CONTENTS

CHAPTER 01

INTRODUCTION

CHAPTER 01

INTRODUCTION

1.1 what are eyelets?

Eyelets are small holes or eye to receive a lace or cord as in garments, sails, files, shoes etc.

1.2 what is eyelet drawing?

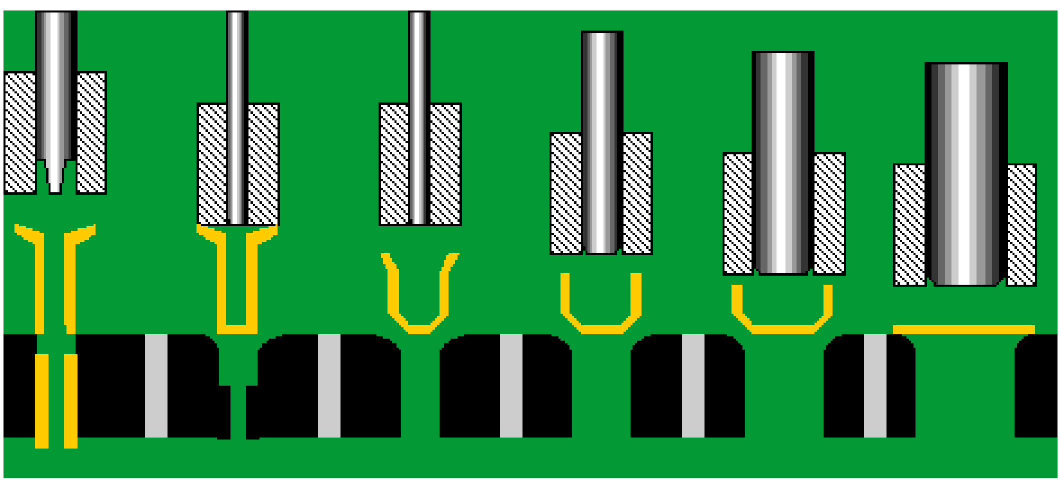
Eyelet drawing is the process of producing small diameter cups by drawing progressively. The main feature of eyelet drawing is that the depth of the shell is more compared to its diameter.

Hence the overall draw ratio is very high. This indicates that these shell cannot be drawn in one stage and manufacturing number of tools to produce these components is uneconomical.

In this method number of stages required are stacked with a single die set, so that the operation can be made in the progressive style.

The tool is similar to progressive tool. Pieces are drawn from the stock strip in single or multiple rows. However, it is observed from the practices the single row method is easier because enough material can be drawn from all sides.

The fig below shows the process of eyelet drawing



1.3 History

Deep drawing of eyelets, rivet bodies, and other tiny parts is a metal forming specialty that relatively few companies in the world perform. Deep drawn eyelet metal stamping originated in the Naugatuck Valley region, near Waterbury, Connecticut, during the Civil War. Interestingly, even today, many of these stamping specialists still operate out of this south central Connecticut area.

CHAPTER 02

EYELET DRAWING

PROCESS

CHAPTER 02

EYELET DRAWING PROCESS

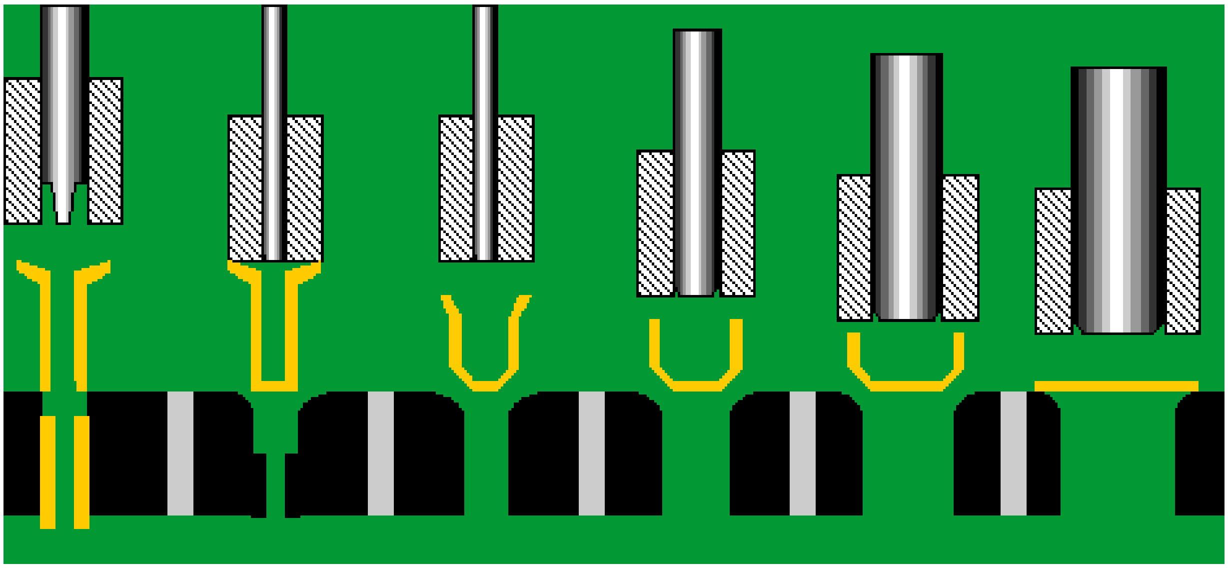
2.1 PROGRESSIVE EYELET DRAWING

Eyelet drawing is a process of producing, small sized, capsule shaped parts, by drawing operation. The main feature of these components is that depth is more compared to its diameter. Obviously from blank Ø to finished size, it cannot be drawn in one stage. It needs multiple stages.

In this special methods these various stages, are accommodated in a single tool, arranged in a progressive manner. It is for this reason, that all materials are not ideal for this process.

The tool is similar to a progressive tool. Pieces are drawn from a stock strip in single or multiple rows. In the first step, a shallow nipple is drawn. The Ø to ht ratio, for this initial nipple, of approximately 2, is ideal i.e. d=2h. if eyelets are drawn in a single row, there is no difficulty in maintaining material thickness, because enough material can be derived, from all sides, while drawing in multirows enough material has to be left between the rows. The distance between two stations, must be maintained exactly.

The fig below shows the eyelet drawing process



2.2 Eyelet - Machine tools

Eyelet machine tools are originally designed to make small metal eyelets for shoes. The conventional eyelet has independently actuated plungers permitting flexibility in setting the stroke and shut height of each station.

There are two methods of stroke control. The smaller machines are cam-driven ; the heavier machines are driven by an eccentric crank mechanism. With the development of large machines, metal up to 1.5 mm thick and shells 75 mm deep can be fabricated.

The eyelet machine combines such operations as blanking, drawing, piercing, trimming and forming, light coining, and even thread rolling and side piercing.

The principal advantages of an eyelet machine over a progressive die lie in the economical tooling and the speed with which it can be produced. Less material waste is involved, because each shell is carried free after the rough blank is cut from the coil stock. There is no material loss due to the necessity of the transfer ribbons associated with progressive- die operation.

The only disadvantage is that eyelet machines operate somewhat more slowly than a progressive die. Normal output in medium-sized eyelet machines is approximately 5000 pieces/hour. If speed- control units are installed on the machine, the output can be increased to 7500 per hour.

Long - run jobs, and especially runs on stainless-steel shells, can be completed with a minimum of down time by using carbide inserts in the draw and redraw stations. In some cases sintered carbide is used for piercing and trimming also.

Eyelet machines range from 6 to 11 individual stations. Normal set up time for an eight – station job would be approximately 6 hours. New jobs require considerably more setup time because carrying fingers must be eliminate wrinkles and die marks.

