An Intelligent feature based process planning for Rotational parts

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***Abstract*— This paper deals with the development of a software package which assists an automatic feature recognition technique to extract the geometrical features from the subsequent Standard for the Exchange of Product model Data (STEP) file which is generated using the 3D CAD model. The following aftermath is a crucial facet in downstream applications like- generation of process plans, part programs etc. A generalized Java code has been formulated to recognize the turning features of the previously extracted information regarding the rotating parts from the STEP file and henceforth this information is employed to effectuate a Computer Numerical Control (CNC) part programs using several logics. Furthermore, with the aid of a statistical technique called Response Surface Methodology (RSM), we optimize the acquired response and using the best combination of surface roughness and machining time, we generate the process plan. The authors present an example to demonstrate the application of the proposed methodology using CNC simulation software and its subsequent validation.**

Keywords—Geometric Data Extraction, Feature Recognition Rotational Parts, STEP standard, CNC Code Generation, Response Surface Methodology (RSM).

I. INTRODUCTION

In recent years, unique procedures have been elaborated by various researchers that give a detailed insight on the different aspects of integrating CAD and CAM. The extent of this integration is greatly influenced by the technique of Automatic Feature Recognition (AFR) from a CAD solid model which proves beneficial for downstream applications like process planning and NC program. The Standard for the Exchange of Product model Data (STEP) file has an eccentric ability to render a favorable generic representation of the simple and compound product data which demonstrates the features, geometries, topologies, and the manufacturing data corresponding to the CAD model. The algorithm for geometric data extraction from STEP file gives a detailed assessment of the geometry, including the normal and edge direction of the plane, which subsequently minimizes the complexity throughout the implementation of the turning feature recognition algorithm. This particular algorithm has the ability to recognize the exclusive features like Cylindrical, Toroidal, Conical, Threading, radial and axial holes etc, along with their attributes.

The generation of G&M codes from CAD DXF file leads to a pivotal loss of geometric information and this successive loss of data in turn has to be edited and compensated by the user. STEP is an international standard of a highly efficient geometric and non geometric data transfer between heterogeneous CAD, CAE and CAM systems and it very efficiently substitutes the previously used Initial Graphics Exchange Specification (IGES) and Drawing eXchange Format (DXF) files. This paper proposes an automatic feature recognition methodology to develop and generate a feature recognition system utilizing the STEP file. There are diverse STEP application Protocols such as AP203, AP214, AP224 etc., which can be employed for different applications. This paper exercises the AP203 protocol of the STEP file which deals with the configuration control in 3D design of mechanical parts and assemblies established on the Boundary representation (B-Rep) data. Henceforth, we give a detailed explanation regarding the simplified and generalized methodology of extracting manufacturing features like straight cylinder, right/left hand taper, convex, concave, grove, and thread information from STEP files. This method operates the acquired extracted feature information to generate CNC codes which are compatible with any FANUC controller..

There have been considerable researches on the feature recognition systems. Automated feature recognition has been an active research area in solid modeling for many years and is considered to be a critical component for integration of CAD/CAM. Over the years, many researchers studied the concept of extracting geometrical data by considering different CAD models in the standard format like Initial Graphics Exchange Specification (IGES), Data Exchange Format (DXF) and STEP file format. Because of its importance in CAD/CAM integration, the extraction of geometric features in a design/drawing database has received considerable attention since the mid-1970s.

Sreeramulu and C S P Rao [1] have present the model of their research effort which is intended to extract the geometric information of rotational parts from STEP file, and utilize this information to recognize the turning features. A turning feature is a very general term which often indicates certain non-unique shape characteristics that the desired part should possess, realized as a consequence of applying some manufacturing processes to the stock [2]. Liu *et.al.* [3] developed a framework and data processing for interfacing CNC with AP238, which represents one of the building blocks for tomorrow's manufacturing workstation. Sivakumar and Dhanalakshmi [4] developed a simplified and generalized methodology of extracting, manufacturing feature information from STEP files for cylindrical parts. The extracted data is used to generate controller dependent NC codes. Grezegorz Nikiel[5] has been developed automatic procedure for conversion of the rotating parts 3D model to the 2D model. In this approach the B-Rep model representation method is applied and a STEP file (ISO 10303:203) as the data carrier is used. Gao et al. [6] discussed conversion algorithm for coaxial hole-series machining feature based on the design feature model of gear box components. The planar-type machining features and non-geometrical attribute features are also studied. The converted machining features model can be transferred to process planning system using STEP file. Malleswaria and Sarcar [7] developed new feature recognition software for rotational parts which uses STEP file as input. The software analyses various strings and entities in the STEP file and extracts dimensional, geometric and topological information, including, EDGE_CURVE construction of surfaces, circle centers, radius of the circles, type of surfaces, surface radius and axis coordinates of surface. C. F. Tan, K. Ismail [8] presented a methodology for implementing the feature recognition system for achieving the Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) integration goals. Prakash et al [9] have been made to overcome problems by use of specially designed software. This software automatically generates CNC part programs, when the part geometry is defined. It reduces the time consumed by the operator to enter the program manually and also eliminate the programming errors. Jaider Oussama et al. [10] presented a new system of recognizing both isolated and interacting features for rotational parts taking STEP AP203 as an input to the system. The methodology works in three main phases. The first phase addresses extraction of geometric and topological information from STEP files. The second phase consists of analyzing the extracted geometric and topological data to recognize turning features. The third phase takes the recognized features as input to generate all possible combinations of interacting features. Nawara and Atia [11] presented a methodology of 3D prismatic parts classification based on the geometry of their machining features.

