AUTOMATIC CNC CODE GENERATION FOR ENGRAVING DEPRESSION AND PROTRUSION FONTS

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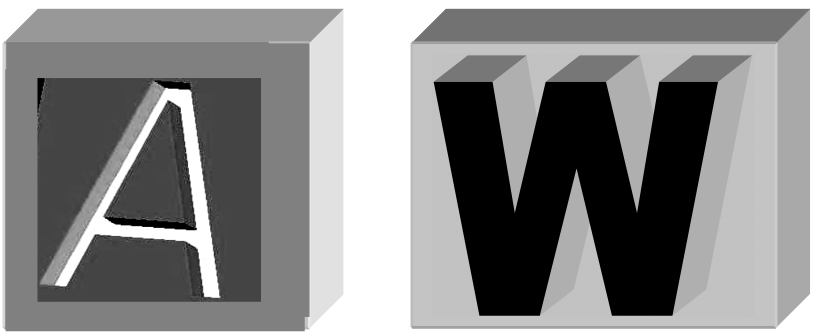
ABSTRACT

In most of the metal forming and plastic industries, product name or name of the manufacturing firm is normally engraved on their products. This necessitates these names to be engraved on the dies. Dies are generally manufactured by die-sinking process and conventional machining process but recently the use of CNC machines in die-making industry is on the increase. Engraving fonts using CNC machines is tedious. For engraving different products, a system that can automatically generate CNC codes for engraving depression and protrusion fonts will greatly reduce the die-making time as well as the cost of engraving. Such a system is proposed in this paper.

Keywords: Engraving, CNC, Protrusion fonts, Depression fonts

1. INTRODUCTION

For a die-maker, engraving fonts on the dies to suit the requirement of the customers consumes considerable time and effort in the process of die making. The font heights, font styles and font fitting styles vary from customer to customer. Even though CNC machines give the flexibility to program for different contours, CNC code generation for engraving fonts is really tedious. CAD/CAM softwares like PRO/E, I-deas, Catia and Unigraphics can generate CNC codes automatically but these softwares cost a fortune to small and medium scale industries. Also, the cost/benefit ratio of these softwares does not work out for small & medium scale industries. On the other hand, it is hard to find any literature on engraving fonts. By considering all these factors, a system that can automatically generate CNC codes for engraving protrusion and depression fonts is proposed in this paper. Protrusion and depression fonts are entirely different in terms of machining. Material is removed along the line or curved segments that constitute a font for depression fonts as shown in Fig. 1(a) whereas material is removed other than the line or curved segments that constitute a font for protrusion fonts as shown in Fig. 1(b).



(a) (b)

Fig. 1 (a) Depression Font (b) Protrusion Font

The proposed system consists of three sections as shown in Fig. 2. They are (i) User interface that receives data from the user (ii) Data processor that uses a standard font database and the inputs from the user interface to arrange and transform the sequence of texts as given by the user to suit the requirements and (iii) CNC code generator that has two subsections to generate CNC codes for engraving depression and protrusion fonts respectively. Each of these sections is explained in detail.

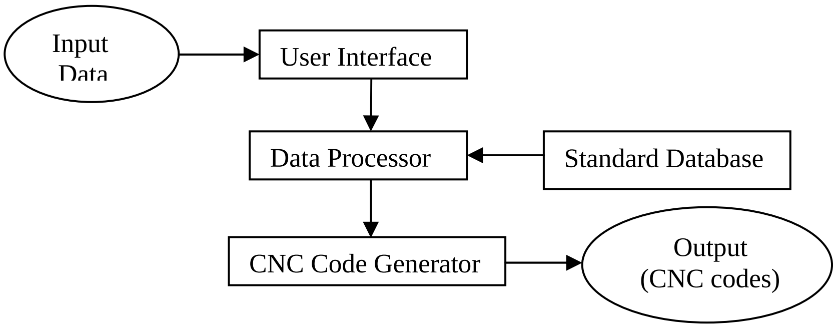


Fig. 2 The Proposed System

2. THE USER INTERFACE

The user interface receives two types of data from the end user namely a) Basic Data and (b) Text fitting data. The Basic data as shown in Fig. 3 are

(i) The series of alphabets and numerals to be engraved
(ii) The font height (H)
(iii) The gap between each alphabet (G)
(iv) Tool diameter (D)
(v) The text fitting style

