Computing Cutting Time in Turning Operation Based on AutoCAD Drawings.

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Abstract

In view of importance the cutting time, it is considered one of the most important factors in different machining processes where it affects production time, cycle time, and product cost consequently. This research aims to build up a system for computing cutting time in turning operations from AutoCAD drawings. The proposed system has been built using Visual Basic programming language and interfacing it with AutoCAD by Visual Basic for Application (VBA) Technique. The system is able to compute cutting time from the drawings according to the color of each solid entity; these colors were defined previously in the system. They are related to the type of turning operation (external, internal, and facing turning operations) as well as the rough and finish machining operations. The system was examined with two models, and it was accurate and efficient. It is possible consideration the proposed system step toward the integration between CAPP/CAM systems.

Keywords: *Cutting Parameters, Cutting Time, CAD, CAM, CIM and VBA with AutoCAD*

1. Introduction:

Turning is the primary operation in most of the production processes in the industry. In this operation, it is an important task to select cutting parameters for achieving high cutting performance. The cutting parameters that determine the rate of metal removal and cutting performance are the cutting speed, the feed rate, and the depth of cut. These cutting conditions and the nature of the material to be cut determine the power required to take the cut. On the other hand these parameters are influential on production cost, machining time and quality of the final product. The cutting conditions must be adjusted to stay within the power available on the machine tool to be used. The selection of cutting parameters is difficult [1-4]. The optimum selection of cutting conditions will lead to reduce the production cost, reduce the production time, and improvement of the product quality [5].

The first step in establishing the cutting conditions is to select the depth of cut. The depth of cut will be limited by the amount of metal that is to be machined from the workpiece, by the power available on the machine tool, by the rigidity of the workpiece and the cutting tool, and by the rigidity of the setup. The depth of cut has the least effect upon the tool life, so the heaviest possible depth of cut should always be used. The second step is to select the feed. The available power must be sufficient to make the required depth of cut at the selected feed. The maximum feed possible that will produce an acceptable surface finish should be selected. The third step is to select the cutting speed. However, in general, the depth of cut should be selected first, followed by the feed, and last the cutting speed [1].

The production time includes cutting time, tool change time, fixturing time, handling time, and the time during which the tool does not cut (tool approach time and tool return time). This work focuses on cutting time only depending on AutoCAD drawing using Visual Basic for Applications, (VBA).

Visual Basic for Applications (VBA) was considered the logical choice for automating the AutoCAD application because it is a Microsoft Windows development environment. In AutoCAD VBA can be used to programmatically control the creation and editing of individual drawing objects, manipulate line types and layers, control text and dimensional styles, and much more [6].

There are four advantages to implementing VBA for AutoCAD [7]:

VBA and its environment are easy to learn and use.

VBA runs in-process with AutoCAD. This translates to very fast program execution.

Dialog box construction is quick and effective. This allows developers to prototype applications and quickly receives feedback on designs.

Projects can be standalone or embedded in drawings. This choice allows developers great flexibility in the distribution of their applications.

There are several researches have used VBA as a tool to automat drawings and extracting objects information. The present work is related to this field.

2. Cutting Time Calculation

The cutting time depends on the following principles machining parameters:

Cutting length
Feed rate
Cutting speed
Depth of cut

The time required to turn a length of metal (i.e. one pass) can be determined by the following formula[1]:

$$T_c = L / f \,.\, N \qquad (1)$$

Where:
Tc: cutting time in minutes,
L : length of cut in millimeters,
f : feed in mm per revolution, and
N : lathe spindle speed in revolutions per minute.