In this paper, the authentication of the efficiency of the approach is accomplished by performing a series of steps. Initially we develop a software package which aids in the extraction of all the geometrical features of a 3D CAD model which is represented in the form of a STEP file. The process of extraction is made possible with the help of feature recognition technique which supports the generated package. Subsequently, we formulate a JAVA code to recognize the turning features of the extracted information concerning the STEP file representing the 3D CAD model. The JAVA code is also designed for the generation of the CNC part program needed to construct the above considered 3D model. Following the formulation of the JAVA code, we make use of RSM which is a statistical technique that objectifies the optimization of a response (input variables) to generate a process plan. This process plan is generated by employing the best combination of surface roughness and machining time which is evaluated using the RSM technique. The values of the attributes hence obtained during the experimentation process are eventually compared with the values acquired from the JAVA code and the variation derived is expressed as the error attained which is revealed to be very minimal.

The paper has been categorized into the five sections. Section 2 describes in detail the proposed methodology employed to carry out the experiment. It proposes the geometric data extraction module, following which the extraction of the 3D model is carried out using JAVA code. This section is concluded by providing a comprehensive design of experiment which establishes a flow chart describing every step of the experiment. Further, Section 3 incorporates the designed JAVA code to recognize the turning features and to formulate a CNC part program required for the fabrication of the considered 3D model. Section 4 capitalizes the RSM technique to generate the process plan by carefully evaluating the best combination of values of the attributes (surface roughness and machining time). This section proceeds by making a thorough comparison between values of the attributes obtained from the JAVA code and the RSM technique. The comparison results provides us with error values associated with the variation acquired. The paper terminates with section 5, thus, proposing the future prospects related to this paper.

II. Proposed Methodology

In the following work, we consider the obtained STEP AP203 file of the 3D model as an input to the developed system. The afore mentioned developed system is demonstrated in Fig. 1 and it encompasses three modules, namely; Geometric data extraction module, feature recognition module and CNC part program generation module.

A. *Geometric Data Extraction Module*

The geometric data extraction algorithm can be articulated in the following steps.

Step1: Enter the work piece file name in .stp format and click the OK button as shown in Fig. 6.
Step2: Using Java code assign the following text field to different variables.

(a) CLOSED_SHELL
(b) CIRCLE
(c) CARTESIAN_POINT
(d) CONICAL_SURFACE
(e) TOROIDAL_SURFACE

(f) B_SPLINE_CURVE_WITH_KNOTS

Step3: Assign geometrical data (co-ordinate points) to different variables against line number & text (#32=CYLINDRICAL_SURFACE). Similarly assign all the fields to respective variables.

Step4: All the extracted data from STEP file will be stored in a separate file.

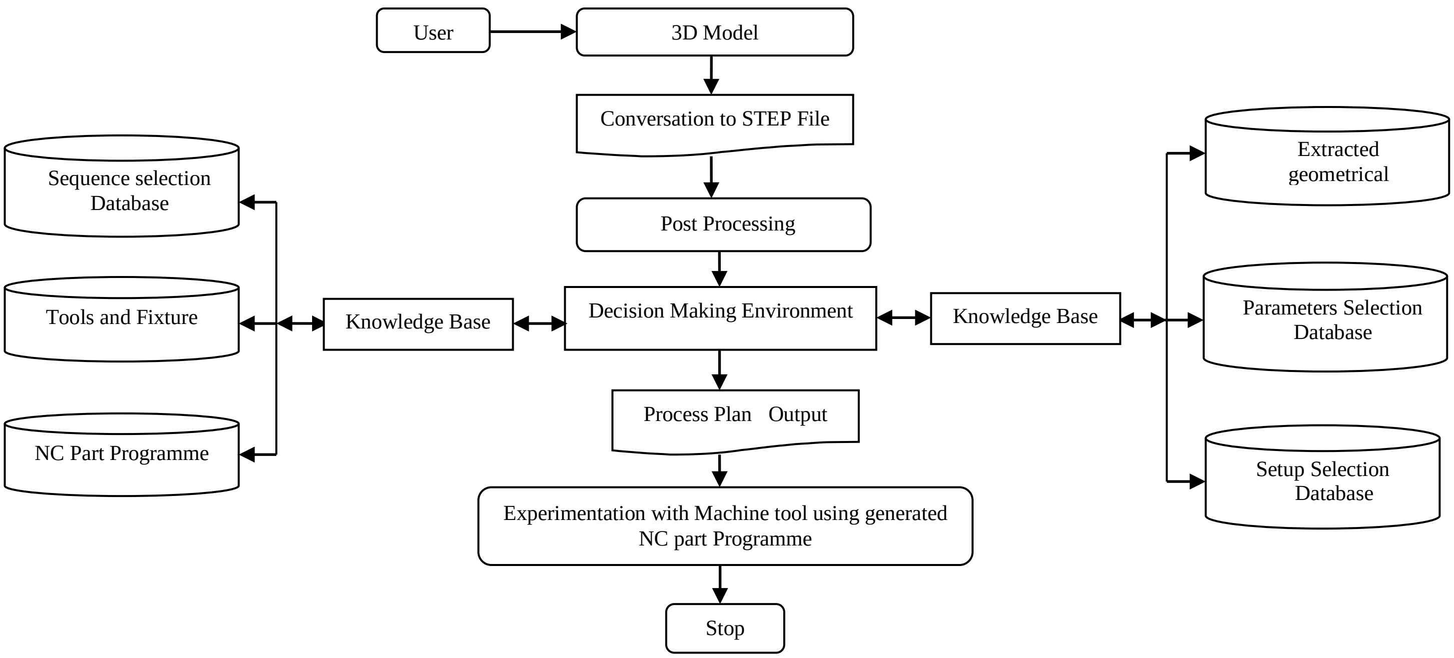
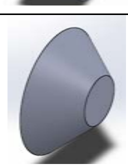
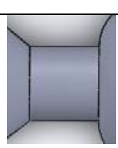
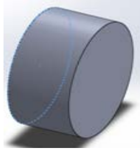


