A low-cost modeller for two-dimensional metal stamping layouts

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Received 26 November 1997

Abstract

This paper presents a method for fast and economical clustering of circular and non-circular components for simple cutting dies. The proposed procedure takes into account different strip layout parameters including the size of the strip, the bridge width and the pitch and the orientation of the components with respect to the direction of the strip edge and the side margin, so as to ensure optimal material utilization. The proposed modeller is interactive in nature and incorporates autoLISP built functions that are called in the prompt area of autoCAD for generating good quality layouts and presenting them graphically for visual examination by the user. Illustrative examples are included for demonstrating the usefulness of the proposed modeller. The paper also includes a listing of the proposed software.

Keywords: Clustering; Cutting dies; Modeller

1. Introduction

In today's highly competitive industrial environment, the press tool serves as one of the most expedient tooling systems for the mass production of sheet metal components for a variety of products such as kitchen ware, electric motors, cabinets, switch gear, electrical devices, automobiles, refrigerators, office furniture and containers. An important activity during the manufacture of these components is the modelling of alternative strip layouts [1,2]. Efficient nesting [3–8] of component blanks lead to economy in material and manufacturing costs. Modelling and selection of a strip layout requires considerable experience, especially when bending and drawing operations are involved also. Optimum stamping layouts [9–13] can yield significant material saving. Traditionally, the nesting process has been performed with the help of templates cut to the exact profile of the proposed blank. The templates are then placed in alternative positions and orientations with respect to the stock sheet so as to obtain as high a material utilization as possible [14,15]. The traditional method of nesting is expertise based. It is also largely manual, tedious and time consuming and often does not yield optimum layouts. In recent years, computer-aided procedures [16–22] are being utilized increasingly to ameliorate the above difficulties. The objective of the present investigation is to develop a low-cost system for the computerized modelling of circular and non-circular components, generating alternative stamping layouts for simple cutting dies and presenting them graphically. The system is capable of dealing with varying strip dimensions, bridge width, pitch, and orientation of the component, with respect to the strip edge and the side margin. The proposed software uses advanced autoCAD and autoLISP routines for exploring alternative strip layout configurations for the clustering of circular and non-circular components for simple cutting dies. The proposed procedure is affordable by small- and medium-sized enterprises.

2. Need for a low-cost modeller

Most of the commercially available packages [23–25] for die design are general purpose in nature and include

Table 1
Typical prompts, user responses and system advice when using module CIRBLK

S. No.	Prompts	User responses			
		Data set 1	Data set 2	Data set 3	Data set 4
1	Please enter x and y co-ordinates of the start point of the strip (cm, cm)	3.7	3.7	3.7	3.7
2	Please enter the x and y co-ordinates of the end point of the strip (cm, cm)	23.7	23.7	23.7	23.7
3	Please enter the half width of the strip in cm	2.40	3.60	4.75	5.875
4	Please enter the radius of circular contour in cm	1.0	1.0	1.0	1.0
5	Please enter the component spacing in cm	0.25	0.25	0.25	0.25
6	Please enter the number of components visualised the screen	15	25	35	45

Advice: Display of the nesting patterns.
Advice: Computed utility ratios: 0.49, 0.54, 0.58 and 0.60).

Table 2
Typical prompts, user responses and the final output when using module NCIRBLK