The total cutting time is computed based on the number of passes according to the featured drawing as shown in Fig. 1 and the following equations are used.

$$R_{diff} = (D_i - D_f) / 2 \qquad (2)$$

$$P_{No} = R_{diff} / a_c \qquad (3)$$

$$T_t = T_c \,.\, P_{No} \qquad (4)$$

Where:
Di : initial diameter of workpice
Df : final diameter of workpice
PNo : number of passes
ac : depth of cut
Tt : total cutting time

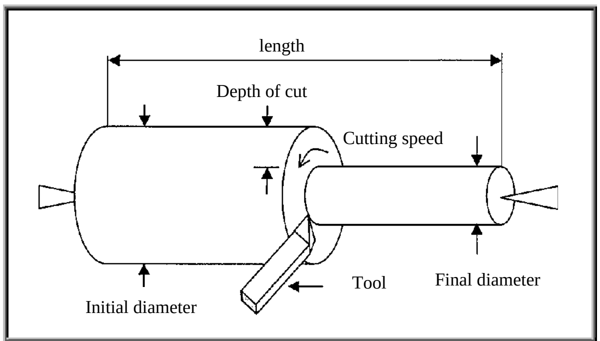

Figure (1) Turning part machining

3. The Proposed Methodology

The proposed system had been built using Visual Basic programming language and interfacing it with AutoCAD using Visual Basic for Application (VBA) Technique. This technique allows opening drawing file and makes any operation like creating drawing objects or getting drawing objects information and control the drawing file programmatically.

As mentioned in advance, the time computed during the turning operation is the cutting time only that is used to remove chip from the base shape to form the required shape (drawing), and the times which are consumed for replacing the cutting tools, setup, handling time, and tool movements without cutting have been excepted from the total time for machining operation.

Obviously, time calculation depends on the design of the part (i.e. depends on the AutoCAD drawing), the right choice of cutting conditions, sequencing of operations, and number of setup selection. The designer can specify the operation required for any region in the part, through drawing this region with associated color defined in the program. These colors are designated in this work as shown in Table 1.

Table (1) The color designated with each operation

Color	Color name	Associated operation
	Magenta	Facing
	Red	External Turning (initial dimension)
	Blue	External Turning rough (final dimension)
	Cyan	External Turning (finishing dimension)
	White	Internal Turning (initial dimension)
	Green	Internal Turning rough (final dimension)
	Yellow	Internal Turning (finishing dimension)

The prepared program for this purpose is able to extract entities information (dimensions and colors) from the drawing. The dimensions include diameter and length. Depending on colors, the program will classify each entity with its associated color operation, and when the classification is completed, the objects (entities) will be sort according to the Z order (third direction), and then the program selects the datum surface (Reference point) artificially according to the maximum compensations of operations.

The program shows the final result which is the cutting time (for each operation; facing, external … etc) that is divided into rough machining time, finish machining time, and summation of their times. As a final result, the total time for all operations will appear on the main application form of the program. These times are computed as shown in the following steps:

3.1 Facing Turning Operation

The equation that is used to determine the facing turning operation time is:

$$T_F = L_F / f_F \,.\, N_F \tag{5}$$

Facing turning operation can be completed with one pass.

3.2 External Turning Operation

3.2.1 For Rough Machining

The difference value between diameters (initial diameter and final diameter) which are distinguished by colors as shown in Fig.2 for rough machining is calculated from:

$$(D_r - D_b) / 2 = R_{dR} \tag{6}$$

Where:
Dr: initial diameter for rough machining (mm) as shown in Fig. 2A.
Db: final diameter for rough machining (mm).
RdR: difference in diameters.

The cutting time for machining one pass is calculated from:

$$T_P = L_R / f_R \,.\, N_R \quad \text{(min)} \tag{7}$$

Number of machined passes depends on depth of cut which can be calculated as below:

$$\text{No. of passes (K)} = R_{dR} / a_R \tag{8}$$

Where:
aR: depth of cut (mm).

Then the total cutting time for rough machining is computed from the following equation:

$$T_R = K \,.\, T_P \tag{9}$$

Where: TR is the rough machining time.