Fig. 1. Overview of the developed system

TABLE I. IDENTIFICATION OF FEATURES FROM STEP FILE

Feature	Feature model	STEP format	Geometrical data	Description
Plain Turning		#32=CYLINDRICAL_SURFACE('NONE', #13, 25.00); #2 = CIRCLE ('NONE', #73,25.00); #72=CIRCLE('NONE'#55,25.0); #30 = CARTESIAN_POINT('NONE',0.00, 0.00, 0.00)); #31=CARTESIAN_POINT('NONE',(30.00, 0.00,0.00)0;	Radius=25mm; Point1=(0,0,0); Point2=(30,0,0) Length=30mm	If the step file contains Cylindrical surface and radius is same at both ends then the feature is identified as Plain Turning. The length is distance between centres of end surfaces.
Right hand tapper turning		#79=CONICAL_SURFACE('NONE',#164,25.00,0.78); #41 = CIRCLE ('NONE', #93, 9.99) ; #115 = CIRCLE ('NONE', #60, 25.00); #138=CARTESIAN_POINT('NONE',(0.00,0.00,0.00)); #129=CARTESIAN_POINT('NONE',(15.00,0.00,0.00));	Major radius=25mm Minor radius=9.99mm Point1=(0,0,0) Point2=(15,0,0); Length=15mm	If the step data contains conical surface with major radius at left end then feature is identified as right hand tapper turning. The length of tapper is distance between end surfaces.
Groove		#14 = CYLINDRICAL_SURFACE ('NONE', #10, 10.00) ; #84 = CIRCLE ('NONE', #86, 10.00) #91 = CIRCLE ('NONE', #163, 10.oo) ; #6 = CARTESIAN_POINT ('NONE',(0.00,0.00,0.00)); #5 = CARTESIAN_POINT ('NONE',(15.00,0.00,0.00));	Radius=10mm Point1=(0,0,0) Point2=(15,0,0) Length=15mm	If the step file contains Cylindrical surface and radius is same at both ends and radius is less than the adjacent features then the feature is recognized as groove turning. the length of groove is distance between two end centres.
Convex contour turning		#15 = TOROIDAL_SURFACE ('NONE', #30, 9.99,15.00); #45 = CIRCLE ('NONE', #154, 10.00); #54 = CIRCLE ('NONE', #79, 24.99); #144 = CARTESIAN_POINT ('NONE', (0.00,0.00,0.00)); #75 = CARTESIAN_POINT ('NONE',(15.00,0.00,0.00)) ; #5 = CARTESIAN_POINT ('NONE',(0.00,0.00,10.00));	Minor radius=10mm; Major radius=24.99mm; Point1=(0,0,0); Point2=(15,0,0); Radius of curvature=10mm Length=15mm	If the step data contains Toroidal surface with minor radius at left end then the feature is identified as convex contour turning.

