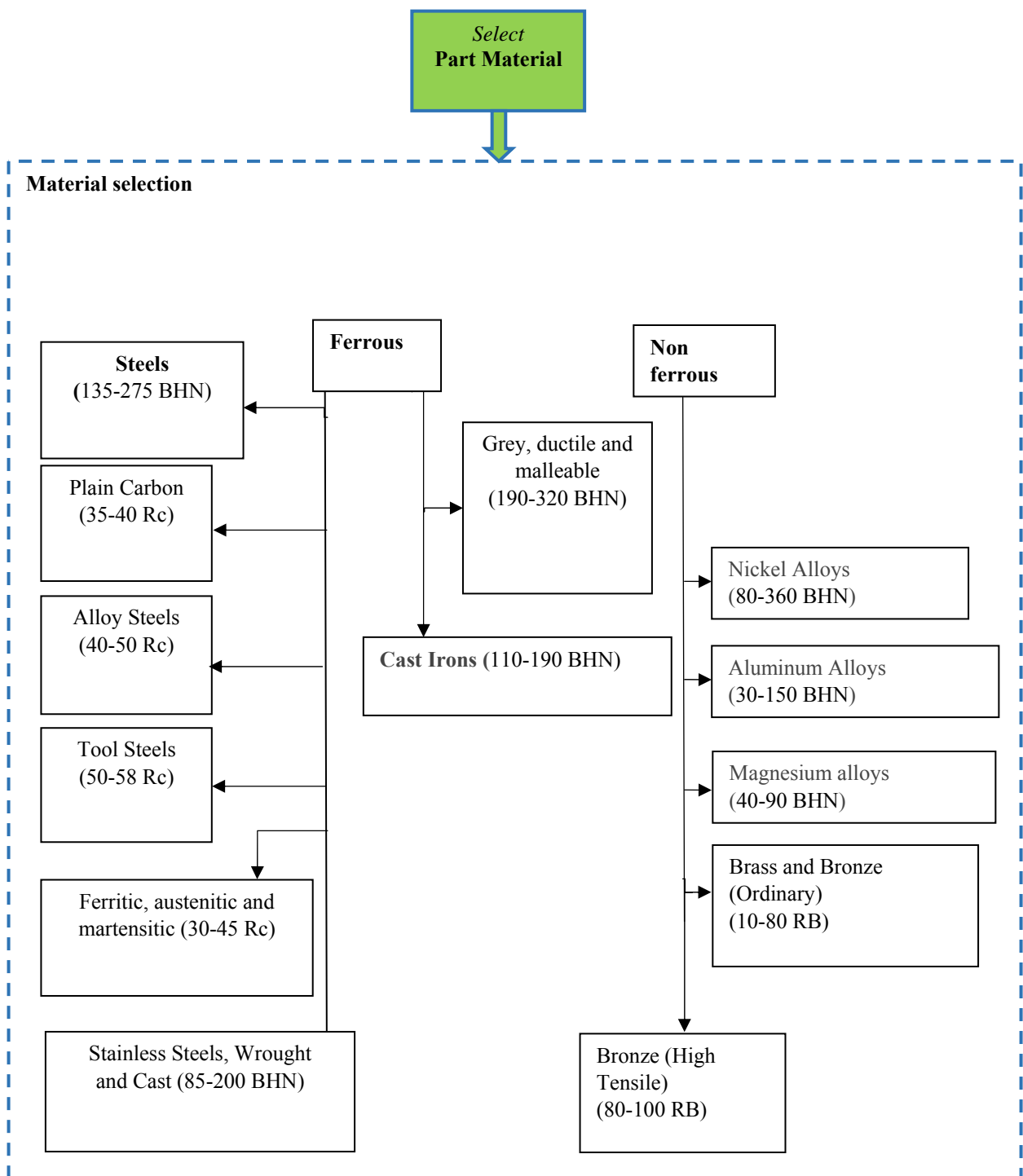


Fig.11 material selection

1. Highly demanded materials for machining in automation industries.

The 3^c-CAPP approach works on the various ferrous and nonferrous materials. The ferrous materials are limited to steel and cast and Iron. The nonferrous materials are aluminium, nickel, magnesium brass and bronze. The 3^c- CAPP does not work out if the material of it's beyond range. The most of the materials are selected based on their use in automated manufacturing industries.

