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A REVIEW PAPER ONFORMING PROCESS OF PERFORATED SHEET METAL

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ABSTRACT: *Perforated sheet metal (PSM) is a technical advancement in manufacturing field. This paper focus on study about forming process of perforated sheet metal as well as effect of various parameters on forming process of perforated sheet metal such as properties of material, thickness of material, punch velocity, spring back force, etc.For reducing manufacturing cost, it is an important task to study about optimization of process parameters and reduced it. Different literature review spotlight on parameters that influence most in profound drawing process. From the study of these parameters, it's possible to get good quality of product.*

KEYWORDS**:** *Forming process, Perforated Sheet Metal (PSM), Optimization*

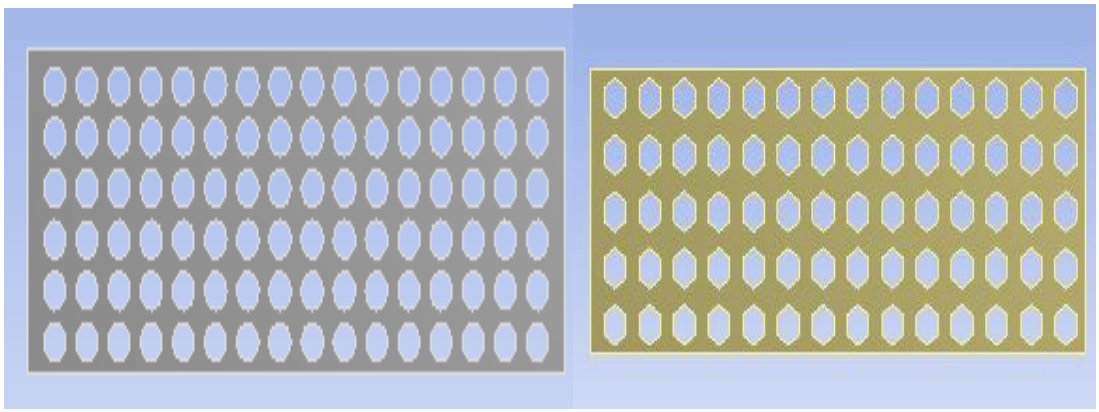
INTRODUCTION

Sheet metal forming process is used since many year ago. Produced sheet metal parts is used for many purpose such as, in automobile application , aerospace field, kitchen ware, etc. the forming of sheet metal for required shapes is mostly old technique. Sheet metal process is simple process in which metal formed into thin or flat pieces up to forming limit. Forming process of sheet metal depends on material of sheet metal, thickness of sheet metal, bending force, etc. during the forming process on sheet metal , the forming operation depend on various parameters its known as forming limits, such parameters are material properties, thickness of sheet metal, punch nose radii, blank (sheet metal) holding force, spring back force,[2]etc.

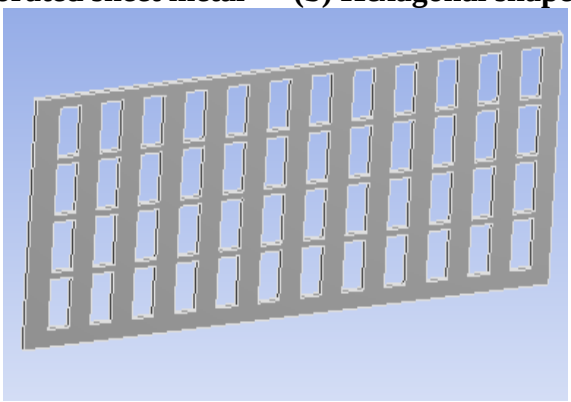
Dr. Waleed K. Jawad and Jamal H. Mohamed, **[13]** focused on effect of punch nose radius during deep drawing process, they work on to find out various effect on deep drawing operation of sheet metal due to different punch nose radii. In these work different 6 types of punch nose radius used to produce or form a cylindrical cup of 44 mm outer diameter, 28 mm height and 0.5 mm thickness of mild steel having 0.15% carbon content. Experiment was done on plain metal sheet with various punch nose radius and analyze what effect occurs. Punch nose radius selected for the 43 mm punch diameter was 3 mm, 6 mm, 9 mm, 15 mm, 18 mm, and 21.5 mm. However dies nose radius is kept 6 mm (constant). From this experiment concluded that for large value of punch nose radii used to deform material near the punch area more than that of cylindrical wall. However more thinning parts generated at large nose radii and punch stroke influences greatly the wall thickness and strain values in which those values increase with respect to increase in speed of stroke. If punch nose radii increase necking effect generated.