Some parts made on the screw machines can, with slight modifications, be made on eyelet machines. (2.2a)

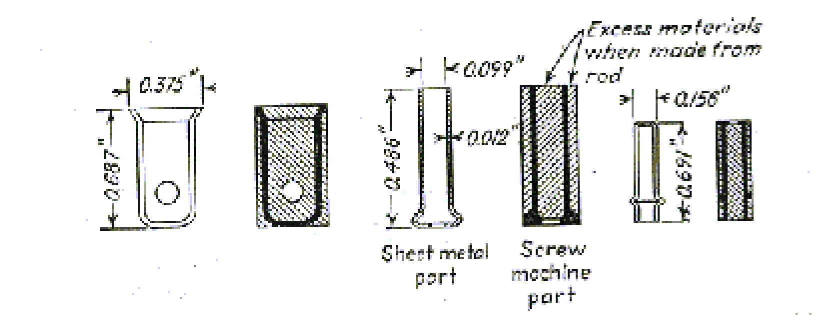


Fig 2.2a Typical screw-machine parts and a similar part produced on the eye let machine

The steps used in producing a brass shell from 0.4 mm thick strip stock are shown in fig 2.2b. The round blank is made in the first station and carried to the second position for cupping. The cup is redrawn in the third and fourth stations and pinch trimmed to height in the fifth station. The shell diameter reduced in the sixth and seventh stations, leaving a short part near the bottom the full diameter to provide material for the flange around the bottom. The flange is flattened in the eighth station and the necking of the top is started. Further reduction of the neck diameter is done in station 9, and the part is finished to diameter in station 10.

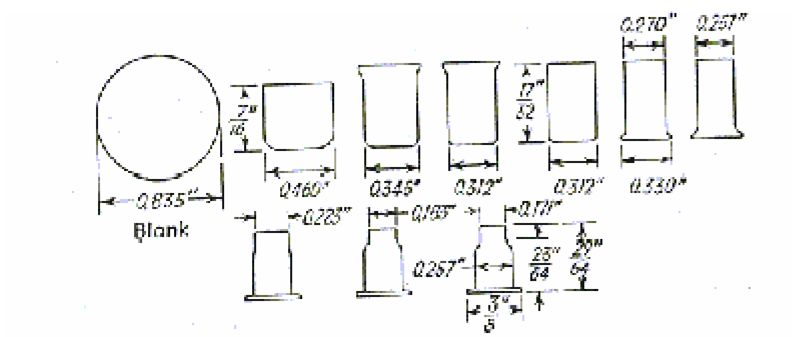


Fig 2.2b steps used in producing a necked and flanged shell on an eyelet machine.

A small brass part and the tools used to produce the parts are shown in fig.2.2c. The operations include blank, draw, flange, coin, and pierce. The first operation blanks a 31 mm diameter blank from a brass strip 0.5 mm thick and 32.5 mm wide. The blanking punch (D1) places the blank into a carrier pad (D2) to be transferred to the second station where it is cupped. The hold-down (D3) in the second station grips the blank while it is drawn by the punch (D4) into the carbide die (D5). Station 3 squares the top edge in preparation for pinch trimming in station 4.

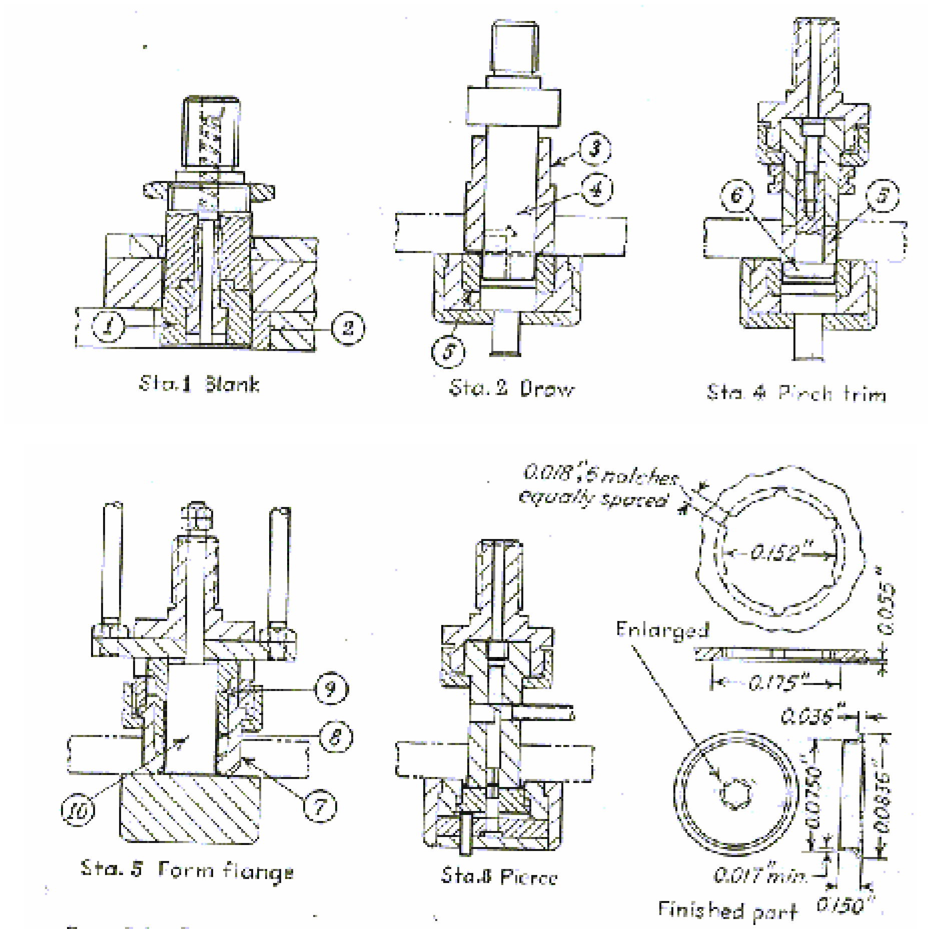


Fig 2.2c part drawing and dies to produce 0.5 mm thick brass barrel on an eyelet machine.

The pinch–trim punch (D5) has a replaceable hardened – steel tip held in place by the pilot (D6). The die at this station has carbide insert. Stations 2,3, and 4 have an ejector to lift the part to the level of the transfer fingers so that it can be moved to the next station. The operations in stations 5 and 6 are performed at the level of transfer and do not require ejectors

At station 5, the part is held in the forming die (D7) while the sleeve (D8), actuated by the sleeve retainer (D9), forms the flange. The punch (D10) guides the inside of the part and holds the bottom flat.

The part is seized in station 6, and an area in the bottom is coined 0.15 mm deep and 4.5 mm, in diameter in station 7. The hole is pierced in the bottom of the cup at station 8.

2.21 Forming an aluminum guide :

The 0.5 mm thick aluminum guide shown in fig 2.2d view A, is made in eight stations on a eyelet machine. The 24.9 mm diameter blank is produced in the first station from 26.2 mm wide, strip stock. The first forming operation on the recess is performed in the second station by the tools in view B. The drawn recess appears to have tapered walls because of a 0.8 mm draw radius and a 1.2 mm punch – nose radius. The flange has a 20° taper for a diameter of about 19 mm ., and the remainder is allowed to wrinkle slightly to facilitate forming the grooves in station 3. This forming punch has an insert to square and set to depth the recess started in station 2. The assembly of the punch and die for station 3 is shown in view C.