Plain Turning		#8 = CYLINDRICAL_SURFACE ('NONE', #122, 25.00) ; #78 = CIRCLE ('NONE', #125, 25.00) ; #83 = CIRCLE ('NONE', #119, 25.00) ; #93 = CARTESIAN_POINT ('NONE',(0.00,0.00,0.00)); #91 = CARTESIAN_POINT ('NONE',(25.00,0.00, 0.00));	Radius=25mm Point1=(0,0,0) Point2=(25,0,0) Length=25mm	If the step file contains Cylindrical surface and radius is same at both ends and the radius is equal to maximum value then feature is recognized as plain turning.
Concave contour turning		#129 = TOROIDAL_SURFACE ('NONE', #80, 25.00), #175 = CIRCLE ('NONE', #67, 25.00);#13 = CIRCLE ('NONE', #90, 9.99999999999994700); #51 = CARTESIAN_POINT ('NONE',(0.00,0.00, 0.00));#44 = CARTESIAN_POINT ('NONE',(15.00, 0.00,0.00)); #69 = CARTESIAN_POINT ('NONE', (15.00,0.00,25.00);	Major Radius=25mm Minor radius=9.99mm; Point1=(0,0,0) Point2=(15,0,0) Radius of curvature=25mm Length=15mm	If the step data contains toroidal surface with major radius at left side then the feature is identified as concave contour turning.
Groove Turning		48 = CYLINDRICAL_SURFACE ('NONE', #138, 5.00) ; #85 = CIRCLE ('NONE', #116, 5.00) ; #86 = CIRCLE ('NONE', #43, 5.00); #156 = CARTESIAN_POINT ('NONE'(0.00,0.00,0.00)); #171=CARTESIAN_POINT('NONE',(8.00,0.00, 0.00));	Radius=5mm Point1=(0,0,0) Point2=(8,0,0) Length=8mm	If the step file contains Cylindrical surface and radius is same at both ends and radius is less than the adjacent features then the feature is recognized as groove .the length of groove is distance between two end centres
Thread cutting		#99=B_SPLINE_CURVE_WITH_KNOTS ('NONE', 3,(#115, #187, #166,#127,#145,#185,#163, #132,#194,#155,#135,#128, #142,#159,#189,#114,#179, #118,#176,#182,#126,#143, #169,#149,#177,#112,#195, #119,#130,#148,#190,#131, #167,#199,#150,#122,#138, #183,#144,#117,#165,#178, #129,#139,#200); #498 = CARTESIAN_POINT ('NONE', (0.00,0.00, 0.00)); #784 = CARTESIAN_POINT ('NONE',(15.00,0.00, 0.00));	Pitch=3mm Point1=(0,0,0) Point2=(15,0,0) Length=15mm Radius=10mm	If the step data contains B spline curve with knots then feature is identified as threads. The length of threads is distance between two end surfaces.

B. Feature extraction

This step comprehends the development of Automatic Feature Recognition system which examines the extracted data, stating it as the input, and aids in recognizing features in accordance with certain pre specified rules that are uniquely characteristic to every feature. The turning features shown in Fig.2 are taken into account in the present research work.

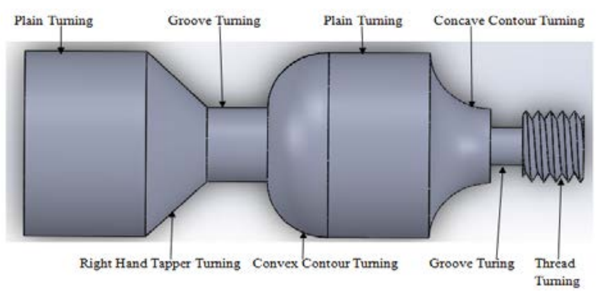


Fig. 2. Turning features of the developed system

A feature can be defined as acquired information analogous to a unique product description. It comprises geometrical data and eccentric attributes such as geometry and topology, configuration parameter, default values, location and orientation parameters, relations, constraints, composite features, symbolic or skeletal representation, feature validation and so on. A comprehensive method of identification of features is given in Table I.

C. Design of Experiment

The turning operation on work piece is carried under cutting conditions such as speed, feed rate, depth of cut and nose radius. These conditions are taken as the process parameters for a carbide cutting tool. RSM (Response surface metrology) is used for carrying out the experimental design with independent variables taking two levels from high to low. In RSM, Box-Behnken approach was used because there were four variables and their limits are known. The experiment is carried out on a aluminium work piece having 138mm length. The surface roughness of work piece is measured and tested using Mitutoyo surface tester. The machining time is observed by using stop watch and values were noted.

1) Response surface methodology **:**

The measurement of surface roughness and machining time values during turning operation, in relation with the independent variables such as speed, feed rate, depth of cut and Nose radius can be expressed mathematically as shown below:

$$\text{SurfaceRoughness}R_a = \frac{(0.032 \times f^2)}{r} \qquad (1)$$

$$MachiningTimeM_t = \frac{l}{s \times f} \times n_p \qquad (2)$$

Where, surface roughness(R_a) in µm, machining time(M_t) in minutes, spindle speed(s) in m/min, feed rate(f) in mm/rev, nose radius(r) in mm, lenth(l) in mm and number of passes(n_p). In machine cutting ,the linear relationship is used for representing a mathematical model :

$$G = \beta\ (s,f,d,r)$$

where s,f,d,r are cutting speed, feed, depth of cut and nose radius. Then G and β are response function.

The parameters and the levels are shown in the form of speed, feed, depth of cut and nose radius in table II.

The linear model equation for first order can be represented by:

$$G_1 = a_0x_0+a_1x_1+a_2x_2+a_3x_3+a_4x_4$$

where a_0,a_1,a_2,a_3,a_4 are parameters of model to be estimated using experimental data, x_0 is the dummy variable,x_1,x_2,x_3 and x_4 are speed, feed rate, depth of cut and nose radius.

$$G_2=a_0x_0+a_1x_1+a_2x_2+a_3x_3+a_4x_4+a_{12}x_1x_2+a_{23}x_2x_3+a_{14}x_1x_4+a_{24}x_2x_4+a_{13}x_1x_3+a_{34}x_3x_4+a_{11}x_1^2+a_{22}x_2^2+a_{33}x_3^2+a_{44}x_4^2$$

Where G_1, G_2 are the estimated response based on first and second order equations.