Figure 1: Various punch nose radius. [13]

Spring back force on perforated sheet metal induced by Yasuhide Nakayama, AlaraLadama, Shigeru Nayala and Takeji Abe, [15] Perforated sheet metal manufactured by various forming process on plain sheet metal with some accurate distance. Vimal N, Pridhar T, Viswanathan P and R. subramaniam[8] worked on "design and structural analysis of perforated sheet metal (PSM). In their point of view, perforated sheet metal is one type of sheet in which some perforations have been removed from metal. In PSM variety of design perforated sheet metal used for various purpose. However perforated sheet metal is industrial product which use in number of purpose such as, strainers in dying industries, wall, grills, stairways, ceilings, floors, conduits, etc. perforated sheet metal produced by standard punching machine, which including punch and die during punching operation for produce good quality perforated sheet metal.



(a) Round shaped perforated sheet metal (b) Hexagonal shaped perforated sheet metal



(c) Square shaped perforated sheet metal

Figure 2: Various PSM [8]

Venkatachalam G. [7] analyzed on square and hexagonal whole perforated sheet metal. He tested tensile tension test on both shaped perforated sheet metal. The result was, hexagonal plate has good load bearing capacity compare to square shaped. However opening area on perforated sheet metal also effect on strength and load bearing capacity During forming process on perforated sheet metal various parameters affected on deformed shape, such as material properties, bending load, thickness, velocity, punch nose radii, spring back force, etc. Spring back force studied by Yasuhide, Akira, Shigeru and Takeji Abe [15] , They focused on elastic and plastic limits of various material. Material properties importance for deformed perforated sheet metal For brittle material deformation was quite difficult compare to ductile material. In ductile material deformation was good due to arrangement and bonding properties of different works. This paper considers the perforated sheets with regularly distributed holes as a plane model for damaged materials. However , more stress distribution generation on perforated sheet metal compare to plain metal sheet, stress and strain distribution generated near at the hole area in perforated sheet metal more because of void created in plain metal sheet. Spring back force is an important parameter for forming process. V. Nasrollahi and B. Arezoo[11] studied about spring back force on perforated sheet metal. Spring back is an issue during forming operation. Spring back is defined as an action of sheet metal to go back in it's original position after forming process. Spring back force only occurs elastic limit. Factor affected on spring back force classified in two types.

1) Related to material properties, young modulus, yield stress, strength co-efficient, Poisson's ratio, etc.
2) Other factor related to bending process, tool, punch velocity, blank holder, and clearances. Etc.

Successful forming process depends on various parameters such as blank thickness, blank material, properties of material, punch, punch velocity, punch nose radii, bending force, spring back force, pressure pad, ect.

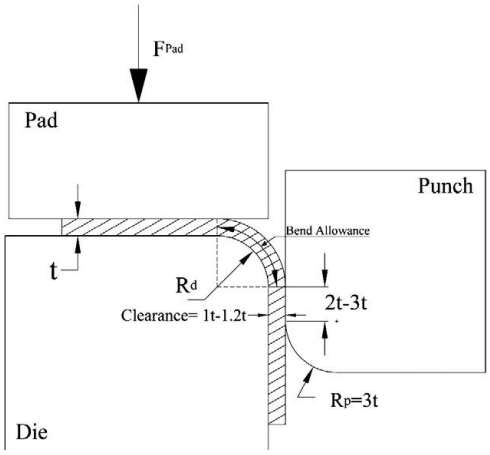


Figure 3: Wipe bending process [11]

However forming limit diagram is helpful to understand forming in sheet. Forming limit diagram (FLD) was studied by U. V. Mangudlcar and Dr. R. B. Hiremath**.** [6] They studied on punch nose radius, blank temperature, blank holding force, initial blank shape, an optimization strategy for the blank holder force (BHF) , spring back, etc. forming limit diagram (FLD) indicate, the sheet metal sustain load or material can sustain strains without failing. [10]

MATERIAL SELECTION

Material selection for forming process is one of best parameter for achieving desire shaped deform sheet metal component. Dr. Kartik D. Kothari and Dr. R. L. Jhala[1] were worked on to investigate and parametric analysis of steel perforated sheet metal. They worked on different four types of perforated sheet metal (PSM), having round and triangular shaped with square and triangular pattern. They examined on 0.8