S. No.	Prompts	User responses			
		Data set 1	Data set 2	Data set 3	Data set 4
1	Please enter the starting point of the first side of the non-circular component (cm, cm)	2.4	2.4	1.1	3.3
2	Please enter the length (L1) of the first side of the component (cm)	0.5	0.5	2.0	0.75
3	Angle of orientation in degrees (Q1) of the first side of the component with respect to the longitudinal direction of the strip	72	45	0	45
4	Please enter the length (L2) of the second side of the component (cm)	0.5	0.5	2.0	0.6
5	Please enter the angle of orientation (Q2) of second side of the component with respect to the longitudinal direction of the strip	144	117	90	135
6	Please enter the number of sides of the component	5	5	5	11
	Please press key ^C if it is the closing side of component	—	—	—	—
	Please enter the length (L3) of the third side of the component (cm)	0.5	0.5	2.0	1
7	Please enter the angle of orientation (Q3) of third side of the component with respect to the longitudinal direction of the strip	216	189	180	90
8	Please press key ^C if it is the closing side of component	—	—	—	—
	Please enter the length (L4) of the fourth side of the component (cm)	0.5	0.5	1	0.375
9	Please enter the angle of orientation (Q4) of fourth side of the component with respect to the longitudinal direction of the strip	288	261	270	0
10	Please press key ^C if it is the closing side of component Please enter the length (L5) of the fifth side of the component (cm)	^C	^C	^C	0.75
11	Please enter the angle of orientation (Q5) of fifth side of the component				90
12	Please press key ^C if it is the closing side of component Please enter the length (L6) of the sixth side of the component (cm)	^C	^C	^C	0.375
13	Please enter the angle of orientation (Q6) of sixth side of the component with respect to the longitudinal direction of the strip				180
14	Please press key ^C if it is the closing side of component Please enter the length (L7) of the seventh side of the component (cm)	^C	^C	^C	0.15
15	Please enter the angle of orientation (Q7) of seventh side of the component with respect to the longitudinal direction of the strip				90
16	Please press key ^C if it is the closing side of component Please enter the length (L8) of the eight side of the component (cm)	^C	^C	^C	0.3
17	Please enter the angle of orientation (Q8) of eight side of the component with respect to the longitudinal direction of the strip				180
18	Please press key ^C if it is the closing side of component Please enter the length (L9) of the ninth side of the component (cm)	^C	^C	^C	1.4
19	Please enter the angle of orientation (Q9) of ninth side of the component with respect to the longitudinal direction of the strip				270
20	Please press key ^C if it is the closing side of component Please enter the length (L10) of the tenth side of the component (cm)	^C	^C	^C	0.6
21	Please enter the angle of orientation (Q10) of tenth side of the component with respect to the longitudinal direction of the strip				225
22	Computed area of non-circular component	0.86	0.86	2.5	1.313

Advice: (display of component drawing).

functional capabilities far exceeding the requirements of a small enterprise. Modelling of the blank is just one of its capabilities and, even here, the built-in capability tends to be rather too comprehensive. These packages are expensive and also difficult to master by the engineering personnel of small enterprises. Small undertakings are able to invest in PCs and inexpensive modelling software. A modeller for use in small factories should possess the following features: (i) low cost, easy maintenance and the capability of being run on a PC; (ii) user-friendliness; (iii) the capacity to model 2-D circular and non-circular components interactively; and (iv) the ability to generate nesting patterns according to the nesting parameters chosen by the user.

3. Relevant design considerations

The shape and size of a blank are chosen by the designer according to functional strength and aesthetic requirements. The nesting of components wherever possible helps in reducing material wastage. A variety of factors have to be considered during layout planning [26]. Chief among these are size of the coiled stock, the stock width, the stock length, the grain direction, the pitch and the orientation of the component relative to the longitudinal direction of the strip, the cluster orientation, the slitting allowance, the blanking pressure, the space available in the die-set, the press specifications, the bridge width and the die cost. The total manufacturing cost comprises the cost of raw material, the dies and tools, the direct labour, the supervision and the machine. It is the total cost that has to be considered when making a choice amongst alternative strip layouts.

4. Proposed CAD procedure

The given two-dimensional shape of the blank is divided into elements such as line segments, arcs and circles. A database is created to store the coordinates of the start and end points of lines and arcs, and the centre and radii of arcs and circles. The procedure allows a component to be inserted, copied, moved from point to point, mirrored horizontally or vertically through a given axis, or rotated clockwise or anti-clockwise by any amount on the strip with the help of commands such as draw, copy, rotate, mirror, move, minsert and block, available in AutoCAD [27–33]. The process is carried out interactively. Components can be paired on different sides and visualized on a graphics screen until a satisfactory layout is obtained. It is up to the user, however, to decide whether or not a satisfactory layout has been reached. Further, the user can obtain and visualize a number of different clustering configurations by changing values of the design parameters including the strip length, the strip width, the pitch, the side margin and the orientation of the component with respect to the longitudinal axis of the strip. AutoLISP [34,35], routines have been developed for this purpose.

The main procedural steps of the proposed modeller LAYOUT.LSP procedure are shown schematically in Fig. 1. Each of these is described briefly as follows:

(1) On loading the module LAYOUT.LSP, the user receives a welcoming message, and an invitation to use command CIRBLK for modelling circular components and NCIRBLK for non-circular components.

(2) For the modelling of circular components, the design function CIRBLK is used as a command. It asks the user to supply the strip layout parameters. A listing of the source program for the function CIRBLK is given in Appendix A. The typical prompts and user responses when using this function are given in Table 1.

On receipt of the user responses, this function creates rows of components of required diameter at desired spacing to be specified by the user. However, if the component spacing (tspac) is not specified in the argument, it is calculated, following Wilson [36], from the following rule:

$$\text{tspac} = 1.25 \times t \quad \text{for} \quad C < 2.5 \text{ in. } (63.5 \text{ mm}) \tag{1.1}$$

$$\text{tspac} = 1.50 \times t \quad \text{for} \quad C > 2.5 \text{ in } (63.5 \text{ mm}) \tag{1.2}$$

where tspac is the component spacing in cm, t is the strip thickness in cm, and C is the distance (cm) from a point on one component to the corresponding point on the next component.