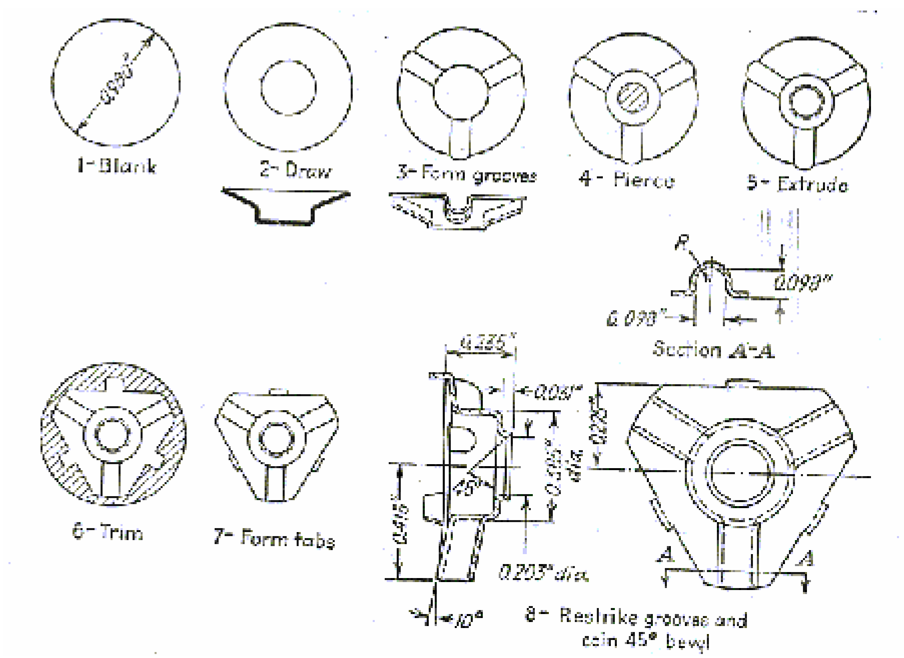


Fig 2.2d - VIEW A

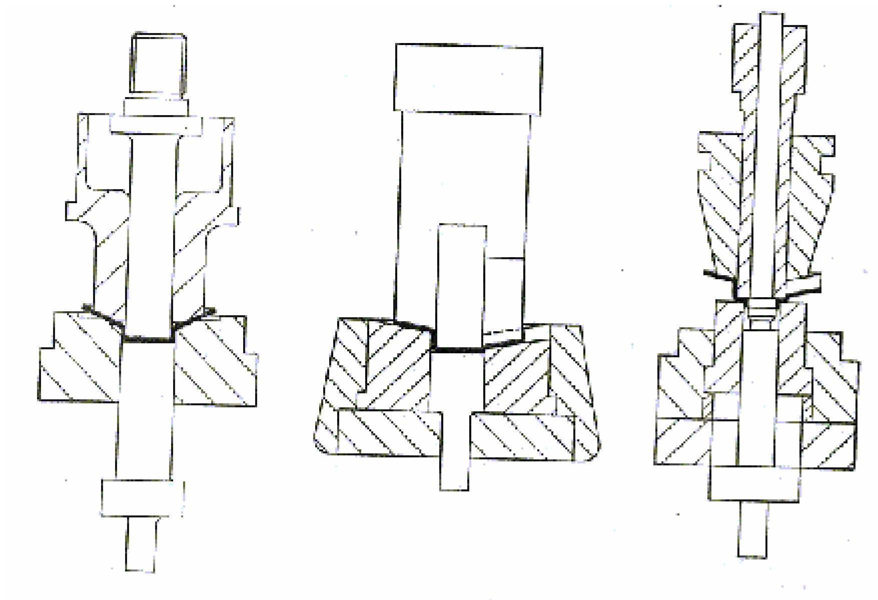


Fig 2.2d - VIEW B stage 2 VIEW C stage 3 VIEW D stage 5

At station 4, a 0.166 in diameter hole is pierced in the bottom of the cup, and a flange is formed around this hole in station 5 by the tools shown is view D. The trimming of the periphery is accomplished in station 6, and the forming of the tabs is done is station 7. In station 8, the grooves are restruck, while the lower edge of the flanged hole is coined t height and to the 45° bevel.

2.3 Materials for Eyelet Drawing

All materials which comes under the group of ductile materials can be eyelet drawn. Ductile materials includes both ferrous and non-ferrous.

Some of the important ferrous ductile materials that are used for eyelet drawing process are -

a) Steel

b) Steel, deep drawing quality

c) Steel, Stainless

d) Deep Draw Steel

e) Extra Deep Draw Steel

Some of the important non-ferrous ductile materials that are used for eyelet drawing process are -

a) Aluminum, Soft

b) Aluminum, deep drawing quality

c) Brass,

d) Copper

e) Zinc

f) tin

2.4 Capabilities in eyelet drawing

Rounds, Tapers, Ovals, Squares Other Irregular Shapes.

Secondary Operations which can be incorporated into primary tooling including:

Threading, Beading, Bottom Piercing, Reverse Drawing, Step, Drawing, Bumping, Fluting, Curling, Necking, Side Lettering, Bottom Flanging, Bulging, Side Piercing, Knurling

2.5 Companies Manufacturing Eyelet Drawing products

Some of the important companies that manufactures eyelet drawing products are

a) Platt Brothers and Company

United States and Canada

b) Gem Manufacturing

United States

c) Press Comp Industries

Peenya, Bangalore, India

----- etc

2.6 Comparison between Deep Drawing and Eyelet Drawing

Sl No	Deep Drawing	Eyelet Drawing
1	Deep drawing is a stage tool process	Eyelet drawing is progressive tool process
2	Separate tools are involved to have separate stage operations.	Only one progressive tool is involved to have all the operations.
3	Designed for only large components	Specially designed for small capsule shaped components.
4	Cost is more	Cost is less
5	Hydraulic press technology is adopted	Transfer press technology is adopted
6	Bigger features necessitate thick tooling subjected to less cyclic shocks, less degradation and less breakage of tools	Small or thin features necessitate very thin tooling, which is subject to intense, cyclic shocks that can lead to tool degradation and breakage.
7	Tool set up time is more to get the final component	Tool set up time is less to get the final component
8	Necessary finishing operations (grinding, polishing etc) of thicker tooling are not so delicate	Necessary finishing operations (grinding, polishing etc) of thinner tooling are more delicate
9	Removes the material from the material strip at the first operation	Removes the finished part from the material strip immediately before ejection from the press
10	Takes more time to complete the full process of component	Takes less time to complete one full process of component
11	Producing big features requires less careful press set up	Producing small features requires more careful press set up
12	No material feeding is required, but the blank material is kept blindly	Manual or Automatic feeding for transfer of component is required

2.7 Graphical representation of deep drawing and eyelet drawing

2.71 U.T.S Vs Strain

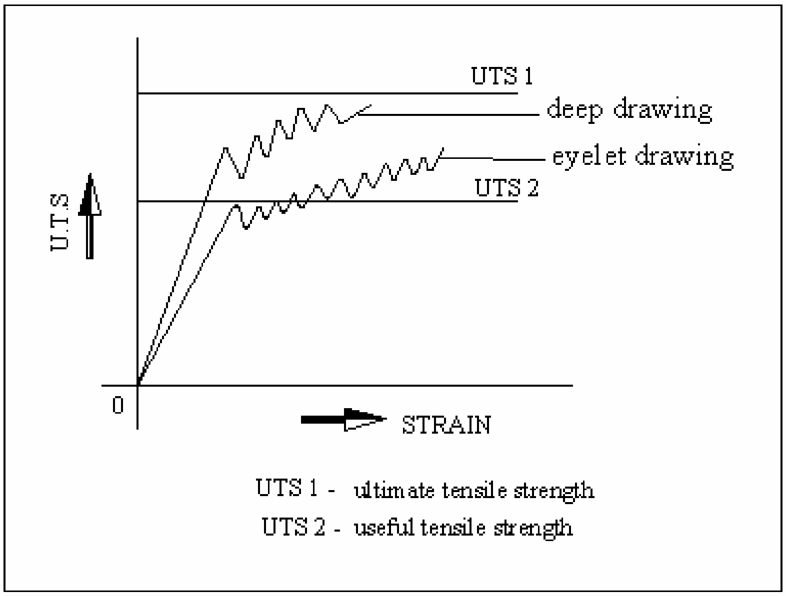


fig 2.7a graph of U.T.S vs Strain

A graph of U.T.S. vs Strain is drawn, just as an example to indicate the behavior of Deep Drawing and Eyelet Drawing.

The curve for Deep Drawing indicates five stages of draw, to which the drawing operation takes place between useful tensile strength and ultimate tensile strength. It clearly indicates that, after fifth draw i.e. in the sixth draw the component gets cracked. In order to eliminate the cracking of component, annealing of component between the fifth and sixth draw is done, so that the component is got without cracking and further increase in the depth of draw.

Similar to deep drawing, the curve for eyelet drawing is also drawn, just as an example. As in the eyelet drawing, the length of draw will be very high compared to the shell diameter, therefore, the number of draws will be more than double the number of deep drawing.

In the graph indicated, there are ten draws, over which, at each and every step of redrawing, a very small amount of height is increased, indicating a very less amount strain to the component and at each redraw some amount of U.T.S. is increased.

After tenth draw, the component may be subjected to further two or three draws so that further increase in height is achieved. And, after this extra, two or three draws, if further draw is done, then the curve may touch the U.T.S. point and indicates the cracking of component. In order to eliminate the cracking, the component is subjected to annealing between thirteenth and fourteenth draw, so that further height is increased.

2.72 Strain Hardening Vs Percent Reduction

After each differential of draw depth, the material has a new group of physical properties resulting from cold working. Elastic limit, hardness, yield point, and to a lesser extent, ultimate strength are increased and plastic range is thereby decreased. The total depth of draw is not limited by the plastic range; only the depth in one operation I thus restricted. Annealing may be resorted to after a draw to restore, almost entirely, the original plasticity.