The output graphs for surface roughness and machining time are shown in Fig. 3. and Fig. 4.

TABLE II. PARAMETERS AND THE LEVELS

S.No	Independent Variables	Units	Levels	
			Low	High
1	Speed	m/min	300	600
2	Feed	mm/rev	0.2	0.4
3	Depth of cut	mm	0.6	0.8
4	Nose Radius	mm	0.4	1.2

a) surface_roghness

Final Equation in Terms of Actual Factors:

surface_roghness =
+3.70000E-007
-2.22222E-010 * speed
+7.66667E-006 * feed
+1.50000E-006 * depth
+5.41667E-007 * nose_radius

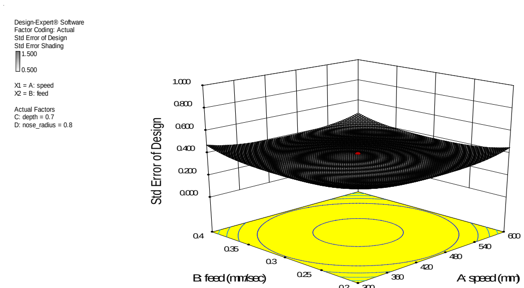


Fig. 3. Graph of the output values of surface roughness

a) machinning_time

Final Equation in Terms of Actual Factors:

machinning_time	=
+16.41406	
-0.025590	* speed
-38.38520	* feed
+0.87809	* depth
+0.062721	* nose_radius
+0.022580	* speed * feed
-3.40777E-017	* speed * depth
-3.17958E-018	* speed * nose_radius
+1.03707E-013	* feed * depth
+4.67668E-016	* feed * nose_radius
-1.35596E-014	* depth * nose_radius
+1.39380E-005	* speed^2
+31.36046	* feed^2
-0.62721	* depth^2
-0.039201	* nose_radius^2

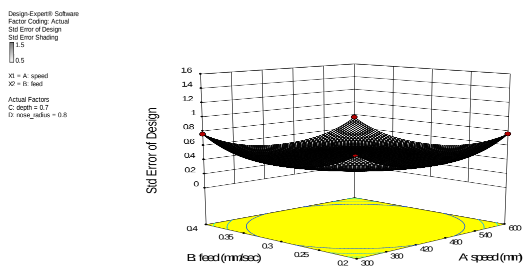


Fig. 4. Graph of the output values of machining time

III. EXPERIMENTATION

Here we can discuss thoroughly how to check the validity of the present software package. It discusses how the user makes use of the package for specific applications pertaining to feature recognition and NC code generation of axisymmetric turned components. With the help of following illustrative example, we can explain the procedure for recognition of features and CNC code generation for a typical axisymmetric component.

A. CNC part program

The different logics used to generate part programs are depicted in the flow chart shown in Fig. 5. The generated NC code will be stored in a separate file which will be sent to CNC machine for machining.

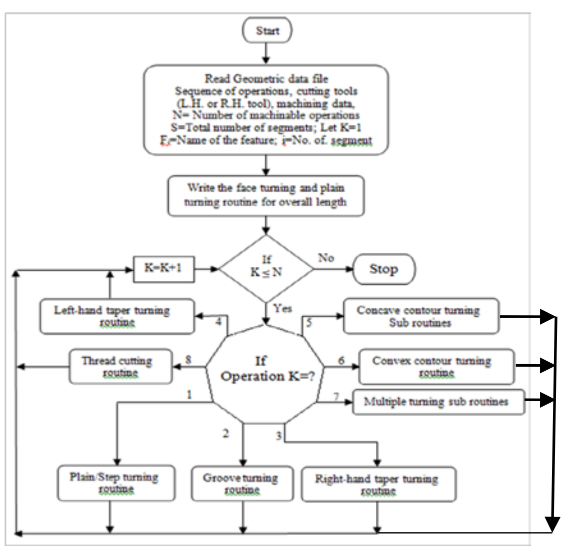


Fig. 5. Flow chart for CNC part program

B. Example 1

When this software is made to execute, it displays the main window as shown in Fig.6. First, enter the STEP file name of the example part work piece as shown in Fig.7. and click OK button, then the geometric data is extracted and assigned to the variables.

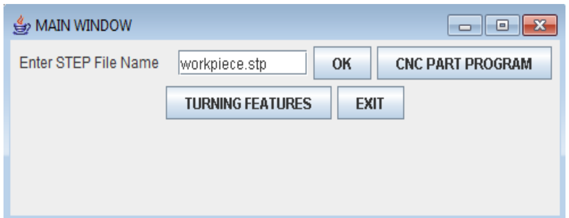


Fig. 6. Mainwindow

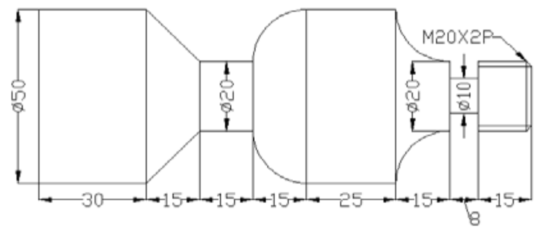


Fig. 7. Part model workpiece

Now click the turning features button then the turning features will be recognized and displayed as shown in Fig. 8.