The function CIRBLK permits the user to offset the circular components in alternate rows. The final output is in the form of a nesting pattern (Figs. 2–5) that is presented on the computer screen along with the corresponding utility ratio in the prompt area of autoCAD. If the utility ratio is not sufficiently high, the user may select another set of design parameters and repeat the foregoing procedure.

(3) A special function NCIRBLK has been developed for the modelling of non-circular components (both regular and irregular polygons) using a local variable that exists only whilst the function is in use: this saves memory space and helps to limit the number of active symbols. The function NCIRBLK permits the user to specify interactively a starting point (pt) for one of its sides, the length (Li) of the side, and the angle of orientation (Qi) of the side with respect to the longitudinal direction of the strip. The ending point of the side is computed automatically with the help of a bit known as POLAR. The input data for the length of the next side and its orientation with respect to the axis of the strip have to be supplied by the user. The foregoing process is repeated until all the sides of the contour are

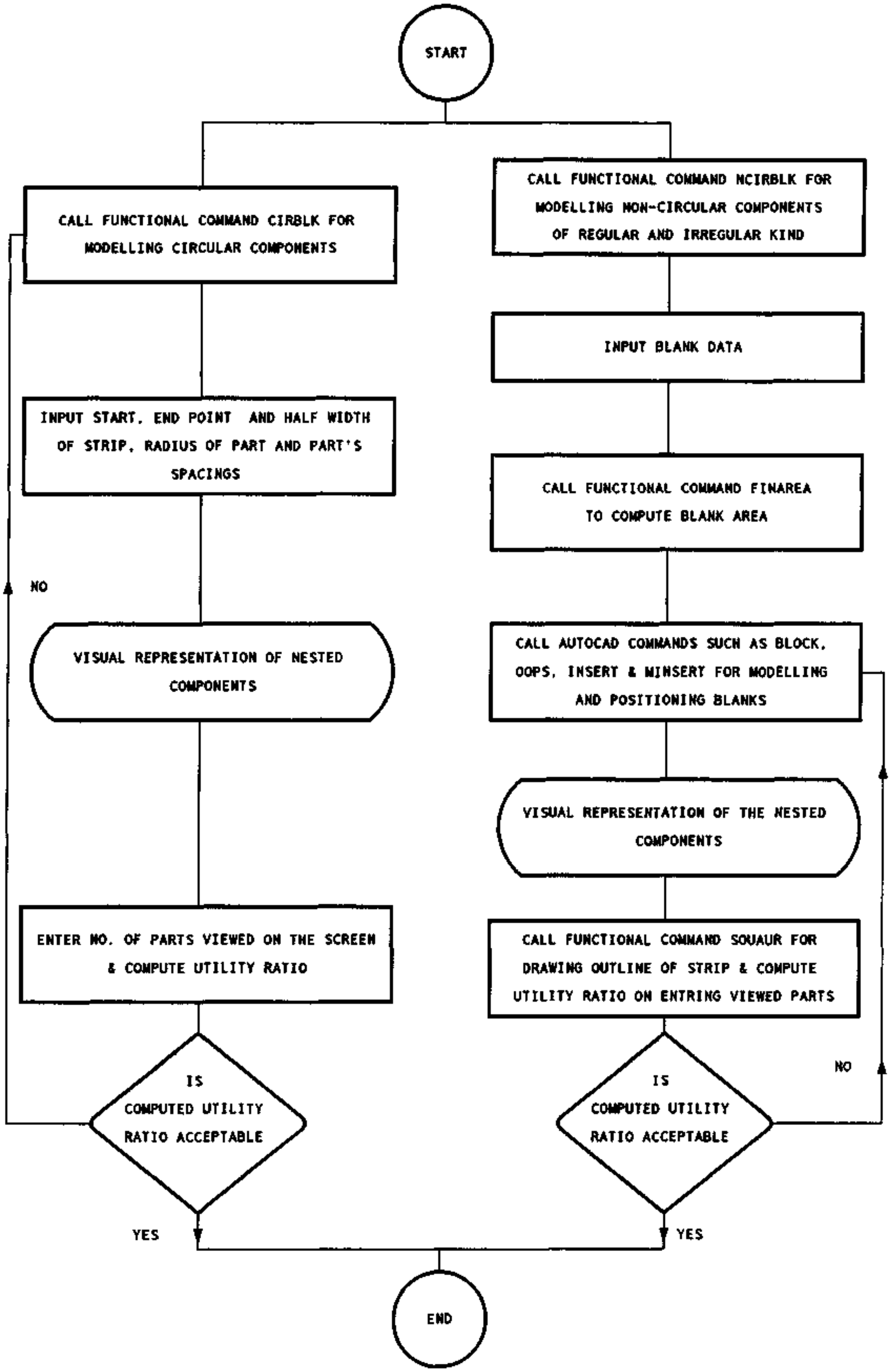

Fig. 1. Flow chart for module LAYOUT. LSP.