3.2.2 for Finish Machining

Computing the difference value between diameters in finishing machining is occurred using the same eq. (3) but the colors are different as shown below:

$$(D_b - D_c) / 2 = R_{dF} \tag{10}$$

Where:
Db: initial diameter for finishing machining as shown in Fig. 2B.
Dc: final diameter for finishing machining.
RdF: difference in diameters.

Finally the total cutting time used to perform external turning operation is computed from the following equation:

$$T_E = T_R + T_F \tag{11}$$

Where: TE is the total time of cut.

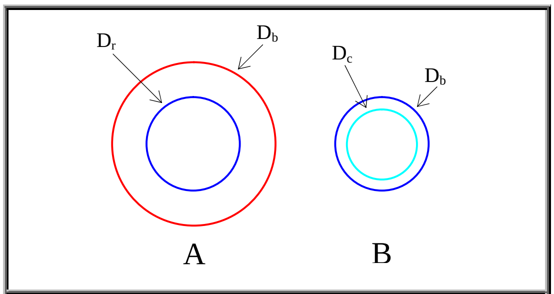

Figure (2) Diameters according to colors.

3.3 Internal Turning Operation

To determine the cutting time of the internal turning, the same way is followed that is used in external turning operation. The colors which are used in this operation are different where white, yellow, and green colors have been used. Also the rough and finish machining were performed in this operation.
The proposed algorithm supports full Object Oriented Programming (OOP) Technique so it consists of many classes. These are described below:

1. CACAD class:
This class handles the interface between Visual Basic program and AutoCAD package. It contains all codes that deal with open drawing file, creating new drawing objects, reading the existing objects and extract the required information from each drawing object.

2. CEntity class
After extracting the required information from each drawing object, the program will create objects from this class type to store the information in the created objects. The number of created objects of this class type must equal to the number of drawing objects.

3. COperation class
This is a base class of the turning operations that contains the functions shared in all operation.

4. CFacing class
This is inherited class from the COperation class that contains the functions specific for the facing operation

5. CExternal Turning class
This is inherited class from the COperation class which contains the functions specific for the facing operation.

6. CInternal Turnning class
This is inherited class from the COperation class, and contains the functions specific for the facing operation.

7. CClassifiction class
This class has functions to classify the type of each operation according to the entity colors and creates number of objects from the operation class type (CFacing, CIntuernalTurning, and CExternalTurning).

The flow chart of the proposed algorithm is shown in Fig. 3

4. Application and Results

In the present work, two models have been concerned. The first model is featured drawing and the second is non – featured as shown in Fig.4 and Fig.5 respectively.