The use of strain-hardening curves to discover the extreme unit stress of a shell after an operation is illustrated in fig 2.7 b. The straight line curve was drawn for a material having a modulus of strain hardening Sx of 110,000 psi, an initial yield point Sy, of 50,000 psi, and a maximum yield point Sz of 90,000 psi.

A reduction of 40 percent of the blank diameter was used for the first draw, and a reduction of 20 percent, of the shell diameter produced in the first draw was used for the second draw. This is a total reduction of 52 percent for the two draws. After the strain-hardening line (O-Sx) is plotted, a line is drawn from the 40 percent point on the X-X axis to point Sx.

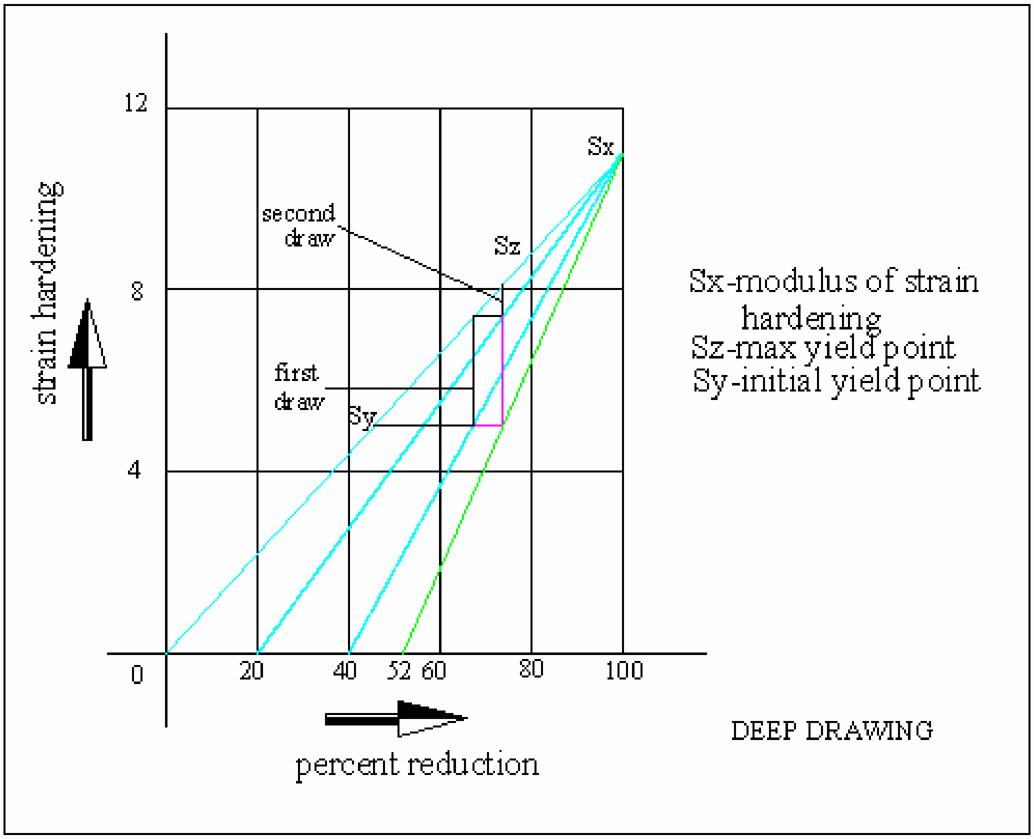


fig 2.7 b strain hardening vs percent reduction (deep drawing)

From point Sy extend a horizontal line until it intersects line (40 percent Sx). From this intersection, extend a vertical line up to the strain-hardening line (O-Sx). This intersection determines the approximate psi value of the yield point after the completion of the first draw. By using the same procedure and the new yield point, the unit stress after the second draw can be determined. Note that, when the vertical line of the second draw is extended downward, it intersects the horizontal line from Sy on the line between the 52 percent point and the point Sx. Considering that the total reduction is above 50 percent and that the unit stress after the second draw moved close to the maximum yield point, raising the possibility of high scrap loss because the shell fractures at local weak points, an annealing operation may be advisable between first and second draw.

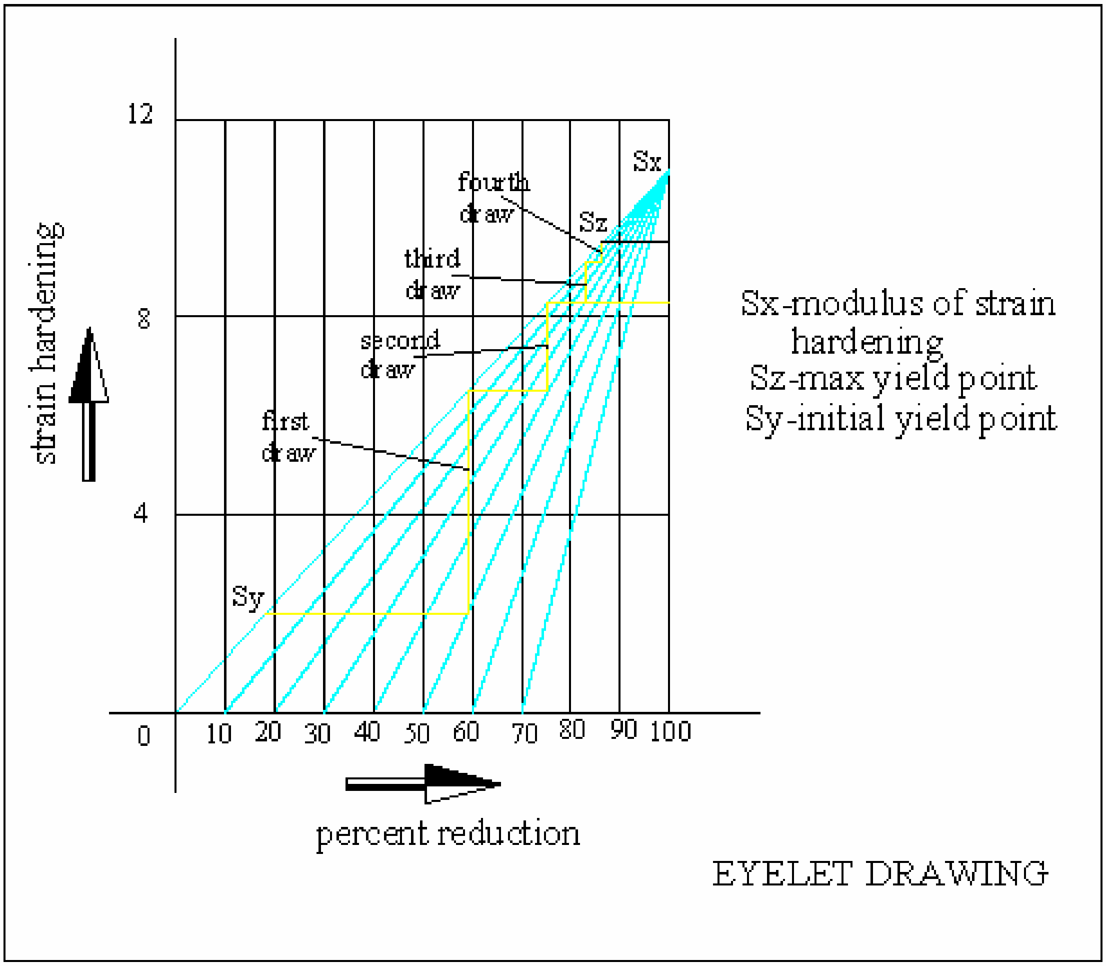


fig 2.7 c strain hardening vs percent reduction (eyelet drawing)

Similarly for the eyelet drawing, involving the more number of draw stages compared to deep drawing, is indicated in the graph. From the graph it clearly indicates the fourth draw point is very close to the maximum yield point and a annealing operation is introduced between third and fourth draw so that a further increase in length of height is done.

CHAPTER 03

CALCULATIONS

CHAPTER 03

CALCULATIONS

3.1 METHOD 1

Calculation of no of draws required, diameter and heights of respective draws.

If we start from the finished product, referring to the fig, it is clear that de,d1,d2, etc, and he,h1,h2, etc, are expressed in terms of he(and ht) by the following empirical formula,

h1=he(1-0.04x1), h2=he (1-0.04x2), ----------- etc.

In general, hn= he(1-0.04xn) where 'n' is the no of stage, preceding the component

similarly, $d1=de+0.1x1^2$, $d2=de+0.1x2^2$, etc

In general, $dn=de+0.1xn^2$ with usual notations.