Table 3
Typical prompts and user responses when using autocad commands for modelling blocks of non-circular parts

S. No.	Prompts	User responses
1	Command	BLOCK
2	Block name	Blank
3	Insertion point	-,-
4	Select object	Window
5	First corner	-,-
6	Other corner	-,-
7	Select object	Enter
8	Command	Enter
9	Block name (or?)	Blank
10	Command	OOPS*
11	Command	Insert
12	Block name (or?)	Blank
13	Insertion point	-,-
14	X scale factor ⟨1⟩/corner/XYZ	Enter
15	Y scale factor ⟨1⟩ default = X	Enter
16	Rotation angle	

* For retaining the blocked figure.

Table 4
Typical prompts, user responses when using autocad commands for positioning blocks of non-circular parts

S. No.	Prompts	User responses
1	Command	MOVE
2	Command	BLOCK
3	Block name	Blank1
4	Insertion point	-,-
5	Select object	Window
6	First corner	-,-
7	Other corner	-,-
8	Select object	Enter
9	Command	MINSERT
10	Block name (or?)	Blank2
11	Insertion point	-,-
12	X scale factor ⟨1⟩/corner/XYZ	Enter
13	Y scale factor ⟨1⟩ default = X	Enter
14	Rotation angle ⟨0⟩	Enter
15	No. of rows (-) or ⟨1⟩	
16	No. of columns (|||) or ⟨1⟩	
18	Unit cell or distance between rows (-)	
19	Unit cell or distance between columns (|||)	

Table 5
Typical prompts, user responses and output from function SOUAUR

S. No.	Prompts	User responses			
		Data set 1	Data set 2	Data set 3	Data set 4
1	Please enter the area of non-circular component in sq. cm	0.860	0.860	2.500	1.313
2	Please enter the lower left point of the strip	1.4	1.4	0.7, 4.2	
3	Please enter the lower right point of strip	12.4	12.4	9.8, 4.2	
4	Please enter the upper right point of strip	12.10	12.10	9.8, 11.0	
5	Please enter the number of components to be projected on the screen	54	54	12	36

Advice: (A) (Display of the nested patterns) (Reproduced in Figs. 7–10).
Advice: (B) Computed utility ratios: 0.70, 0.70, 0.48, and 0.45.

accounted for. The function NCIRBLK then makes use of the autoCAD LINE command for drawing a contour of the component. A listing of the source program for the function NCIRBLK is given in Appendix A. An example of the prompts, user responses and component display when using the function NCIRBLK is given in Table 2 and Fig. 6.

The above component may be positioned and rotated to any desired angle with respect to the longitudinal axis of the strip by the user, either by appropriately orienting the first side of the component or by using the BLOCK and ROTATE commands of autoCAD sequentially. For the modelling and positioning of blocks of non-circular blanks, the user may make use of the BLOCK, OOPS, INSERT and MINSERT commands of autoCAD. The user can thereby cluster blanks and provide spacing between blanks of the same row and between successive rows. Examples of the prompts and user responses when using these autoCAD commands for modelling the nesting patterns are given in Tables 3

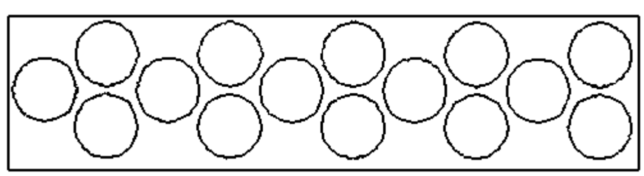

Fig. 2. Computed nesting pattern for circular part data set 1.

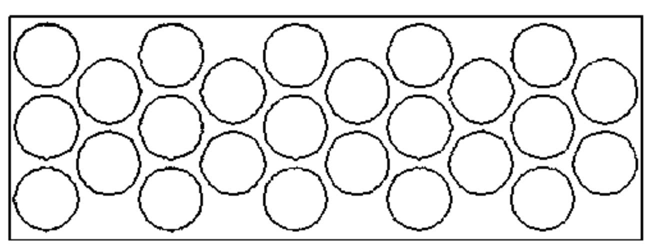

Fig. 3. Computed nesting pattern for circular part data set 2.