Steels: The steel in a machinery industry and metal products industry each consume approximately 14% of the world consumption. Even transport sector (cars, trucks, aviation, shipbuilding, and rail) is the second. It is

anticipated that the global nickel consumption will grow at a Compound Annual Growth Rate (CAGR) of around 11% during 2015-2020.

Nickel: The global nickel market has witnessed large consumption in automated manufacturing industries.

Although consumption levels increased across the world in various industries that have high application of refined nickel, for instance, developed automotive and aerospace industries are raising the demand for the metal.

Brass & bronze: Most CNC milling machines (also called machining centres) are computer controlled vertical mills with the ability to move the spindle vertically along the Z-axis. This extra degree of freedom permits their use in 2.5D surfaces such as relief sculptures. Valves fitting and musical instruments etc., components are machined extensively.

Aluminium

Parts made of this popular metal include electronic device enclosures, containers, lids, handles, auto parts, aircraft parts, marine parts, and engine parts, cooking utensils, optical reflectors, lighting fixtures and medical devices.

X. SELECTION OF CORNER RADIUS

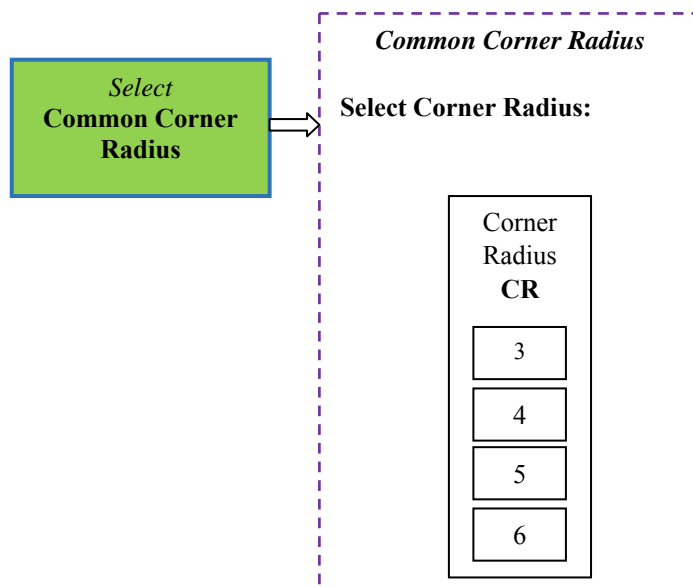


Fig.12 Corner radius selection

The selected Common Corner Radius assigned to a letter 'CR',

Step#1:

If CR = 3 then **Display 6 @ CMT_[R1, C3]**

Go to Step#5

Else; go to Step#2.

Step#2:

If CR = 4 then **Display: 8 @ CMT_[R1, C3]**

Go to Step#5

Else; go to Step#2.

Step#3:

If CR = 5 then **Display: 10 @ CMT_[R1, C3]**

Go to Step#5

Else; go to Step#2.

Step#4:

If CR = 6 then **Display: 12 @ CMT_[R1, C3]**

Go to Step#5

Else;

Do not display CMT.

End.

Step#5:

From MIC for material I pickup C_s, C_z

Display: $C_s @ CMT_{[R1, C6]}$

$C_z @ CMT_{[R1, C5]}$

Go to Step#6

Step#6:

From MIC for material I pickup P_m

Display: $[0.02*10*P_m*C_z] @ CMT_{[R1, C7]}$

Go to Step#7

Step#7:

Display: CMT

End.

1. Explanation of corner radius selection

Data flow from feature extraction and standard data charts for the preparation of corner mill table.

CMT preparation:

If corner radius '3' is selected then 6 is displayed @ $CMT_{[R1, C3]}$, same as 4, 5, 6 are selected 8, 10, 12 are displayed @ $CMT_{[R1, C3]}$ respectively. Speed and feed rates are selected from standard charts. Power requirements are computed and finally Corner mill Table [CMT] will be displayed.