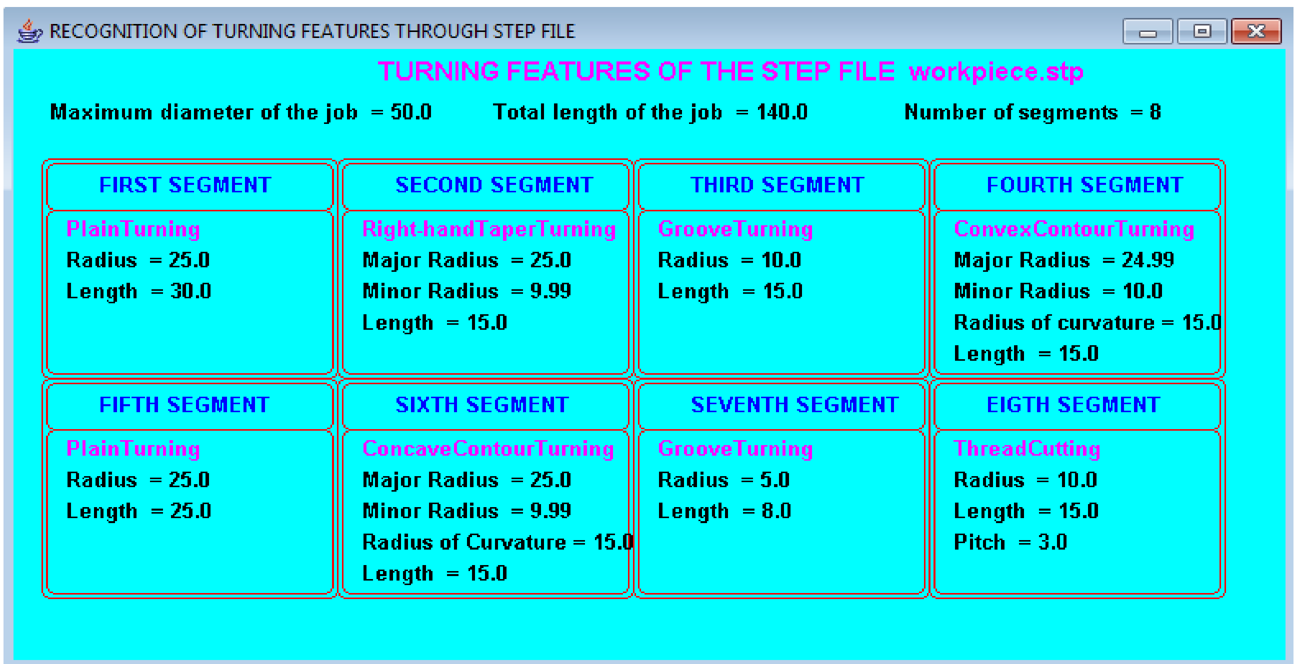


Fig. 8. Turning features of the work piece from left to right

By clicking CNC part program button, the developed software will generate and display a CNC code as shown in Table III.

TABLE III. SYSTEM GENERATED CNC PART PROGRAM

BILLET X55 Z142;	N180 G01 X20.11 F50;	N360 M03 S880;	N560 M06 T03;
N10 G21 G98;	N190 Z-24.83;	N370 G00 X50.0 Z-94.4;	N570 M03 S880;
N20 G28 U0 W0;	N200 G02 X50.0 Z-37.78 R15.37;	N380 G90 X50.0 Z-109.35 R0	N580 G00 X50.0 Z-79.45
N30 M06 T02;	N210 G70 P180 Q200 S1040 F25;	N390 F50;	N590 G01 X25.54 F50;
N40 M03 S920;	N220 G28 U0 W0;	N400 R-1.0;	N600 G02 X50.0 Z-64.78
N50 G00 X55 Z1;	N230 M06 T06;	N410 R-2.0;	R15.73;
N60 G94 X-1 Z-0.5 F55;	N240 M03 S584;	N420 R-3.0;	N610 G28 U0 W0;
N70 Z-1;	N250 G00 X20.11 Z-16.95;	N430 R-4.0;	N620 M06 T04;
N80 Z-1.5;	N260 G75 R1;	N440 R-5.0;	N630 M03 S240;
N90 Z-2;	N270 G75 X9.78 W-4.88 P100 N280	N450 R-6.0;	N640 G00 X20.11 Z1;