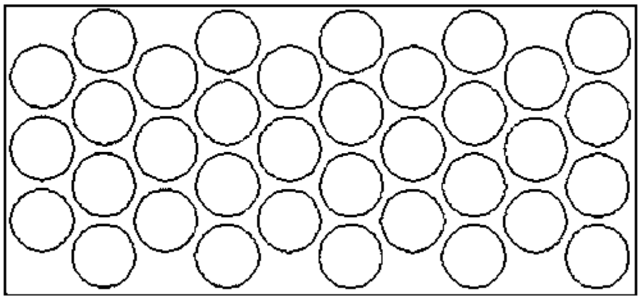

Fig. 4. Computed nesting pattern for circular part data set 3.

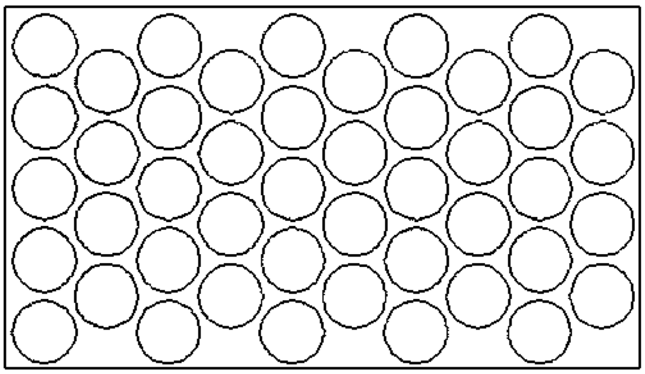

Fig. 5. Computed nesting pattern for circular part data set 4.

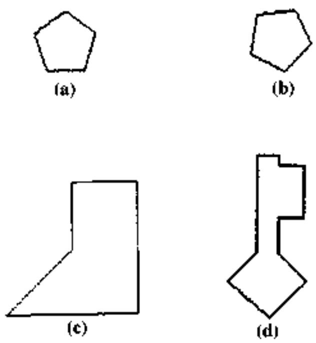

Fig. 6. Modelling of non-circular components using the function NCIR BLK, for a component corresponding to data set: (a) 1; (b) 2; (3); and (d) 4.

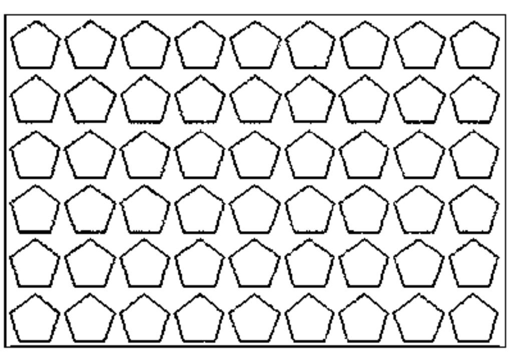

Fig. 7. Computer nesting pattern for non-circular part data set 1.

and 4. After making the required nesting of non-circular blanks using autoCAD commands, the functional command SOUAUR of module NCIRBLK is invoked

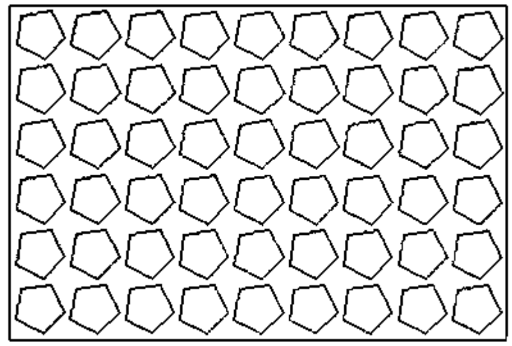

Fig. 8. Computer nesting pattern for non-circular part data set 2.

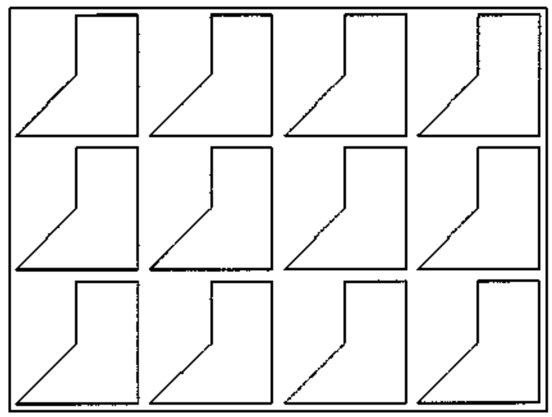

Fig. 9. Computed nesting pattern for non-circular part data set 3.