11. Cutting tools & power necessities

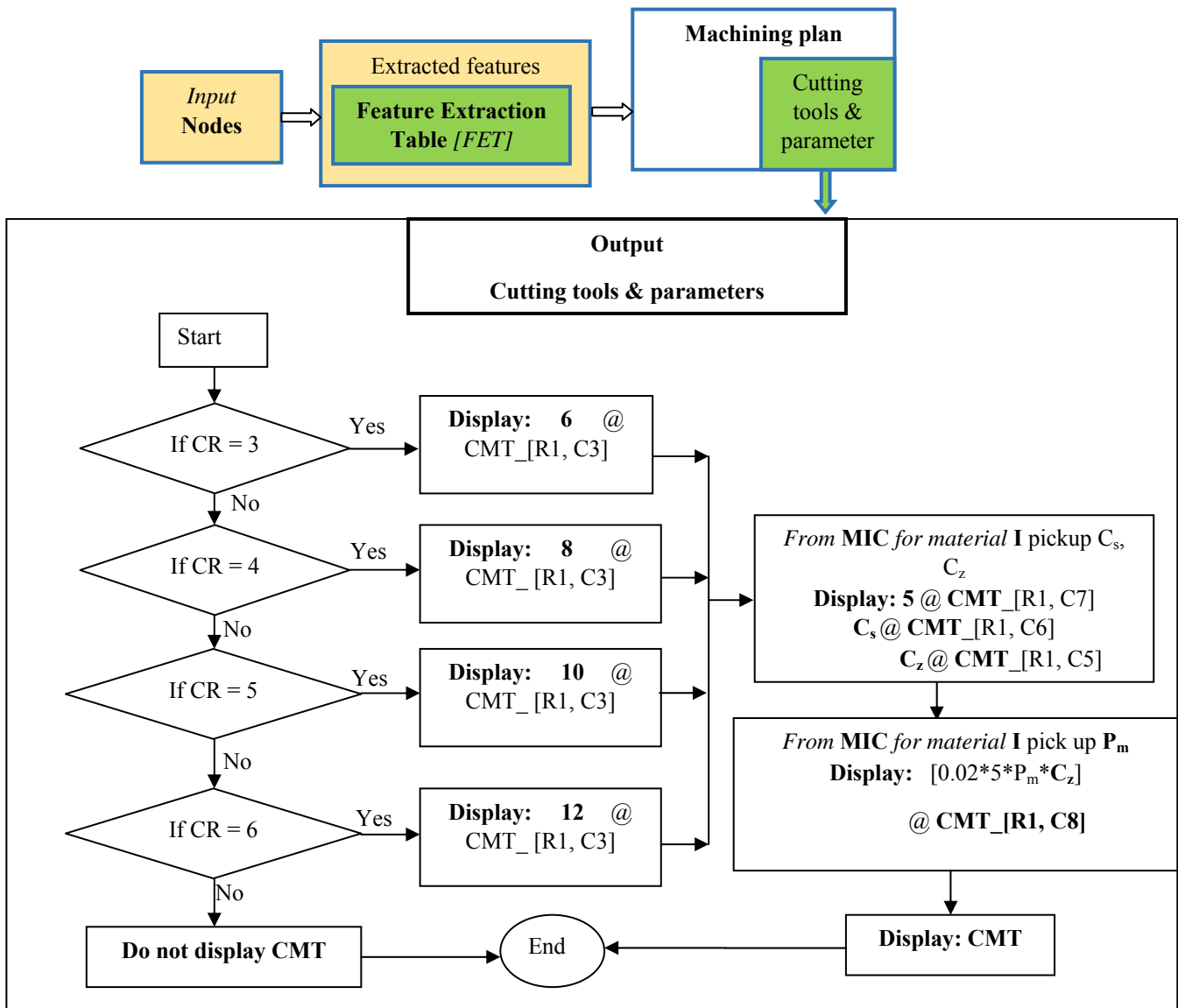


Fig.13 Flow chart for Cutting tools & Power requirement of corner mill

Corner end mill parameters table:

Table operating function ID: **CMT_[R1, CB]**, table call code **CMT**.

	C0	C1	C2	C3	C4	C5	C6	C7	C8
R0	S.No	milling cutter type	Milling cutter material	mill diameter mm	No. of flutes	Feed mm/min	Speed RPM	Depth of cut mm	Power required for milling KW
R1	1	Corner End mill	Carbide		3			5	