The process of calculating d1,h1 and d2,h2, is continued, till dn=2hn. The 'n' corresponding to this stages, determines, no of stages involved. This empirical formula holds good for stock material from 0.25 to 0.5 thick.

Example :- calculate the no of draws and intermediate dimensions, to produce the component of Ø 5mm, height = 18mm, and 0.3mm thick.

Solution :- $dn=de+0.1n^2$

hn=he(1-0.04xn)

$d1=de+0.1xn_1^2$	h1=he(1-0.04xn1)
$=5+0.1x1^2$	=18(1-0.04x1)
=5+0.1	=18(0.96)
=5.1	=17.28
$d2=de+0.1xn_2^2$	h2=he(1-0.04xn2)
$=5+0.1x2^2$	=18(1-0.04x2)
=5+0.4	=18(0.92)
=5.4	=16.56
$d3=de+0.1xn_3^2$	h3=he(1-0.04xn3)
$=5+0.1x3^2$	=18(1-0.04x2)

$=5+0.9$ $=18(0.88)$

$=5.9$ $=15.84$

$d4=5+0.1xn_4^2$ $h4=18(1-0.04xn4)$

$=6.6$ $=15.12$

$d5=5+0.1xn_5^2$ $h5=18(1-0.04xn5)$

$=7.5$ $=14.4$

$d6=5+0.1xn_6^2$ $h6=18(1-0.04xn6)$

$=8.6$ $=13.68$

$d7=5+0.1xn_7^2$ $h7=18(1-0.04xn7)$

$=9.9$ $=12.96$

$d8=5+0.1xn_8^2$ $h8=18(1-0.04xn8)$

$=11.4$ $=12.24$

$d9=5+0.1xn_9^2$ $h9=18(1-0.04xn9)$

$=13.1$ $=11.52$

$d10=5+0.1xn_{10}^2$ $h10=18(1-0.04xn10)$

$=15$ $=10.8$

$d11=5+0.1xn_{11}^2$ $h11=18(1-0.04xn11)$

$=17.1$ $=10.08$

$d12=5+0.1xn_{12}^2$ $h12=18(1-0.04xn12)$

$=19.4$ $=9.36$

there fore 12 stages are necessary

By inspection we notice that, d12= 19.4 is approximate 2h12.

Hence process of calculation is to be stopped at 12.

For providing blanks, calculations are based on the initial cup dimensions, and not on those of the component. It obviously provides more materials which automatically forms collar. For eg. In the foregoing eg. If the blank Ø is determined, based on the component, then D=19.62mm. From this blank, forming initial shallow cup of 19.4Ø, and 9mm deep, is not possible for the initial draw.

Blank Ø $d = v(d_{12}2)^2 + 4d_{12}xh1^2$

d = (19.4)2 + 4x19.4x9.36 = Ø33.21 mm

In actual practice, manufacturing all the punches and dies, is not necessary. To start with punches and dies corresponding to d12,h12, _ _ _ _ _ d8,h8, _ _ _ _ _ d4,h4, _ _ _ _ _ d1,h1 etc,may be prepared leaving space for the others stages blank. If material undergoes deformation at any stage, intermediate punch and dies, are introduced in the tool. If no deformation takes place, the tool is left with intermediate idler stages. It makes the tool economical. Thus in practice, though various stage dims are empirically calculated the tool is finished on trial and error passes. The advance of strip is given by the formula, p=1.15xdi

Where di = initial Ø .

In this ex, it corresponds to p= 1.15x33.2=38.2.

Naturally this pitch is maintained between following stages too.Width of the strip is calculated, after calculating the blank dims.

For drawing operation width of the strip=blank Ø + allowance of about 2 mm(total).

In the present example, blank Ø = 33.2

Width = 33.2+2 = 35.2

3.2 METHOD 2

Calculation of number of draws, draw ratio

Experiments coupled with trials, lead to the right blank development. According to thumb rule, we decide the drawing contour through the circumference of the blank. And obtain an approximate value for the draw ratio

$$\text{Therefore draw ratio} = m = \frac{\text{circumference of the drawn part}}{\text{circumference of the blank}}$$

We have to remember generally that thinner sheet have unfavorable draw ratio than thicker ones.

The majority of the drawn parts are in the thickness range of 0.75 to 1.5 mm

In addition to the draw ratio we have to be aware of the ratio of blank diameter to sheet thickness, while determining the number of draws.

If you want to draw in one stage to save the tooling and operation cost, we may have to consider additional processing of materials like bondorising (phosphating) etching , annealing.

m is the function of blank diameter, drawn diameter, thickness (0.97 is the standard.)

It must be remembered that the most favorable number of drawing stages are the least material stress can be achieved when in subsequent draws.

$$n = \text{number of draws} = \frac{\text{length of drawn component}}{0.97 \times \text{diameter of drawn component}}$$

$$n = \text{number of draws} = \frac{335}{0.97 \times 24} = 14.39 \sim 14 \text{ stages}$$

Under no circumstances should the value of m be less than that of the previous draw. In the case depicted, after the fourth draw more favorable draw ratios have been tried which automatically led to the reduction of drawing steps of 10.

It is to be noted that the difference b/w the length 'hm' of the last drawing stage and the finished length of drawn part made compulsory by the + tolerance of the sheet.

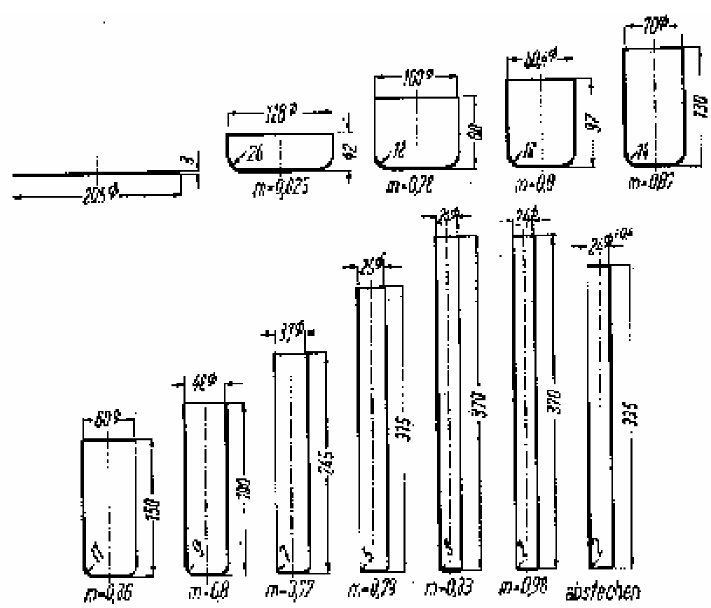


Fig 3.2

CHAPTER 04

APPLICATIONS

CHAPTER 04

APPLICATIONS

4.1 Introduction

Eyelet drawing is one of the major applications in the mechanical, electronic, automobile field, leather industry etc. As the name itself suggests, the components are small in size.

4.2 General Applications

Some of the general eyelet drawing applications used are discussed below.

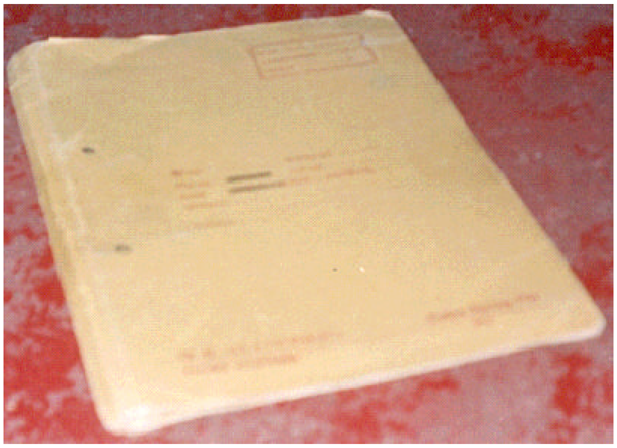
4.21 PAPER FILE

Properties

a) good stiffness

b) resistance to wear

c) good grip to hold paper, documents etc.