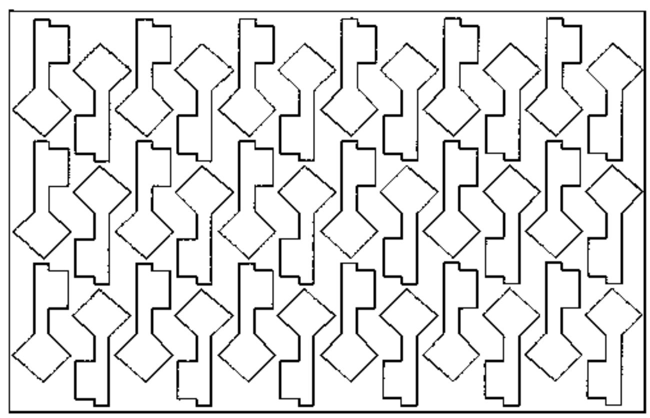

Fig. 10. Computed nesting pattern for non-circular part data set 4.

for generating the strip outline and computing the utility ratio. The typical prompts, user responses and component nesting patterns when using the command SQUAUR of function NCIRBLK are given in Table 5 and Figs. 7–10.

5. Loading of auto LIST routines

LISP routines are executed after the LISP files are located in the memory area reserved for this purpose by autoCAD. The loading process is accomplished with the help of an autoLISP function called LOAD [37] as follows: `(LOAD ''A:filename'')` such as `(LOAD ''A: LAYOUT.LSP'')`

This function would cause autoCAD to work for the filename (LAYOUT.LSP).

6. Conclusions

The proposed modelling routine LAYOUT.LSP enables the generation and visualization of alternative layouts for circular and non-circular metal stamping blanks as well as their evaluation on the basis of material utilization. For circular components, the user interactively provides values of different layout parameters, namely the start point of the strip, the end point of the strip, the half width of the strip, the radius of the circular contour, the component spacing and the number of components. The routine displays the nesting pattern as well as corresponding utility ratio. If the user so wishes, he–she can choose another set of layout parameters and obtain a new nesting pattern and corresponding utility ratio. The process can be repeated until the nesting pattern is found to be satisfactory.

For non-circular components, the proposed procedure allows the user to interactively model the blank. However he–she has to reply upon personal skill to construct and appropriatively position a block comprising two or more blanks using suitable autoCAD commands. The strip outline as well as the nested pattern are presented graphically to the user. The computed utility ratio is also displayed. The above procedure may be repeated until a satisfactory nesting pattern is obtained. The program is user-friendly, implementable on a PC, and affordably by small enterprises.

Appendix A. Source program LAYOUT.LSP for modelling of circular and non-circular components

```
 Draw circular components on rectangular sheet
(prompt ''Welcome the user for modelling, use commands CIRBLK for
circular and NCIRBLK for non-circular components'')(terpri)
;Convert degress to radians
  (defun dtr(a)
(*pi(/a 180.00))
)
;Start of module CIRBLK for modelling circular components
;draw circular rows of components offsetting alternatively
(defun dcc(pd offset)
  (setq pfirst (polar sp pangle pd))
  (setq pchole (polar pfirst angp90 offset))
  (setq plhole pchold)
  (while (<(distance pfirst plhole)(-hwidth trad))
(command ''circle'' plhole trad)
  (setq plhole (polar plhole angp90 (+tspac trad trad)))
  )
  (setq psecond (polar sp pangle pd))
  (setq pc2hole (polar psecond angm90 offset))
  (setq pl2hole pc2hole)
  (while (<(distance psecond pl2hole)(-hwidth trad))
(if (/=psecond pl2hole)
(command ''circle pl2hole trad))
  (setq pl2hole (polar pl2hole angm90 (+tspac trad trad)))
  )
)
;acquire information for strip layout variables
(defun c:cirblk()
  (prompt ''Welcome the user for modelling circular
components'')(terpri)
  (command ''limits'' ''0,0'' ''24, 20'' ''zoon'' ''all'' '''')
  (setq sp (getpoint ''nPlease enter x & y co-ordinates
```