mm, 1.2 mm, 1.6 mm thickness perforated sheet metal for 100 mm/s and 150 mm/s punch velocity. Total 36 experiments were carried out with help of universal testing machine (UTM). They experiment on different perforated sheet metal (PSM) for find out best stress sustained shaped in perforated sheet metal (PSM). They reasoned that biggest multi reaction execution record esteem 0.008(square-design) and 0.0063 (triangular-design) gave the required ideal parameters. Experimental investigations on the ballistic impact performances of sheet metals was carried out by A. Durmus, M. Guden, B. Gulcimen, S. Ulicu and E. Musa [12] on experiment work ballistic impact on plain metal sheet with help of trigger arrangement. In this setup material selection was low carbon cold rolled steel sheets having 1 mm and 2 mm thickness. Tested sheet was low carbon alloy steel sheet. Tensile test was carried out on plain metal sheet and result was highest ballistic limit was found in 2 mm thick plate at 332 m/s velocity of bullet. However lowest ballistic limit was occurs at 1 mm thickness plate at 97 m/s velocity of bullet.

EXPERIMENTAL SETUP

For analyze behavior of various shapes perforated sheet metal during forming process, experimental work have to carried out and taking various reading during forming process. Dirk Mohr, [14] researcher have experimented on sandwich sheet metal with perforated sheet metal. He selected 1 mm thin prototype structure for examination. He analyzed on two types of prototype sandwich sheet metal first one is Fiber core sandwich sheet (FCSS) material. In this material 0.2 mm thick austenitic stainless steel 316L face sheets were separated by 0.8 mm thickness of core material. Other one is perforated core sandwich sheet (PCSS) material. During this experimental work he analyzed that shear stress value required high for low carbon steel face sheets, approx. 28 MPa. Shear stress value increase with respect to thickness of faces sheet metal. Shear stress value for perforated sandwich sheet metal approx... 28% to 35% less compare to that of faced carbon steel

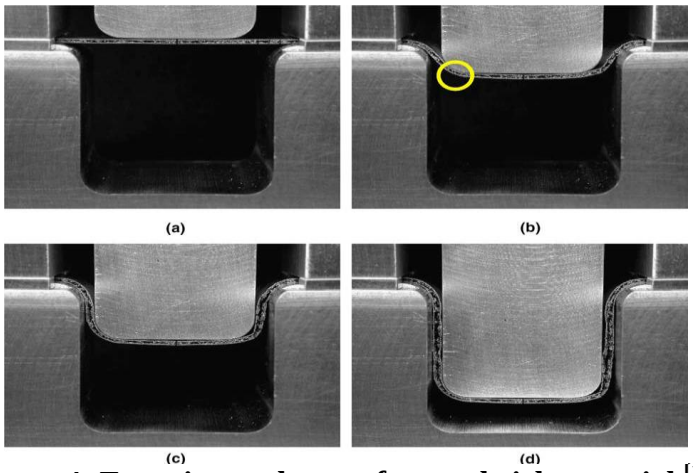
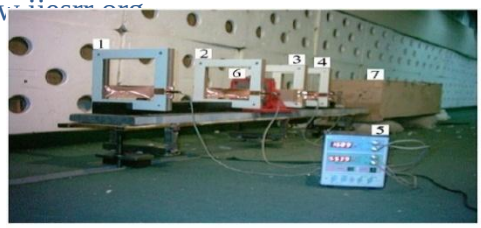
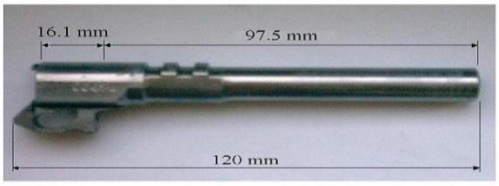


Figure 4: Experimental setup for sandwich material [14]

Ballistic impact performance of cold rolled was analyzed by A Durmus, M Gaden, B. Gulcimen, S. Ullal, E. Musa. [12] A projectile impact test was used to measure ballistic impact on sheet metal. Trigger system was utilizing to measure initial bullet velocity and finalize bullet velocity. A trigger system was connected with trigger. This all arrangement used to find out the shear stress effect on different bullets velocity.

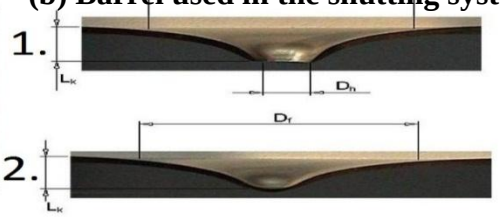


(a) Experimental setup



(b) Barrel used in the shutting system.