4.22 AIR PILLOW

Properties

a) good stiffness

b) resistance to wear

c) to make a connection for thread to pass in

4.23 CAP

Properties

a) air vent

b) resistance to wear

4.24 PAPER CARRY BAG

Properties

a) good stiffness

b) resistance to wear

c) with stand more load

4.25 CARRY BAG

Properties

a) good stiffness

b) resistance to wear

c) with stand more load

4.26 BELT

Properties

a) good stiffness

b) resistance to wear

c) to hold the buckle in correct location

4.27 HAIR BAND

Propertie

a) good stiffness

b) resistance to wear

c) good grip to hold hair

4.28 PHOTO ALBUM

Properties

a) good stiffness

b) resistance to wear

c) to hold the photo covers in good position

4.29 CALENDAR

Properties

a) good stiffness

b) resistance to wear

c) to easily mount on wall

4.30 LADIES BAG

Properties

a) to have a aesthetic approach

4.31 BERMUDA

Properties

a) good stiffness

b) resistance to wear

c) to have a free movement of thread for tightening and loosening

4.32 LUNCH BAG

Properties

a) good stiffness

b) resistance to wear

c) to load and unload the Tiffin box easily

4.33 SHOES and SLIPPERS

Properties

a) good stiffness

b) resistance to wear

c) to insert the lace easily

4.34 T-SHIRT

a) good stiffness

b) resistance to wear

c) to tighten and untighten the thread when ever required in both neck and bottom portion

4.35 STATIONERY BAG

Properties

a) good stiffness

b) resistance to wear

c) to hold the thread in good position for mounting

4.36 TRACK PANT

Properties

a) good stiffness

b) resistance to wear

c) to tighten and loosen the thread connection in the bottom portion

4.37 HANGING OF BINDIS,

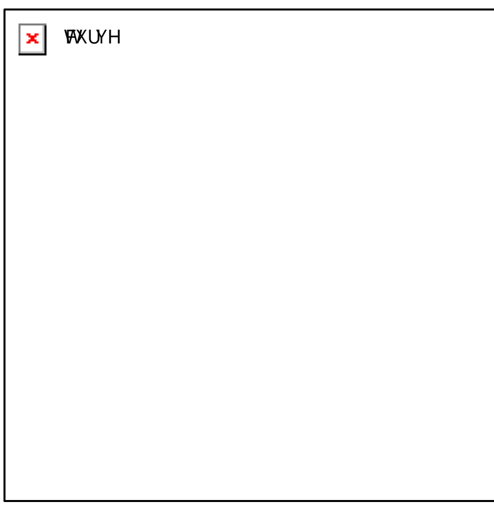
Properties

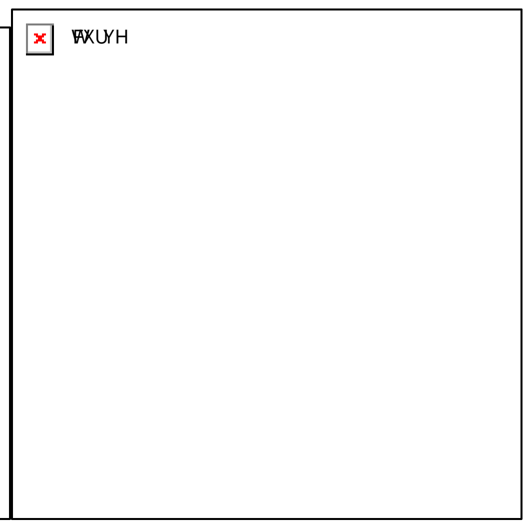
a) good stiffness

b) resistance to wear

c) to easy mounting on wall

4.38 LADIES FANCY BOOT





Properties

a) good stiffness

b) resistance to wear

c) to tighten and loosen the lace inside this eyelet

CHAPTER 05

CASE STUDY

CHAPTER 05

CASE STUDY

Eyelet drawing sheet metal processes have been developed as low cost tooling methods in many industries. They find wide applications by the way of improving tool for many sheet metal parts where the drawing limits of the metal are limited and it becomes necessary to form parts in progressive tool.

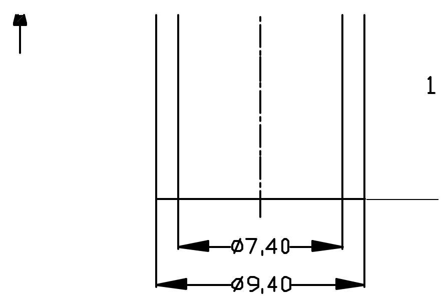
An interesting example of use of eyelet drawing to reduce cost as well as improving the tooling is discussed in this case study work.

The following sections describes the different steps of this case study work.

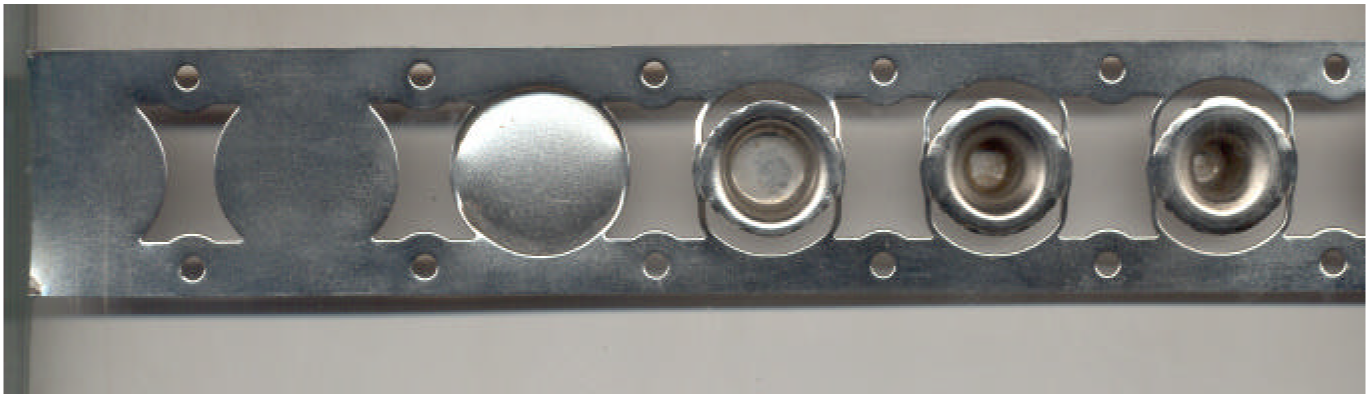
5.1 Material Specifications

Component	: Not known
Material	: CRCA (Cr coated)
Strip width	: 36.50
Strip length	: 8
Material thickness	: 1 mm
Company	: Wire Form, Bangkok, Thailand.
Pitch	: 34 mm