Table: 2 Model Cutting tools & Parameters for corner milling

XI. CUTTING PARAMETERS FOR DRILLING AND CIRCULAR INTERPOLATION

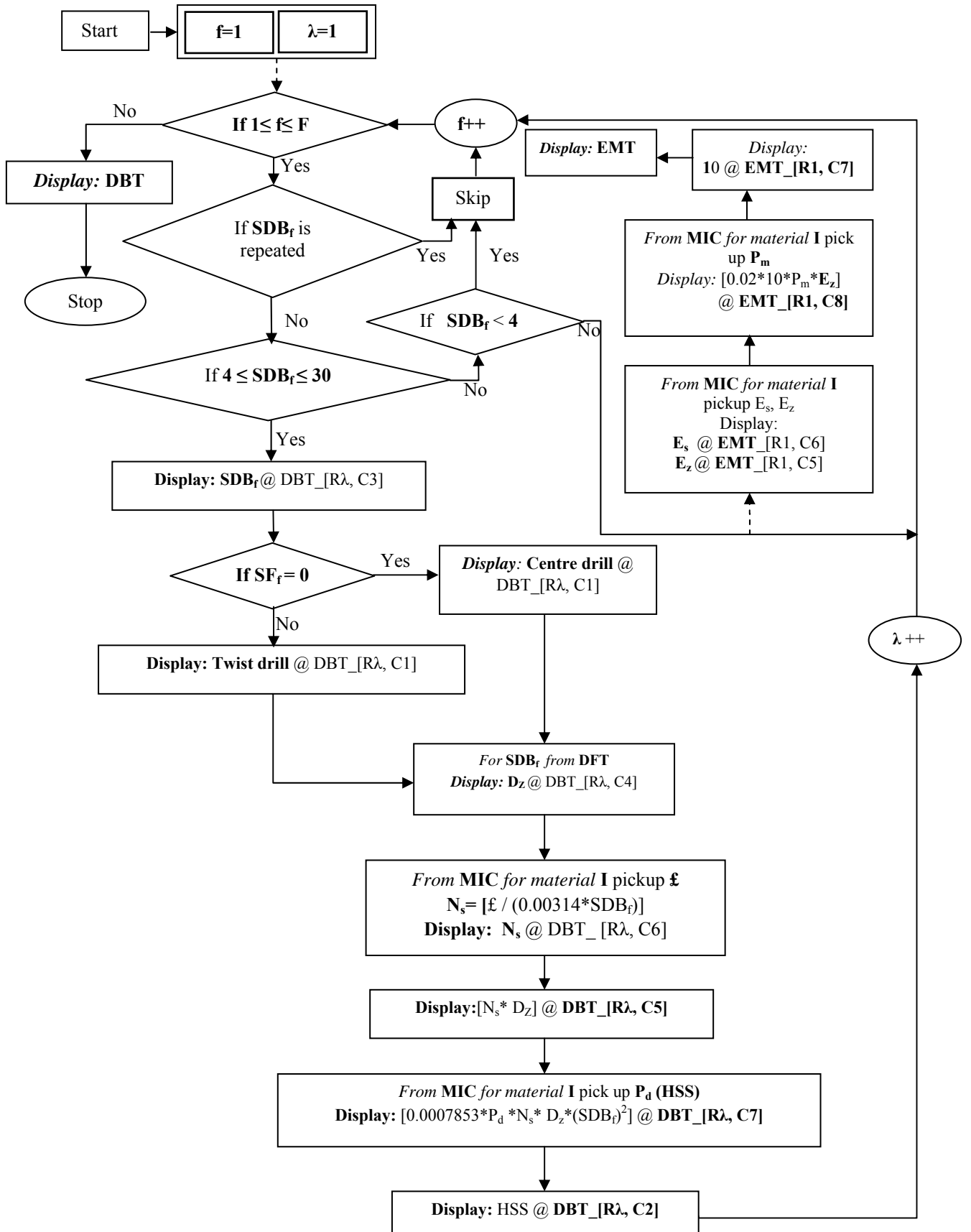


Fig.14 Flow chart for Cutting tools & parameters of circular-interpolation and drilling

Drill bit & power table:

Table operating function ID: **DBT**_[Rλ, CB], table call code **DBT**.

	C0	C1	C2	C3	C4	C5	C6	C7	
R0	S.no	Drill Bit type	Drill material	Drill diameter mm	Feed mm/rev D_z	Feed speed mm/min	Speed RPM N_s	Power required for drilling KW	
R1	1								

End mill & power table:

Table operating function ID: **EMT**_[Rλ, CB], table call code **EMT**.

	C0	C1	C2	C3	C4	C5	C6	C7	C8
R0	S.No	milling cutter type	Milling cutter material	mill diameter mm	No. of flutes	Feed mm/min E_z	Speed RPM E_s	Depth of cut mm	Power required for milling KW
R1	1	End mill	Carbide	20	4				

Table 3&4: Model Cutting tools & Parameters for Drilling & Circular interpolation

1. Explanation Cutting tools & Parameters

The selection of first feature represents $f=1$, then the predetermined row $\lambda=1$ is selected; the f value enters into the decision $1 \leq f \leq F$ if the condition is not satisfied a Drill Bit Table (DBT) is prepared and displayed.