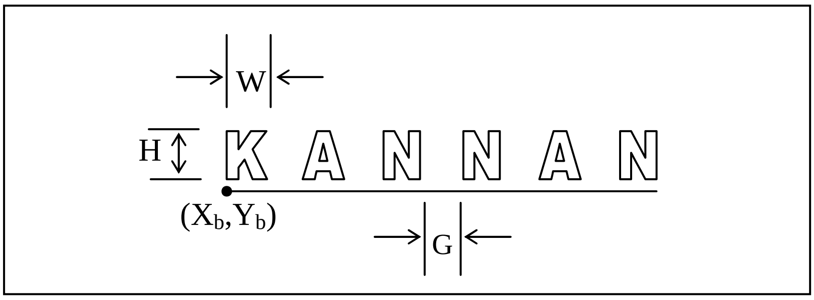


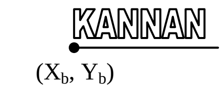
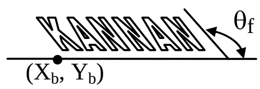
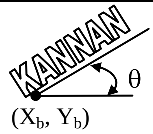
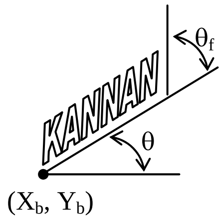
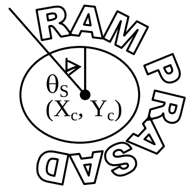
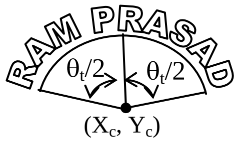
Fig. 3 Diagram depicting Basic Data (W -Width of the alphabet; (X_b,Y_b) – Location of text on work piece)

The text fitting data demanded by the system from the user vary depending on the type of text fitting style. The system provides three types of text fitting styles. They are linear text fitting, angular text fitting and circular text fitting. The text fitting data received by the end user and the different options under each fitting style are shown in Table 1. Apart from this, the system also provides mirroring option.

3. DATA PROCESSOR

The system uses a standard font database that contains the graphical data of one set of each alphabet and numerals for various font styles. The font database contains these data for a standard font height. Hereafter alphabets will mean both alphabets and numerals in this paper. In order to store the graphical data of alphabets, each alphabet is fragmented in to a series of line segments and/or curved segments. An example of fragmentation of the letter 'D' is shown in Fig. 4 and the corresponding data are shown in Table 2. For line segments and curved segments, the start and end points are stored. Apart from these data, the arc radius is also stored for curved segments. Similarly for

Table 1: Inputs to different Text Fitting Styles

Text Fitting Style	Options	Inputs	Text Fitting Illustration
Linear Text Fitting	Normal Font	X_b, Y_b	
	Inclined Font	X_b, Y_b, θ_f	
Inclined Text Fitting	Normal Font	X_b, Y_b, θ	
	Inclined Font	$X_b, Y_b, \theta, \theta_f$	
Curved Text Fitting	User Defined Starting Angle	X_c, Y_c, R, θ_s	
	Self Centred Text	$X_c, Y_c, R,$	

θ - Line inclination; θ_f - Font inclination; θ_s - Text-starting angle; θ_t – Included angle; (X_b,Y_b) – Base point for linear and inclined text fitting; (X_c,Y_c) – Base point for circular text fitting.

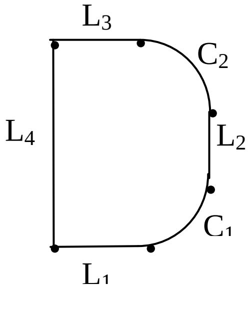


Fig. 4 Fragmentation of the alphabet “D”

Table 2: Graphical data of the alphabet "D"

S.No	ENTITY	TAG	START POINT (X_1,Y_1)	END POINT (X_2,Y_2)	RADIUS (r)
1	LINE	L_1	(0,0)	(0.749,0)	-
2	ARC	C_1	(0.749,0)	(1.6646,0.9167)	0.92
3	LINE	L_2	(1.6646,0.9167)	(1.6646,2.0835)	-
4	ARC	C_2	(1.6646,2.0835)	(0.8020,2.9807)	0.92
5	LINE	L_3	(0.8020,2.9807)	(0,3)	-
6	LINE	L_4	(0,3)	(0,0)	
STANDARD TEXT HEIGHT = 3					

each alphabet, the font database contains the data of the series of line and/or curved segments that constitute a font. The data are stored in such a way that the lower left corner of each alphabet is at the origin (0,0). The role of the data processor is to process the data received from the user and to present the graphical data of the series of alphabets in a form suitable to the CNC code generator. The functions of the data processor are explained below.