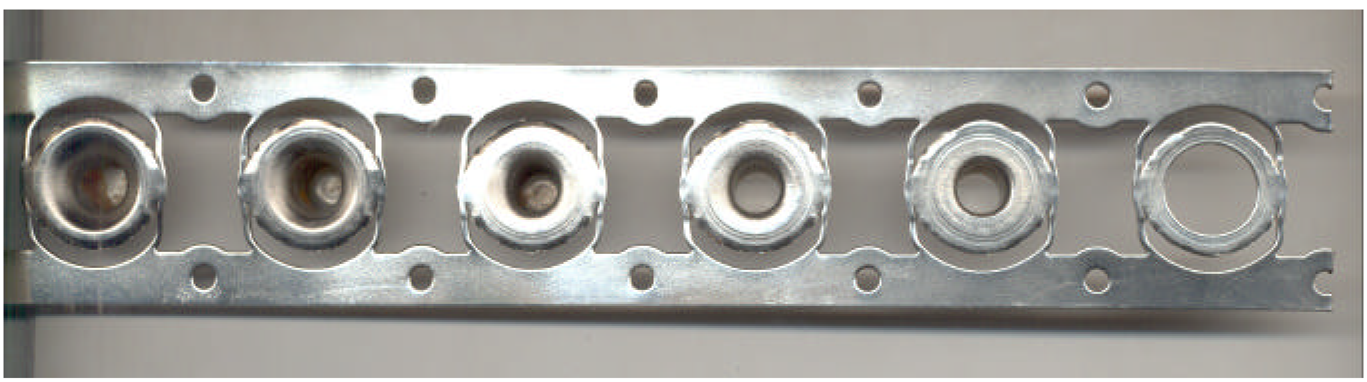
5.2 Component Drawing



5.3 Strip Layout



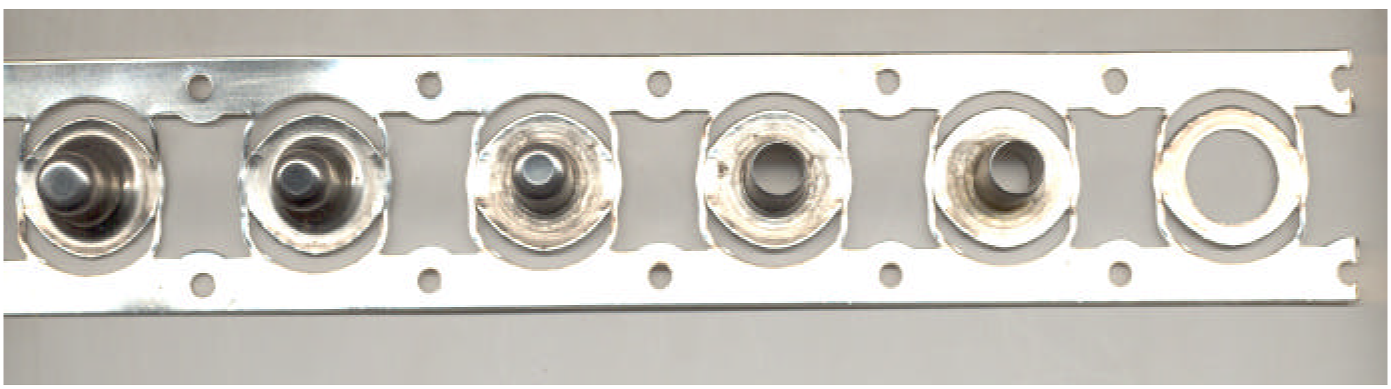
I STAGE	II STAGE	III STAGE	IV STAGE	V STAGE	VI STSAGE
Piercing	Idle Stage	Lancing	First Draw	Second Draw	Third Draw



V STAGE	VI STAGE	VII STAGE	VIII STAGE	IX STAGE	X STSAGE
Second Draw	Third Draw	Fourth Draw	Piercing	Flattening	Trimming

STRIP LAYOUT - BOTTOM VIEW

I STAGE	II STAGE	III STAGE	IV STAGE	V STAGE	VI STSAGE
Piercing	Idle Stage	Lancing	First Draw	Second Draw	Third Draw



V STAGE	VI STAGE	VII STAGE	VIII STAGE	IX STAGE	X STSAGE
Second Draw	Third Draw	Fourth Draw	Piercing	Flattening	Trimming

STRIP LAYOUT - TOP VIEW

The Strip Layout involves ten stages, each and every step of the process is described as below. The following are the steps involved in the strip layout process and discussed as stage wise.

Stage I

In the I stage, a piercing of Ø3.5 of 2 holes is done and another piercing of the required profile is done. The piercing of 2 holes are done to guide the strip for each and every step and another piercing of required profile is done to have the blank profile in the II stage.

Stage II

The second stage is the idle stage for the lancing operation in the third stage.

Stage III

The third stage involves the operation of lancing. This lancing of strip, to the required profile of the blank diameter of Ø24.9 is done to have the easy material flow in the forthcoming stages of drawing.

Stage IV

In the fourth stage, the lanced part takes the initial draw of the component with a very less amount of material flow, i.e. the component takes the dimensions of Drawing Height = 7.50mm, Shell Diameter = Ø13.15mm.

Stage V

The fifth stage involves another drawing operation, where further flow of material is carried on. In this the height of draw is increased from 7.5mm to 10.9mm and diameter of the shell is decreased from Ø13.15mm to Ø7.8mm.

Stage VI

The sixth stage involves another drawing operation, where further flow of material is carried on. In this the height of draw is increased from 10.9 mm to 11.4 mm and diameter of the shell is decreased from Ø7.8 mm to Ø7.6 mm.

Stage VII

The seventh stage involves some drawing and flattening operation above the component so that the height of draw is decreased from 11.4 mm to 10.7 mm and diameter of the shell is decreased from Ø7.6 mm to Ø7.5 mm.

Stage VIII

The eighth stage involves some drawing and piercing operation in the component, so that the height of draw is decreased from 10.7 mm to 10.6 mm and diameter of the shell is decreased from Ø7.5 mm to Ø7.4 mm.

Stage IX

The ninth stage involves flattening operation in the component, so that the height of draw is decreased from 10.6 mm to 10.3 mm and diameter of the shell is not altered.

Stage X

The tenth stage involves trimming and a very small amount of drawing operation in the component, so that the height of draw is decreased from 10.3 mm to 10.2 mm and diameter of the shell is not altered. A trimming of Ø13.9 mm is done and the required component is got out.