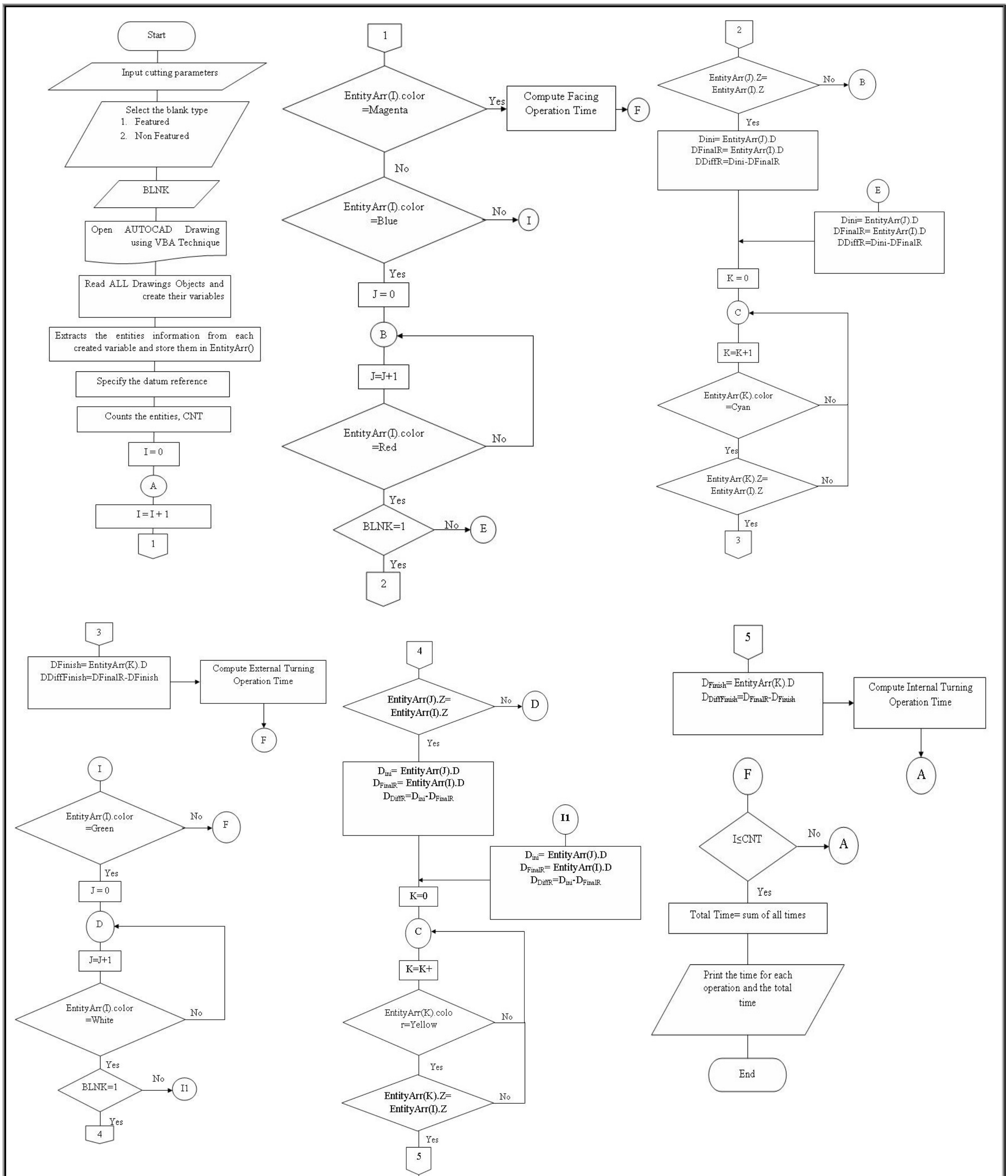

Figure (3) the flow chart of the suggested system.

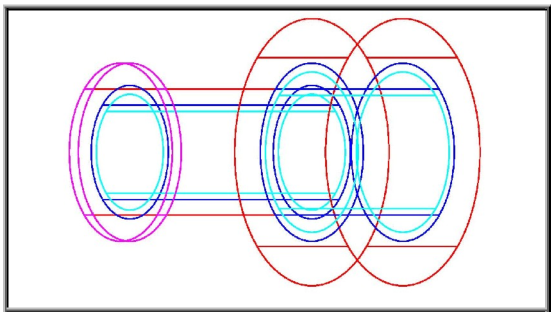

Figure (4) Featured drawing model.

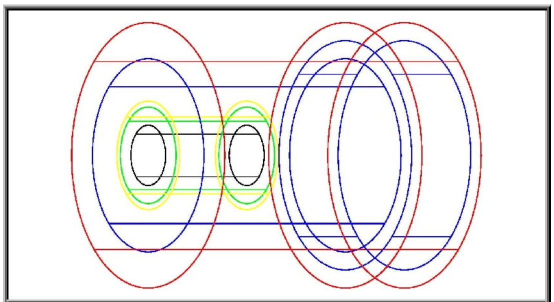

Figure (5) Non-featured drawing model.

The system was applied, where two case studies are considered as shown in details below:

4.1 Case Study 1

The model shown in Fig.4 is featured drawing and it contains the processes (facing and two external turning operations). The drawing objects will be read by the program, and are displayed their information in a tabulated form as shown in Table 2.