If the above condition is satisfied, then it enters into the SDBM where, if SDB_f is repeated select once among the remaining values in the Standard Drill Bit Module (SDBM) then it skips to subsequent feature increment of $f++$ otherwise, enters $4 \leq SDB_f \leq 30$.

If $4 \leq SDB_f \leq 30$ is satisfied, $SDB_f @ DBT_ [R\lambda, C3]$ is displayed and consequently Drill bit table for a particular row (λ), is prepared then row increments and feature increments by 1.

if not, it checks the condition $SDB_f < 4$ if it is satisfied then it skips to subsequent feature increment of $f++$ otherwise, for single turn the logic generates and displays the End Mill Table, of course simultaneously increments the feature.

2. Algorithm for Cutting tools & power requirements

f=1, λ=1

Step#1

If $1 \leq f \leq F$

Go to Step#2

Else;

Display: DBT

End.

Step#2

If SDB_f is repeated

Go to Step#4

Else;

Go to Step#3

Step#3

If $4 \leq SDB_f \leq 30$, then Display: $SDB_f @ DBT_ [R\lambda, C3]$

Go to Step#6

Else;

Go to Step#4

Step#4

Skip

Go for **f** increment **f++**;

Go to Step#1

Step#5

If $SDB_f < 4$

Go to Step#4

Else;

For **single turn** only go to **Step#10**

Go for **f** increment **f++**

Step#6

If $SF_f = 0$

Display: Centre drill @ DBT_[Rλ, C1]

Go to Step#7

Else;

Display: Twist drill @ DBT_[Rλ, C1]

Go to Step#7

Step#7:

For SDB_f pick up D_z from **DFT**

Display: D_z @ DBT_[Rλ, C4]

Step#8:

From **MIC I** for material **I** pickup \mathcal{E}

$N_s = [\mathcal{E} / (0.00314 * SDB_f)]$

Display: N_s @ DBT_[Rλ, C6]

*Display: $[N_s * D_z]$ @ DBT_[Rλ, C5]*

Step#9:

From **MIC for material I** pickup P_d

*Display: $[0.0007853 * P_d * N_s * D_z * (SDB_f)^2]$ @ DBT_[Rλ, C7]*

Display: HSS @ DBT_[Rλ, C2]

Go for λ increment $[\lambda ++]$,

Go to Step#4

Step#10:

From **MIC for material I** pickup E_s, E_z

Display: E_s @ EMT_[R1, C6]

E_z @ EMT_[R1, C5]

From **MIC for material I** pickup P_m

*Display: $0.02 * 10 * P_m * E_z$ @ EMT_[R1, C8]*

Display: 10 @ EMT_[R1, C7]

Display: EMT

Go for **f** increment **f++**;

Go to Step#1

XII. CASE STUDY

Nodes: coordinates of the given features from 3'CAM technique

Material selection: Commercial Aluminum

Corner radius (CR): 3

Machining plan:

Operations: Drilling precedes milling

Cutting tools & power requirement:

Mock-up calculation:

Drilling: (HSS drill)

Surface speed for Al $\text{f} = 76.5 \text{ m/min}$, $\text{SDB}_4 = 12 \text{ mm}$,

Feed (mm/rev) $\text{D}_z = 0.2$

Drilling speed Ns (rev/min) = $[\text{f} / (0.00314 * \text{SDB}_f)]$

$\text{Ns} = [76.5 / (0.00314 * 12)] = 6067$

Feed (mm/min) = $\text{D}_z * \text{Ns} = 0.2 * 6067 = 404.4$

Unit power for Aluminum (HSS), P_d (KW/cm³/min) = 0.009

Drilling Power (KW) = $[0.0007853 * \text{P}_d * \text{N}_s * \text{D}_z * (\text{SDB}_f)^2]$

= $0.0007853 * 0.009 * 6067 * 0.2 * (12)^2$

= 0.411

Milling: (Carbide mill)