5.4 Calculations

5.41 Practical Calculations

5.411 Draw Dimensions

I STAGE - Piercing 2 holes of Ø3.5 mm and center piercing of required profile

II STAGE - Idle stage

III STAGE - Lancing operation - Blank Diameter = Ø24.90 mm

IV STAGE - Drawing - Height = 7.50 mm, Diameter = Ø 13.15 mm

V STAGE - Drawing - Height = 10.90 mm, Diameter = Ø 7.80mm

VI STAGE - Drawing - Height = 11.40 mm, Diameter = Ø 7.60 mm

VII STAGE - Drawing - Height = 10.70 mm, Diameter = Ø 7.5 mm

VIII STAGE - Piercing and Drawing - Height = 10.60 mm, Diameter = Ø 7.4 mm

IX STAGE - Drawing - Height = 10.30 mm, Diameter = Ø 7.4 mm

X STAGE - Trimming - Diameter = 13.90 mm

Total number of stages = n = 10 STAGES

5.412 Force Calculations

I STAGE - Piercing 2 holes of Ø3.5 and center piercing of required profile

tmax = shear strength = 28 kg/mm$_2$

t = thickness = 1 mm

Force for piercing 2 holes = Fp = tmax * p * t * n

p = perimeter = 3.14 * 3.5 = 10.99mm

Fp = 28 * 10.99 * 1 * 2 = 615.44 kgs

Fp = 0.615 tons

Force for piercing the required profile = Fp = tmax * p * t * n

p = perimeter = 24.90/2 + 16*2 = 44.45 mm

Fp = 28 * 44.45 * 1 * 1 = 1244.6 kgs

Fp = 1.244 tons

Total force for piercing Ft = 0.615 + 1.244

Ft = 1.859 tons

II STAGE - Idle stage

III STAGE - Lancing operation - Blank Diameter = Ø24.90

Force for lancing = Fp = tmax * p * t * n

p = perimeter = 3.14 * 24.90 = 78.186 mm

Fp = 28 * 78.186 * 1 * 1

Fp = 2189.20 kgs

Fp = 2.189 tons

IV STAGE - Drawing - Height = 7.50 mm, Diameter = Ø 13.15 mm

Su - ultimate tensile strength = 45 kg/mm^2

Sy - yield strength = 25 kg/mm^2

t - thickness = 1 mm

Force for Drawing = Fp = ? * d * t * (Su + Sy)/2

d - shell diameter = Ø13.15 mm

Fp = ? * 13.15 * 1 * (45 + 25)/2

Fp = 1445.91 kgs

Fp = 1.445 tons

Blank holding pressure Fb = 0.3 * Fp

Fb = 0.3 * 1.445

Fp = 0.4335 tons

Total force Ft = 1.445 + 0.4335

Fb = 1.8785 tons

V STAGE - Drawing - Height = 10.90 mm, Diameter = Ø 7.80 mm

Force for Drawing = Fp = ? * d * t * (Su + Sy)/2

d - shell diameter = Ø7.80 mm

Fp = ? * 7.80 * 1 * (45 + 25)/2

Fp = 857.65 kgs

Fp = 0.857 tons

Blank holding pressure Fb = 0.3 * Fp

Fb = 0.3 * 0.857

Fp = 0.2571 tons

Total force Ft = 0.857 + 0.2571

Fb = 1.1141 tons

VI STAGE - Drawing - Height = 11.40 mm, Diameter = Ø 7.60 mm

Force for Drawing = Fp = ? * d * t * (Su + Sy)/2

d - shell diameter = Ø7.60 mm

Fp = ? * 7.60 * 1 * (45 + 25)/2

Fp = 835.66 kgs

Fp = 0.835 tons

Blank holding pressure Fb = 0.3 * Fp

Fb = 0.3 * 0.835

Fp = 0.2505 tons

Total force Ft = 0.835 + 0.2505

Fb = 1.0855 tons

VII STAGE - Drawing - Height = 10.70 mm, Diameter = Ø 7.5 mm

Force for Drawing = Fp = ? * d * t * (Su + Sy)/2

d - shell diameter = Ø7.50 mm

Fp = ? * 7.50 * 1 * (45 + 25)/2

Fp = 824.66 kgs

Fp = 0.824 tons

Blank holding pressure Fb = 0.3 * Fp

Fb = 0.3 * 0.824

Fp = 0.2472 tons

Total force Ft = 0.824 + 0.2472

Fb = 1.0712 tons

VIII STAGE - Piercing and Drawing - Height = 10.60 mm, Diameter = Ø 7.4 mm

tmax = shear strength = 28 kg/mm2

t = thickness = 1 mm

Force for piercing a holes = Fp = tmax * p * t * n

p = perimeter = 3.14 * 7.4 = 23.24 mm

Fp = 28 * 23.24 * 1 * 1

Fp = 650.72 kgs

Fp = 0.650 tons

Force for Drawing = Fp = ? * d * t * (Su + Sy)/2

d - shell diameter = Ø7.40 mm

Fp = ? * 7.40 * 1 * (45 + 25)/2

Fp = 813.67 kgs

Fp = 0.813 tons

Blank holding pressure Fb = 0.3 * Fp

Fb = 0.3 * 0.813

Fp = 0.2439 tons

Total force Ft = 0.650 + 0.813 + 0.2439

Fb = 1.7069 tons

IX STAGE - Drawing - Height = 10.30 mm, Diameter = Ø 7.4 mm

Force for Drawing = Fp = ? * d * t * (Su + Sy)/2

d - shell diameter = Ø7.40 mm

Fp = ? * 7.40 * 1 * (45 + 25)/2

Fp = 813.67 kgs

Fp = 0.813 tons

Blank holding pressure Fb = 0.3 * Fp

Fb = 0.3 * 0.813

Fp = 0.2439 tons

Total force Ft = 0.813 + 0.2439

Fb = 1.0569 tons

X STAGE - Trimming of Ø 13.90 mm

Force for Trimming = Fp = tmax * p * t * n

p = perimeter = 3.14 * 13.90 = 43.66 mm

Fp = 28 * 43.66 * 1 * 1

Fp = 1222.48 kgs

Fp = 1.222 tons

Total Force = Ft = 13.18 tons

Considering a stripping force of 25% of total force

Stripping force Fs = 0.25 * 13.18

= 3.295 tons

Total Force = Ft = 13.18 + 3.295

= 16.475 tons

Considering a f.o.s of 1.25

Total force Ft = 1.25 * 16.475 = **20.29 tons**

Hence from the above calculations it is clear that the total number of stages of operation are ten stages and the total amount of force required to make all the stages of operation is equal to 20.29 tons.

5.42 Theoretical Calculations

5.421 To calculate number of Draws

If we start from the finished product, referring to the component, it is clear that de,d1,d2, etc, and he,h1,h2, etc, are expressed in terms of he(and ht) by the following empirical formula, h1=he(1-0.04x1), h2=he)1-0.04x2), ----------- etc.

In general, hn= he(1-0.04xn) where 'n' is the no of stage, preceding the component similarly, $d1=de+0.1x1^2$, $d2=de+0.1x2^2$, etc

In general, $dn=de+0.1xn^2$ with usual notations.

The process of calculating d1,h1 and d2,h2, is continued, till dn=2hn. The 'n' corresponding to this stages, determines, no of stages involved.

I STAGE -	$d1 = de+0.1xn_1^2$	h1 = he(1-0.04xn1)
	$= Ø7.4+0.1x1^2$	= 10.2(1-0.04x1)
	= Ø7.4+0.1	= 10.2(0.96)
	= Ø7.5	= 9.792 mm
II STAGE -	$d2 = de+0.1xn_2^2$	h2 = he(1-0.04xn2)
	$= Ø7.4+0.1x2^2$	=10.2(1-0.04x2)
	= Ø7.4+0.4	=10.2(0.92)
	= Ø7.8	= 9.382
III STAGE -	$d3 = de+0.1xn_3^2$	h3 = he(1-0.04xn3)
	$= Ø7.4+0.1x3^2$	=10.2(1-0.04x2)
	= Ø7.4+0.9	=10.2(0.88)
	= Ø8.3 mm	=8.976
IV STAGE -	$d4 = Ø7.4+0.1xn_4^2$	h4 = 10.2(1-0.04xn4)
	= Ø9.0 mm	= 8.568
V STAGE -	$d5 = Ø7.4+0.1xn_5^2$	h5 = 10.2(1-0.04xn5)
	=Ø9.9 mm	= 8.16 mm
VI STAGE -	$d6 = Ø7.4+0.1xn_6^2$	h6 = 10.2(1-0.04xn6)
	= Ø11 mm	=7.752 mm
VII STAGE -	$d7 = Ø7.4+0.1xn_7^2$	h7 = 10.2(1-0.04xn7)
	=Ø12.3 mm	= 7.344 mm
VIII STAGE -	$d8 = Ø7.4+0.1xn_8^2$	h8 = 10.2(1-0.04xn8)
	=Ø13.8 mm	= 6.936 mm

therefore 8 stages are necessary for drawing only.

By inspection we notice that, d8 = Ø13.8 is approximate 2h8.

Hence process of calculation is to be stopped at 8.

Other than drawing operations the component has to under go trimming, initial blanking, piloting if needed, piercing if needed in the component etc, then additional stages are adopted before or after the drawing operation.

For providing blanks, calculations are based on the initial cup dimensions, and not on those of the component. It obviously provides more materials which automatically forms collar. For eg. In the foregoing eg. If the blank Ø is determined, based on the component, then D = Ø13.8 mm . From this blank, forming initial shallow cup of Ø13.8 mm , and 6.9mm deep, is not possible for the initial draw.

Blank Ø d = v(d8)2 + 4d8xh8

d = v(13.8)2 + 4x13.8x6.9

d = Ø 23.90 mm

In actual practice, manufacturing all the punches and dies, is not necessary. To start with punches and dies corresponding to d8,h8, _ _ _ _ _ d4,h4, _ _ _ _ _ d1,h1 etc, may be prepared leaving space for the others stages blank. If material undergoes deformation at any stage, intermediate punch and dies, are introduced in the tool. If no deformation takes place, the tool is left with intermediate idler stages. It makes the tool economical. Thus in practice, though various stage dims are empirically calculated the tool is finished on trial and error passes. The advance of strip is given by the formula, p=1.15xdi

Where di = initial Ø .

In this ex, it corresponds to p= 1.15 x 23.90 = Ø 27.485 mm

Naturally this pitch is maintained between following stages too.

Width of the strip is calculated, after calculating the blank dims.

For drawing operation width of the strip = blank Ø + allowance of about 2 mm(total).

In the present example, blank Ø = 23.90

Width = 23.90 + 2 = 25.90mm

CHAPTER 06

CONCLUSION

CHAPTER 06

CONCLUSION

Eyelet drawing is a special technique of forming sheet metal. From soft materials like aluminum to hard alloys like stainless steels can be formed successfully. Variety of shapes have been formed to close tolerances with this technique. Eyelet drawing with flexible tooling offers advantages for short, medium and large production runs.

Eyelet drawing has come a long way since its inception as the deep drawing process. Eyelet drawing, sheet metal process has emerged as major forming technique for many industries. The quality of parts produced, surface finish, simplicity of tool and low cost have made this forming technique a highly popular among domestic uses.

In many industries, this forming technique is yet to make an impact. The process which involves many stages have hindered the applications of eyelet drawing.

The fast changing developments of eyelet drawing are concentrated towards reduction of number of stages and with improved cycle time.

The future of eyelet drawing, sheet metal process is bright considering the advancements being made, but many parts, components are replaced by some other reliable process.

REFERENCE

1. DIE DESIGN HAND BOOK - ASTME National Book Committee,
AMERICAN SOCIETY OF TOOL AND
MANUFACTURING ENGINEERS,
Detroit, MICH.

2. DIE DESIGN HAND BOOK - David A Smith - Editor,
Ramon Bakerjian - Staff Editor.

3. TOOL ENGINEERING PARAMETERS - Central Institute of Tool Design,
Hyderabad.

4. WESTERMANN TABLES - Hermann Jutz and Eduard Scharkus

5. PRESS TOOLS AND PRESS WORK - John A Waller

6. MASTER FILE FOR PRESS TOOL TECHNOLOGY -
Prepared by Dharwad Training Centre and
Approved by - Director (T)

7. METAL FORMING HAND BOOK - Schuler