First the data of the series of alphabets as entered by the user are stored in a separate temporary database. Then based on the text height specified by the user, it performs scaling to all the data in the temporary database. Depending on the text fitting style and the options chosen by the user, it performs different transformations, which are explained one by one in the following subsections. All the transformation operations are performed using homogeneous matrices (Ibrahim Zeid, 1998 and Joe Rooney, Philip Steadman, 1990 and D.F.Rogers and J.A.Adams, 1976). Thus the data processor processes the text data as per the user requirements and stores these data in a temporary database, which can be used by the CNC code generator.

3.1 Linear Text Fitting

In linear text fitting, the location on the work piece where the fonts are to be engraved is taken as the base point (i.e. X_b,Y_b). The first letter in the series of alphabets to be engraved is translated to the base point (X_b, Y_b). Then the next letter is translated to a point (X_{b1},Y_b), where $X_{b1} = X_b + W + G$. Similarly, the subsequent letters are translated to points (X_{bi},Y_b), where $X_{bi} = X_b + i\,(W+G)$; i = 1 to n ; n is the total no of alphabets. If the user has specified font inclination θ_f, then it performs shearing operation to all the data. These processed data are stored again in the temporary database for subsequent use in the CNC code generator.

3.2 Inclined Text Fitting

In Inclined text fitting, all the operations as explained in linear text fitting are first performed. Then based on the line inclination 'θ' specified by the user, rotation about the base point by an angle 'θ' is performed to all the data in the temporary database.

3.3 Circular text fitting

In Circular text fitting, the circle center specified by the user is taken as the base point. The user can choose between two options in circular text fitting. They are (a) Circular text fitting with user specified text starting angle θ_s and (b) Circular text fitting with automatically centered text. The illustrations are shown in Table 1.

In the first option, the first letter in the series of alphabets to be engraved is translated to a point $(X_c, Y_c + R)$. Then, this alphabet is rotated about the base point (i.e. circle center) to an angle θ_s, which is specified by the user as the starting angle. Then the subsequent letters are translated to the point $(X_c, Y_c + R)$ and then rotated about the base point by an angle θ_i,

Where $\theta_i = \theta_s - \Delta\theta\,(i-1)$; $\Delta\theta = S/R$; $S = W + G$; i = 1 to n ; n is the total number of alphabets and R is the circle radius.

For circular text fitting with automatically centered text the system itself calculates the starting angle 'θ_s' which is given by $\theta_s = 90 + \theta_t / 2$; Where $\theta_t = S_T / R$ and $S_T = n W + (n-1) G$. Then, all the operations as explained in circular text fitting with user specified text starting angle is performed.

3.4 Mirroring

In die making, the mirror images of the texts as shown in Fig. 5 are often required on the die to form these fonts on the work piece. To cater this need, mirroring option is also incorporated. If the user chooses mirroring option in the user interface, then the series of alphabets entered by the user are stored in the reverse order in the temporary database. Then mirroring of all these alphabets are performed before performing any other operations for the text fitting styles.

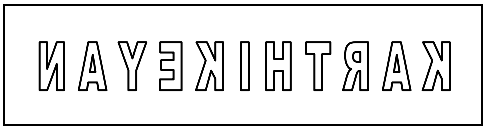


Fig. 5 An Example of Mirrored fonts

4. CNC CODE GENERATOR

The CNC code generator receives the processed data from the data processor in the form of a temporary database. It has two subsections, one for protrusion fonts and the other one for depression fonts. Both the sections use prewritten parametric subprograms for each individual alphabet. The CNC code generator generates a main program (CNC code/program) with separate subprograms (CNC subprogram) for each alphabet. It also arranges the parametric subprograms within the main program as per the sequence of alphabets entered by the user in the user interface.