Surface speed for Al, (m/min) $\text{f} = 152.4$

Mill diameter (constant) mm = 20

Depth of cut mm = T (thickness of part) = 40

Milling Feed (mm/min) = $\text{E}_z = 1020$

Unit power for Aluminum (Carbide), P_m (KW/cm³/min) = 0.18

End Milling power (KW) = $[0.02 * \text{T} * \text{P}_m * \text{E}_z]$

= $0.002 * 10 * 0.18 * 497.53 = 1.79$

Corner mill diameter (mm) = 6

Depth of cut (constant) mm = 10

Unit power for Aluminum, P_m (KW/cm³/min) = 0.18

Corner Milling power (KW) = $[0.0006 * 10 * \text{P}_m * \text{C}_z] = 0.0006 * 5 * 0.18 * 1270$

= 1.3716

XIII. RESULT

Sr. No	Drill Bit type	Drill material	Drill diameter mm	Feed mm/rev D_z	Feed speed mm/min	Speed RPM Ns	Power required for drilling KW
1	Twist Drill	HSS	4	0.1	606.7	6067	0.0686
2	Twist Drill	HSS	6	0.1	404.5	4045	0.103
3	Twist Drill	HSS	12	0.2	404.4	2022	0.411
4	Twist Drill	HSS	11	0.2	441.2	2206	0.377

Sr. No	Milling cutter type	Milling cutter material	Mill diameter mm	No. of flutes	Feed mm/min	Speed RPM	Depth of cut mm	Power required for milling KW
1	End mill	Carbide	20	4	497.53	2449	10	1.79

Sr. No	milling cutter type	Milling cutter material	mill diameter <i>mm</i>	No. of flutes	Depth of cut <i>mm</i>	Feed <i>mm/min</i>	Speed <i>RPM</i>	Power required for milling <i>KW</i>
1	Corner End mill	Carbide	6	3	5	1270	8304	0.6858

Table 5, 6 & 7: Cutting tools & Parameters for the proposed part

XIV. CONCLUSION

In this paper, an efficient approach of machining plan has been presented using 3'C-CAPP approach. This is a simple, user friendly approach than some of those which had been proposed previously. All the modules that have been discussed here are basically output from so called 3'CAM technique and input to the 3'C-CAPP for an interactive G-CAPP system. The necessary data is collected from 3'CAM and other required inputs to generate well-organized machining plan for a proposed model. The most important four topics discussed in brief. The approach proposed here, the machining operations selection is done by 3'CAM. Not like the preceding publications we have not used an arduous task to generate operation sequences for machining a certain feature to minimize the cost. In the present approach, the thumb rules developed along the constraints for selection of features and machining operations. Finally, the two approaches have been applied, verified and approved for selected part.

XV. REFERENCE

- [1] Shirur, Arvind, Shah, Jami J., and Hirode, Kartheek. Machining Algebra for Mapping Volumes to Machining Operations for Developing Extensible Generative CAPP. *Journal of Manufacturing Systems*, 1998, 17(3), 167-182.
- [2] Qiao, Li-Hong, Yang, Zhi-Bing, Ben Wang, H.-P. A computer-aided process planning methodology. *Computers in Industry*, 1994, 25, 83-94.
- [3] Wang, K. An integrated intelligent process planning system for machining. *Journal of Intelligent Manufacturing*, 1998, 9, 503-514.
- [4] Yongtao, H. and Jingying, M. A knowledge-based auto-reasoning methodology in hole machining process planning. *Computers in Industry*, 2006, 57, 297-304.
- [5] Khoshnevis, B., Tan, W. Automated process planning for hole-making. *American Society of Mechanical Engineers, Manufacturing Review*, 1995, 8(2), 106-113.
- [6] Wong, T.N. and Siu, S.L. A knowledge based approach to automated machining process selection and sequencing. *International Journal of Production Research*, 1995, 33(12), 3465-3484.
- [7] Dana S. Nau and Tien-Chien Chang. Prospects for Process Selection Using Artificial Intelligence. *Computers in Industry* 1983, 4, 253-263
- [8] Eskicioolu, Hakki. The Use of Expert System Building Tools in Process Planning. *Engg. Applications Artificial Intelligence*, 1992, 5(1), 33-42.
- [9] Sabourin, L. and Villeneuve, F. OMEGA, an expert CAPP system. *Advances in Engineering Software*, 1996, 25, 51-59.
- [10] Jiang, B., Lau, H., Chang, F.T.S. and Jiang, H. An automatic process planning system for the quick generation of manufacturing process plans directly from CAD drawings. *Journal of Materials Processing Technology*, 1999, 87, 97-106.
- [11] Waiyagan, K. and Bohez, E.L.J. Intelligent feature based process planning for five-axis mill-turn parts. *Computers in Industry*, 2009, 60, 296-316.

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