Table (2) Information extracted from drawing programaticly

No. of entities	Color	Length (mm)	Diameter. (mm)	Process type	Z – Coor.
1	Magenta	5.0	80.0	facing	0.0
2	Cyan	50.0	72.0	Ext. turning	105.0
3	Blue	50.0	80.0	Ext. turning	105.0
4	Red	50.0	120.0	Ext. turning	105.0
5	Cyan	100.0	52.0	Ext. turning	5.0
6	Blue	100.0	60.0	Ext. turning	5.0
7	Red	100.0	80.0	Ext. turning	5.0

Datum surface (Reference point) is determined in automatically way on Z - coordinate depending on facing operation. The cutting time is computed for each operation, and the total time is the resultant of times all operations. The results are showed as shown in Table 3.

Table (3) Results of program

No.	Process type	Z – Coor.	Length (mm)	Time (Rough)	Time (Finish)	Time (Total)
1	facing	0.0	5.0	0.05	-	0.05
2	Ex. turning	5.0	100.0	5.0	23.86	28.86
3	Ext. turning	100.0	50.0	5.0	11.43	16.43
					Total cutting time (min) :	45.34

The program's Graphical User Interface (GUI) is designed as shown in Fig. 6 where the results are appeared on it. The final product (machined part) after computing cutting time will be as shown in Fig. 7.

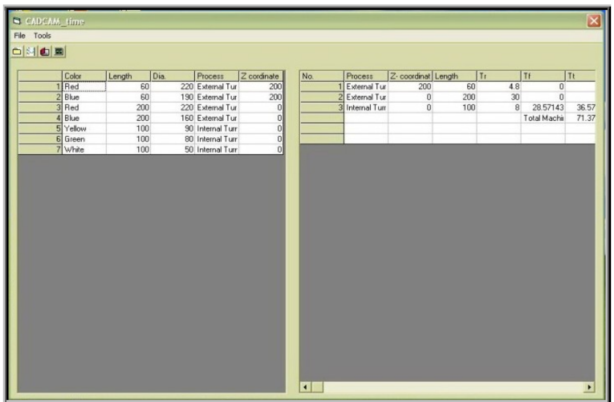

Figure (6) Graphical user interface.

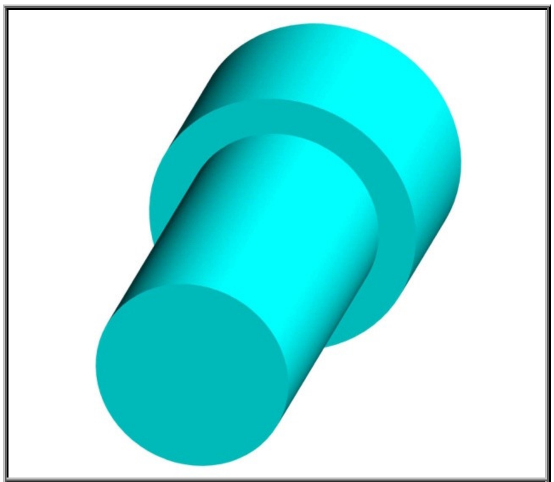

Figure (7) the final product for case study 1.

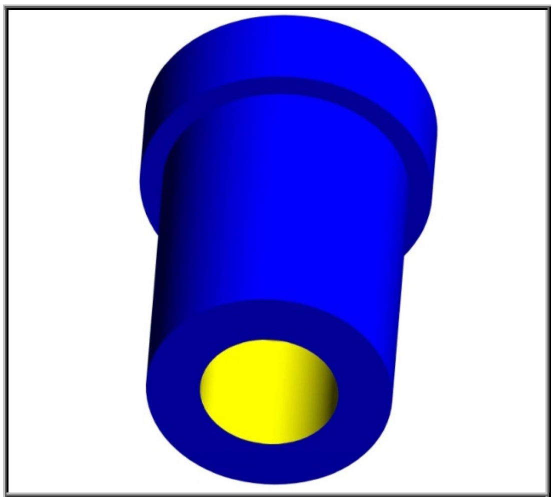

Figure (8) the final product for case study 2.