4.1 Depression font generator

CNC code generation for depression fonts is comparatively easier as the tool path centre for the series of alphabets are directly obtained from the temporary database. The geometric data of each entity that constitute the alphabet are thus obtained from the temporary database and substituted for the parameters in the subprograms. The CNC code for the tool path centre for depression fonts are generated using linear interpolation (G01) for line segments and circular interpolation (G02 and G03) for curved segments. Fig. 6 shows the tool path centre and the unmachined areas of two alphabets.

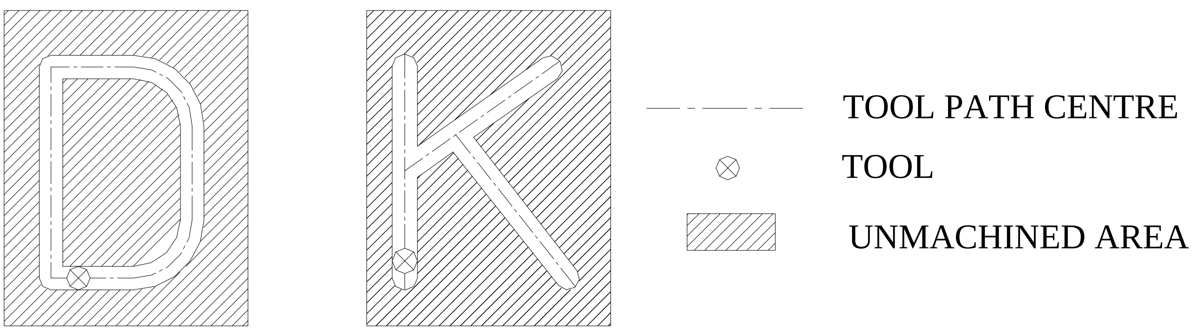


Fig. 6 Examples of depression font machining

4.2 Protrusion font generator

For protrusion fonts, machining has to be carried out other than the line and curved segments that form the alphabets. So, the system uses four edge pocketing and three edge pocketing routines to machine the stock. Separate "C" functions are written for four edge pocketing and three edge pocketing. These functions receive the data of the edges and perform inner offsetting operations (Tiller, 1984, Ibrahim Zeid, 1998 and Hoschek, 1993) with tool diameter as the offset distance and calculate intermediate points within the pocket to form the tool path centre for tool movement. In these pocketing routines, edges may be straight lines or curves. Typical four edge pockets and three edge pockets are shown in Fig. 7. Similar to depression font generator, the protrusion font generator also uses a code generation subroutine that gets data from the temporary database and generates CNC subprograms for these alphabets. Apart from this, a rectangular boundary enclosing all the alphabets is also machined with a width equal to tool diameter. Fig 8 shows the tool path centre and the unmachined areas of the alphabet.