Appendix A. (Continued)

```
of the start point of the strip (cm, cm):''))
  (setq ep (getpoint ''\nPlease enter the x & y co-ordinates
of the end point of the strip (cm, cm):''))
  (setq hwidth (getdist sp ''\nPlease enter the half width of
strip in cm:''))
  (setq trad (getdist sp ''\nPlease enter radius of
component contour (holes) in cm:''))
  (setq tspac (getdist sp ''\nPlease enter spacing
between holes in cm:''))
  (setq pangle (angle sp ep))
  (setq plength (distance sp ep))
  (setq width (* 2 hwidth))
  (setq angpo90 (+ pangle (dtr 90))); Path angle +90 degrees
  (setq angm90 (-pangle (dtr 90))); Path angle -90 degrees
(command ''pline''
(setq p (polar sp angm90 hwidth))
(setq p (polar p pangle plength))
(setq p (polar p angp90 width))
(polar p (+ pangle (dtr 180)) plength)
''close''
)
  (setq pdist (+ trad spac))
  (setq off 0.0)
  (while (<=pdist (-plength trad))
(dcc pdist off)
  (setq pdist (+pdist (* (+ tspac trad trad)
  (sin (dtr 60)))))
(if (=off 0.0)
  (setq off (* tspac trad trad)(cos (dtr 60))))
  (setq off 0.0)
  )
  )
  (setq starea(* plength width))
  (setq rsqr(* trad trad))
  (setq z1 22.0)
  (setq z2 7.0)
  (setq pi (/z1 z2))
  (setq blkarea(* pi rsqr))
  (prompt ''For computing utility ratio'')(terpri)
  (setq noc(getreal ''\nPlease enter number of viewed
circular parts in strip on screen:''))
  (setq tblarea(* noc blkarea))
  (setq ur(/tblarea starea))
  (prompt ''Utility Ratio='')(princ ur)(terpri)
)
;Start of module NCIRBLK for modelling non-circular components
;draw non-circular polygons by calling strip layout variables
(DEFUN c:ncirblk(/pt1 pt2 pt3 pt4 pt5 pt6 pt7 py8 pt9 pt10 pt11
 l1 l2 l3 l4 l5 l6 l7 l8 l9 l10 q1 q2 q3 q4 q5 q6 q7 q8 q9 q10)
(prompt ''Welcome the user for modelling non-circular components'')
(terpri)
(setq pt1(getpoint ''\Please enter the lower left corner
of the component (cm, cm)'')
(setq l1(getdist ''\n Please enter l1 length of first side
```

Appendix A. (Continued)

```
of the component'' pt1))
(setq q1(getangle ''\n Please enter angle Q1 (1st side angle)
wrt strip edge:''))
(setq pt2(polar pt1 q1 l1))
(set l2(getdist pt2 ''\n Please enter l2 length of 2nd side
of the component''))
(setq q2(getangle ''\n Please enter angle Q2 (2nd side angle)
wrt strip edge:''))
(setq pt3(polar pt2 q2 l2))
(setq l3(getdist ''\n Please enter l3 length of third side
of the component''))
(setq q3(getangle ''\n Please enter angle Q3 (3ed side angle)
wrt strip edge:''))
(setq pt4(angle pt3 q3 l3))
(set l4(getdist ''\n Please enter l4 length of fourth side
of the component''))
(setq q4(getangle ''\n Please enter angle Q4 (4th side angle)
wrt strip edge:'')
(setq pt5(polar pt4 Q4 l4))
(setq l5(getdist ''\n Please enter l5 length of fifth side
of the component''))
(setq q5(getangle ''\n Please enter angle Q5 (5th side angle)
wrt strip edge:'')
(setq pt6(polar pt5 Q5 l5))
(setq l6(getdist ''\n Please enter l6 length of sixth side
of the component''))
(setq q6(getangle ''\n Please enter angle Q6 (6th side angle)
wrt strip edge:''))
(setq pt7(polar pt6 Q6 l6))
(setq l7(getdist ''\n Please enter l7 length of seventh side
of the component''))
(setq q7(getangle ''\n Please enter angle Q7 (7th side angle)
wrt strip edge:''))
(setq pt8(polar pt7 Q7 l7))
(setq l8(getdist ''\n Please enter l8 length of eight side
of the component''))
(setq q8(getangle ''\n Please enter angle Q8 (8th side angle)
  wrt strip edge:''))
(setq pt9(polar pt8 Q8 l8))
(setq l9(getdist ''\n Please enter l9 length of ninth side
of the component''))
(setq q9(getangle ''\n Please enter angle Q9 (9th side angle)
wrt strip edge:''))
(setq pt10(polar pt9 Q9 l9))
(setq l10(getdist ''\n Please enter l10 length of tenth side
of the component''))
(setq q10(getangle ''\n Please enter angle Q10 (10th side angle)
wrt strip edge:''))
(setq pt11(polar pt10 q10 l10))
;(setq l11(getdist ''\n enter l11 length of eleventh side
of the component''))
;(setq q11(getangle ''\n enter angle Q11 (11th side angle)
wrt strip edge:''))
;(setq pt12(polar pt11 Q11 l11))
```