4.2 Case Study 2

The model that is referred in Fig. 5 is non-featured drawing and it has two external turning operations and one internal. In reference to these operations, the program extracts the information shown in Table 4 and labels it in the left side of (GUI). The output results that represent cutting time for each operation and the total time are shown in Table 5. The final drawing produced from the applying is appeared in Fig. 8.

Table (4) Information extracted from drawing programaticly

No. of entities	Color	Length (mm)	Diameter (mm)	Process type	Z – Coor.
1	Red	60.0	220.0	Ext. turning	200.0
2	Blue	60.0	190.0	Ext. turning	200.0
3	red	200.0	220.0	Ext. turning	0.0
4	Blue	200.0	160.0	Ext. turning	0.0
5	Yellow	100.0	90.0	Int. turning	0.0
6	Green	100.0	80.0	Int. turning	0.0
7	White	100.0	50.0	Int. turning	0.0

Table (5) Results of program

No.	Process type	Z– Coor.	Length (mm)	Time (Rough)	Time (Finish)	Time (Total)
1	Ex. turning	0.0	200.0	16.0	-	16.0
2	Ext. turning	200.0	60.0	9.0	-	9.0
3	Int. turning	0.0	100.0	8.0	28.6	36.6
				Total cutting time (min):		61.6

5. Conclusions

The cutting time is one of the most important parameters which affect the production time, cycle time, and product cost consequently.

In this research, AutoCAD was used as a tool for computing cutting time, this leads to reduced the time consumed for building the system, because the AutoCAD has multi abilities in manipulating drawings (drawing solid objects, gives enough information about entities, … etc). The ability to use AutoCAD as a tool is the VBA technique which is used to extract the information from the solid entities and send it to the Visual Basic programming.

The created system, through its multi abilities is able to:

- Serve as CAM / CAPP systems, through the classification of color for each entity directly and arrangement operations with Z – coordinate. It can be considered as a step toward integration those systems approaching to CIM.
- The right selection of Z – coordinate and reference point leads to the minimum machining time.
- Computing the cutting time quickly and accurately, and the system had proved its efficiency and reliability in the computations, where the final cutting time for the first model was approximately (45 min) while it was (61 min) for the second model.
- The designed system allows the user get the results through few second depending on PC performance.

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حساب زمن القطع في عملية الخراطة بالاعتماد على رسومات الاوتوكاد

الخلاصة:

بالنظر الى اهمية زمن القطع في عمليات التشغيل المختلفة، يمكن اعتباره من العوامل المهمة التي تؤثر في زمن الانتاج وزمن دورة الانتاج وبالنتيجة على كلفة المنتج. يهدف البحث الحالي الى بناء نظام لحساب زمن القطع في عمليات الخراطة من خلال قراءة ملفات الرسم لبرنامج الأوتوكاد. بني هذا النظام باستخدام لغة البرمجة فيجوال بيسك ومن ثم ربطها بنظام الأوتوكاد بواسطة تقنية فجوال بيسك للتطبيقات. ان البرنامج المعد يقوم باحتساب زمن القطع من خلال استخلاص البيانات من عناصر الرسم المجسمة و اعتمادا على الوان تلك العناصر. هذه الألوان تم تعريفها مسبقا لدى النظام، بحيث يمثل كل لون منها عملية خراطة معينة (خراطة خارجية وخراطة داخلية وخراطة و جهية) بالاضافة إلى عمليات التشغيل الخشن و الناعم. اختبر النظام بنموذجين، وأ ظهرت النتائج دقة النظام و كفائته ومن الممكن اعتبار النظام خطوة نحو التكامل بين انظمة التخطيط والتصنيع.