N100 G90 X54 Z-139.23 F50; N110 X53; N120 X52; N130 X51; N140 X50.0; N150 G00 X50.0 Z-2; N160 G71 U0.5 R1; N170 G71 P180 Q200 U0.1 W0.1 S1000 F50;	Q1500 F20; N290 G01 X50.0; N300 Z-79.45; N310 G75 R1; N320 G75 X20.11 W-11.95 P100 N330 Q1500 F20; N340 G28 U0 W0; N350 M06 T02;	N460 R-7.0; N470 R-8.0; N480 R-9.0; N490 R-10.0; N500 R-11.0; N510 R-12.0; N520 R-13.0; N530 R-14.0; N540 R-14.945; N550 G28 U0 W0;	N650 G92 X19.11 Z-16.95 F1.88; N660 X18.11; N670 X17.11; N680 X16.85; N690 G28 U0 W0; N700 M05; N710 M30;

C. Validation of the Developed of work.

In order to verify the developed methodology the extracted geometrical data through software package is verified with the actual dimensions of the work piece. Almost all the dimensions are accurate and the percentage error found is 0.1% as shown in the Table. IV. The generated CNC part programs also verified using simulation package and found a sequence of machining operations and finished part as per the required work piece shape and size as shown in Fig. 9.

TABLE IV. COMPARISON OF EXTRACTING DATA TO THE ORIGINAL DATA

Sl.No.	Extracted Feature	Parameter	Dimensions (mm)		Difference	Percentage
			Extracted	Orginal		error (%)
1	Plain Turning	Radius	25	25	0	0
		Length	30	30	0	0
2	Right hand Taper Turning	Major Radius	25	25	0	0
		Minor Radius	9.99	10	0.01	0.1
		Length	15	15	0	0
3	Groovr Turning	Radius	10	10	0	0
		Length	15	15	0	0
4	Convex contour turning	Major Radius	24.99	25	0.01	0.04
		Minor Radius	10	10	0	0
		Length	15	15	0	0
		Radius of curvature	15	15	0	0
5	Plain Turning	Radius	25	25	0	0
		Length	25	25	0	0
6	Concave contour turning	Major Radius	25	25	0	0
		Minor Radius	9.99	10	0.01	0.01
		Length	15	15	0	0
		Radius of curvature	15	15	0	0
7	Groovr Turning	Radius	5	5	0	0
		Length	8	8	0	0
8	Thread Cutting	Radius	10	10	0	0
		Length	15	15	0	0
		Pitch	3	3	0	0

TABLE V. ACTUAL AND EXPERIMENTAL VALUES FOR VARIOUS PARAMETERS

S.No	Speed (m/min)	Feed (mm/rev)	Depth of cut (mm)	Nose radius (mm)	Actual		Experimental		Difference		Error(%)	
					Surface Roughness (µm)	Machining time (min)	Surface Roughness (µm)	Machining time (min)	Surface Roughness (µm)	Machining time (min)	Surface Roughness	Machining time
1	600	0.2	0.7	0.8	1.6	2.71	1.6016	2.7127	-0.0016	-0.0027	0.1	0.1
2	300	0.3	0.7	1.2	2.4	3.61	2.3800	3.6063	0.0020	0.0037	0.1	0.1
3	450	0.2	0.7	1.2	1.0	3.61	1.0020	3.6100	-0.0020	0.0000	0.2	0.0
4	450	0.3	0.7	0.8	3.6	2.40	3.6040	2.4021	-0.0040	-0.0021	0.1	0.09
5	600	0.3	0.8	0.8	3.6	1.81	3.5960	1.8118	0.0040	-0.0018	0.1	0.1
6	450	0.3	0.6	0.4	7.2	2.41	7.2072	2.4124	-0.0072	-0.0024	0.1	0.1
7	450	0.4	0.8	0.8	6.4	1.81	6.3940	1.8136	0.0060	-0.0036	0.09	0.2
8	450	0.2	0.8	0.8	1.6	3.61	1.6016	3.6100	-0.0016	0.0000	0.1	0.0
9	300	0.3	0.7	0.4	7.2	3.61	7.1930	3.6100	0.0070	0.0000	0.09	0.0
10	450	0.3	0.8	1.2	2.4	2.41	2.4048	2.4148	-0.0048	-0.0048	0.2	0.2
11	600	0.3	0.6	0.8	3.6	1.81	3.6039	1.8118	-0.0039	-0.0018	0.1	0.1
12	450	0.3	0.6	1.2	2.4	2.41	2.4049	2.4121	-0.0049	-0.0021	0.1	0.09
13	450	0.2	0.7	0.4	3.2	3.61	3.2000	3.6063	0.000	0.0037	0.0	0.1
14	300	0.4	0.7	0.8	6.4	2.71	6.3938	2.7127	0.0062	-0.0027	0.1	0.1
15	450	0.4	0.7	0.4	12.8	1.81	12.8256	1.8136	-0.0256	-0.0036	0.2	0.2
16	450	0.4	0.7	1.2	4.26	1.81	4.2642	1.8100	-0.0042	0.0000	0.1	0.0
17	450	0.4	0.6	0.8	6.4	1.81	6.3940	1.8116	0.0060	-0.0016	0.09	0.09
18	450	0.3	0.7	0.8	3.6	2.41	3.5960	2.4124	0.0040	-0.0024	0.1	0.1
19	300	0.3	0.8	0.8	3.6	3.61	3.5960	3.6208	0.0040	-0.0108	0.1	0.3
20	300	0.3	0.6	0.8	3.6	3.61	3.5959	3.6100	0.0041	0.0000	0.1	0.0
21	600	0.3	0.7	0.4	7.2	1.81	7.2000	1.8081	0.000	-0.0081	0.0	0.1
22	300	0.2	0.7	0.8	1.6	5.42	1.6016	5.3766	-0.0016	0.0234	0.1	0.08
23	600	0.3	0.7	1.2	2.4	1.81	2.4000	1.8100	0.000	0.0000	0.0	0.0
24	600	0.4	0.7	0.8	6.4	1.35	6.3938	1.3513	0.0062	-0.0013	0.1	0.1
25	450	0.3	0.8	0.4	7.2	2.41	7.2000	2.4075	0.000	0.0925	0.0	0.1
26	450	0.3	0.7	0.8	3.6	2.41	3.6040	2.4075	-0.0040	0.0925	0.1	0.1
27	450	0.2	0.6	0.8	1.6	3.61	1.6014	3.6136	-0.0014	-0.0036	0.09	0.1
28	450	0.3	0.7	0.8	3.6	2.41	3.6040	2.4075	-0.0040	0.0925	0.1	0.1