Appendix A. (Continued)

```
;end of setq)
(command ''line'' pt1 pt2 pt3 pt4 pt5 pt6 pt7 pt8
pt9 pt10 pt11 ''close'')
(prompt ''Compute component area with FINAREA command'')
);end of defun
;INSERT the block at 180 to make nested pair'')(terpri)
;(prompt ''Now please make block again of nested pair, and
;    minsert that block with MINSERT command
;and load SOU module for making sheet and to
;compute utility ratio'')
;Start of function FINAREA for computing area of component
  (defun c:finarea (/a n c1 c2 c3 c4 c5 c6 c7 c8 c9 c10 c11)
  (graphscr)
  (setq a(ssget))
  (setq n (sslength a))
  (if (>n 0)(setq c1 (cdr (assoc 10 (entget (ssname a 0))))))
  (if (>n 1)(setq c2 (cdr (assoc 10 (entget (ssname a 1))))))
  (if (>n 2)(setq c3 (cdr (assoc 10 (entget (ssname a 2))))))
  (if (>n 3)(setq c4 (cdr (assoc 10 (entget (ssname a 3))))))
  (if (>n 4)(setq c5 (cdr (assoc 10 (entget (ssname a 4))))))
  (if (>n 5)(setq c6 (cdr (assoc 10 (entget (ssname a 5))))))
  (if (>n 6)(setq c7 (cdr (assoc 10 (entget (ssname a 6))))))
  (if (>n 7)(setq c8 (cdr (assoc 10 (entget (ssname a 7))))))
  (if (>n 8)(setq c9 (cdr (assoc 10 (entget (ssname a 8))))))
  (if (>n 9)(setq c10 (cdr (assoc 10 (entget (ssname a 9))))))
  (if (>n 10)(setq c11 (cdr (assoc 10 (entget (ssname a 10))))))
  (if (=n 3)(command ''area'' c1 c2 c3''''))
  (if (=n 4)(command ''area'' c1 c2 c3 c4''''))
  (if (=n 5)(command ''area'' c1 c2 c3 c4 c5 ''''))
  (if (=n 6)(command ''area'' c1 c2 c3 c4 c5 c6''''))
  (if (=n 7)(command ''area'' c1 c2 c3 c4 c5 c6 c7''''))
  (if (=n 8)(command ''area'' c1 c2 c3 c4 c5 c6 c7 c8''''))
  (if (=n 9)(command ''area'' c1 c2 c3 c4 c5 c6 c7 c8 c9''''))
  (if (=n 10)(command ''area'' c1 c2 c3 c4 c5 c6 c7 c8 c9 c10 ''''))
  (if (=n 11)(command ''area'' c1 c2 c3 c4 c5 c6 c7 c8 c9 c10

    c11''''))
  (prompt ''Now use command BLOCK and name it by blank, retain fig.
  using command OOPS'')(terpri)
  (prompt ''Use command INSERT to make a nested pair and block it
  as blank1 using command BLOCK'')(terpri)
  (prompt ''Use command MINSERT for multiple modelling'')
  (prompt ''Use command SOUAUR for modelling sheet and to compute
utility ratio'')
  (prompt ''Use Function Key F1'')
)
;Start of function SOUAUR draw strip outline aground nesting
;and computing utility ratio
(defun c:souaur (/blarea tblarea noc sp ep pt3 width plength
pt4 starea ur)
  (setq blarea(getreal ''\n Please enter area of irregular
blank in sq.mm:''))
  (setq sp(getpoint ''\n Please enter lower left
```

Appendix A. (Continued)

```
point  of  the  strip''))
  (setq  ep(getpoint  ''\n  Please  enter  right  point  of  the  strip''))
  (setq  pt3(getpoint  ''\n  Please  enter  upper  right  point  to  the
strip''))
  (setq  width(distance  pt3  ep))
  (setq  plength(distance  sp  ep))
  (setq  pt4(polar  sp  (/pi  2.0)  width))
  ;Draw  outline  of  the  strip
(command  ''line''  sp  ep  pt3  pt4  ''close)
  (prompt  ''For  computing  utility  ratio'')(terpri)
  (setq  noc(getreal  ''\n  Please  enter  number  of  viewed  parts  in
strip  on  screen:''))
  (setq  tblarea(*  noc  blarea))
  (setq  starea(*  plength  width))
  (setq  ur(/tblarea  starea))
  (prompt  ''Utility  Ratio='')(princ  ur)(terpri))
```

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