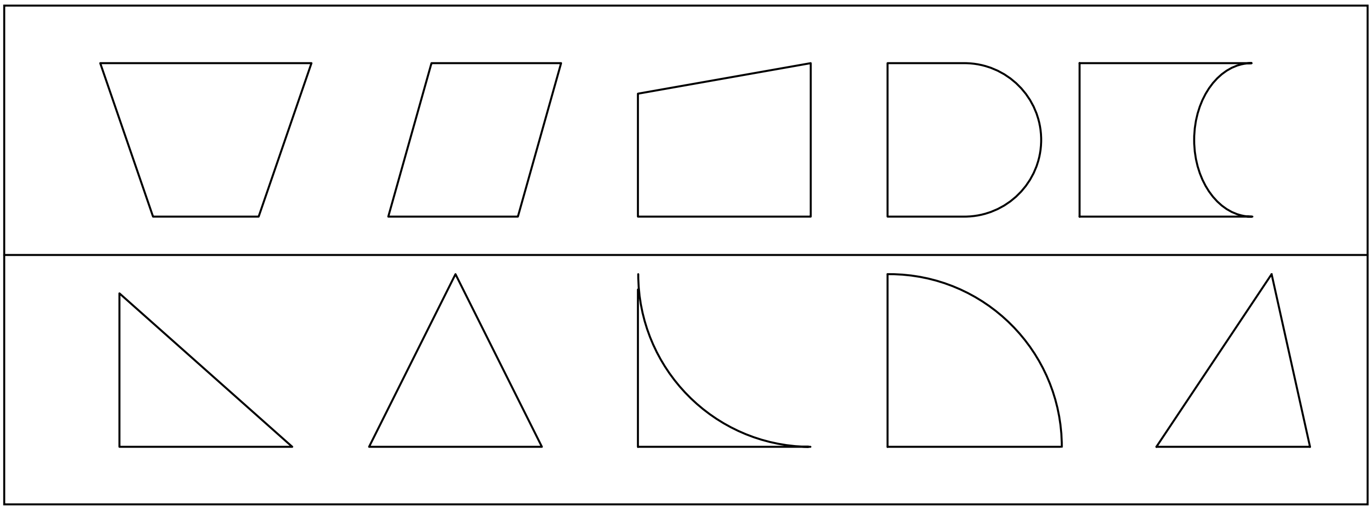


Fig. 7 Different types of four edge pockets and three edge pockets

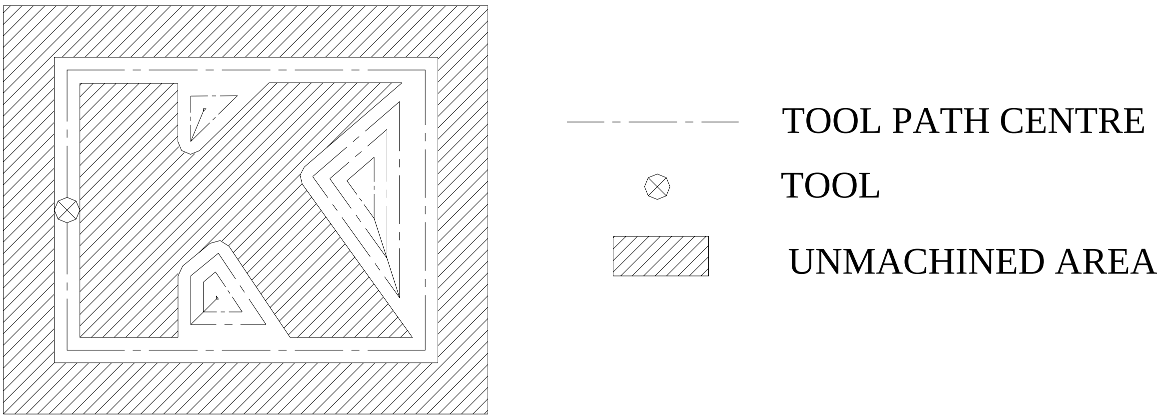


Fig. 8 An Example of protrusion font machining

5. CONCLUSION

The system effectively generates CNC codes for engraving different types of fonts with different text fitting styles. Two photographs of depression fonts and a protrusion font machined using this system are shown in Fig. 9. The material used for machining the fonts shown in Fig. 9 is composite wood. For depression fonts, same font sizes with different tool diameters are machined. Machining in aluminum and copper work pieces for both types of fonts are also carried out. The machining time for protrusion fonts are longer than that of depression fonts, as large amount of stock is removed for protrusion fonts. Further work is also being tried to generate CNC codes for engraving fonts on free form surfaces.

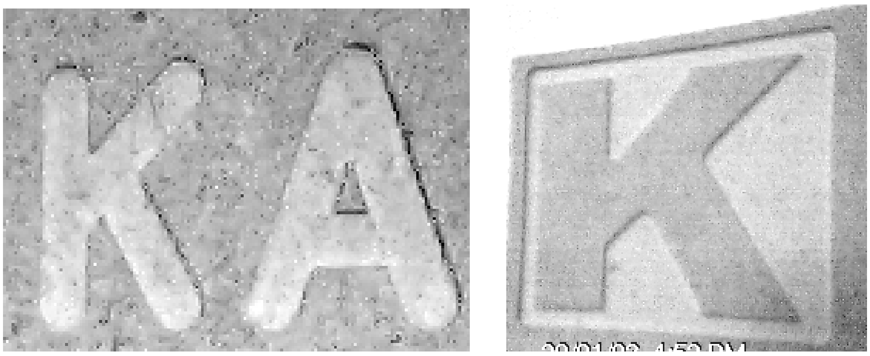


Fig. 9 Depression and protrusion fonts machined using the system.

6. REFERENCES

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