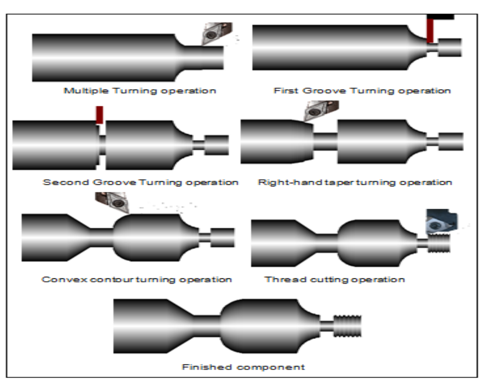


Fig. 9. Final Workpiece

IV. CONCLUSIONS

The present software accelerates the extraction and recognition of the external turning features associated with the 3D model and the generation of a CNC part programs for axisymmetrical components. A Generalized logic is employed to extract geometrical data from the STEP file and subsequently recognize the turning features. This information is sent to the next module where a JAVA code is implemented to generate the CNC part programs. The process is fabricated in an automated manner in order to reduce human interference so that we can obtain minimal human errors during the manual part programming. The designed system facilitates reduction of overall lead time and distinctly enhances the efficiency of the machining process. In the devised part program module, the system generates the CNC code and stores it in a file which is sent to the CNC lathe for executing the machining operation of the component. The previously generated NC code is analyzed for a diverse variety of external features of axisymetric components in MTAB and the results are found to be satisfactory. The designed system is limited to experimentation analogous to rotational components.

REFERENCES

[1] Sreeramulu, D., Rao, C. S. P.: A new methodology for recognizing features in rotational parts using STEP data exchange standard. In.: International Journal of Engineering, Science and Technology, Vol. 3, No. 6, pp. 102-115 (2011)

[2] Li, S. and Shah J.J.: Recognition of user-defined turning features for Mill/Turn parts. In.: Journal of Computing and Information Science in Engineering, Vol.7, pp.225-235(2007)

[3] Lee, H and Han, S.: Reconstruction of 3D interacting solids of revolution from 2D orthographic views. In.: Computer-Aided Design, Vol. 37, pp. 1388-1398 (2005)

[4] Sivakumar,S and Dhanalakshmi, V.:A feature-based system for CAD/CAM integration through STEP file for cylindrical parts. In.: Indian journal of Engineering and Material sciences. Vol. 20., pp. 21-26 (2013)

[5] Grzegorz Nikiel, : Geometrical data Extraction of Axisymetric parts from the B-Rep models. In.: Advance in Manufacturing Science and Technology, Vol.35, No.2 (2010)

[6] Gao, J, Zheng, D.T and Gindy, N.: Extraction of machining features for CAD/CAM integration, In.:International Journal of Advanced Manufacturing Technology (2004).

[7] Malleswari, A, V. N., Valli, P. M., Sarcar, M M M., :Automatic Recognition of Machining Features using STEP Files. In.: International Journal of Engineering Research and Technology (IJERT) Vol. 2 Issue 3(2013)

[8] Chee Fai Tan, Kher, N, Ismail, K.: Design of a Feature Recognition System for CAD/CAM Integration World Applied Sciences Journal 21 (8): 1162-1166(2013)

[9] Prakash, M., Hariharan, P. and Kanthababu. M.: Automation in CNC Code Generation and Tool Path Optimization for Micro-milling Machine.In.: international journal of innovative research and development Vol 3 Issue 5 pp. 447-454(2014)

[10] Jaider Oussama, Elmesbahi Abdelilah, Rechia Ahmed.: Manufacturing Computer Aided Process Planning For Rotational Parts. Part 1: Automatic Feature Recognition From STEP AP203 Ed2. In.: Int. Journal of Engineering Research and Applications Vol. 4, Issue 5(Version 6), pp.14-25(2014)

[11] Nawara, G ELBaz, A., Attia, A. M.,: Parts Classification Based on Solid Model and Neural Networks, In.: Contemporary Engineering Sciences, Vol. 3, no. 8, 395 – 417(2010).

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