(c) Projectile of 9 mm × 19 mm

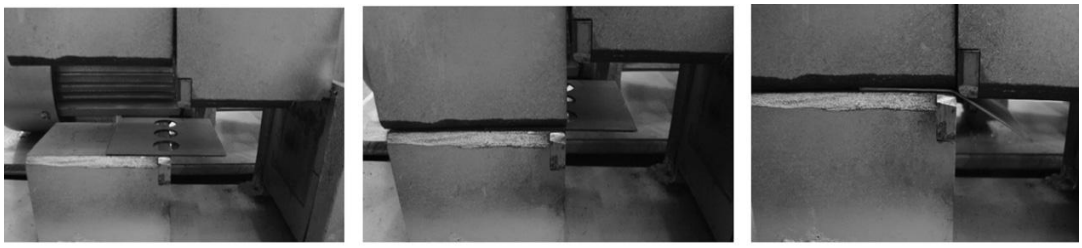


(d) I-perforated and II-non-perforated

Figure 5: Experimental Setup [12]

On other hand to study about spring back effect in perforated sheet metal was selected by V. Nasrollahi, B. Arezo, [11] they arranged die-punch setup for calculate and prediction of spring back force. They used wipe bending process, in which die radius is implemented. Pad used to apply holding force to blank. Some steps was used during this process, as shown in below

1. To check clearance and bending parameters.
2. Load work piece and apply holding force by pressure pad.
3. Travel punch by defining velocity at constant speed in down word direction and apply bending force.
4. After bending sheet metal remove punch by travel in upward direction.
5. Measure bending angle and examine all parameters
6.



(a) (b) (c)

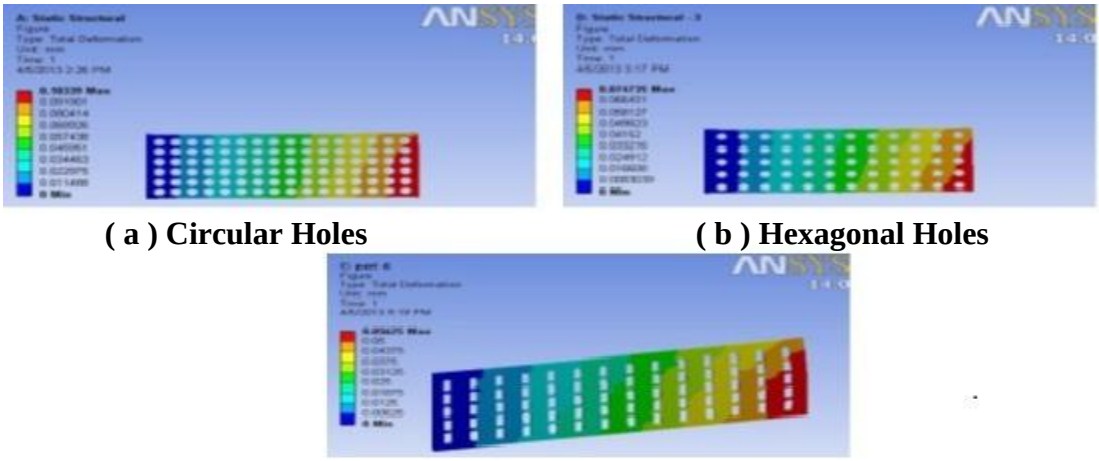
Figure 6: Arranged die-punch setup for spring back [11]

This all steps were used to find out spring back effect during forming process on sheet metal.

COMPUTATIONAL TOOLS

Design and structural analysis of perforated sheet metals by Vimal M. N, Pridhar, Viswanathan P and R Subramanian [7] They design perforated sheet metal and fabricated perforated sheet metal having three type of shape, hexagonal, square and round shaped for square pattern. Fabricated perforated sheet's modeling done with help of pro-engineering software Figure shows FEM using ANSYS software. Boundary condition was given as one end fixed and other end pulled position. 95 solid elements are selected after that material select from library was mild steel with 151 GPa young modulus and 0.28 Poisson ratio. After Appling all process required process parameter then run problem and conclude and collect results from simulation work. However to find out residual stress during deep drawing process several techniques used to find out residual stress. Dr. B. Linga Reddy, Dr. P. V. Ravindra Reddy, Dr. B. Chennakesavarao, [9] studied on residual

stresses technique. Destructive and non-destructive tests are developed by several principals. Diffraction technique, ultrasonic technique, bending method and non-destructive testing used measure residual stress.



(a) Circular Holes **(b) Hexagonal Holes**

(c) Slotted Holes

Figure 7: Deformation Distribution [8]

They measure residual stress on sheet metal with some drilled hole. This method known as semi-destructive test Destructive test based on physical contact while non-destructive test based on non-physical contact test. Dr. Kartik D. Kothari and Dr. R. L Jhala, [1] have used DEFORM-3D software for simulation on perforated sheet metal (PSM) with round and triangular shape for square and triangular pattern. DEFORM-3D FEA software package is used to analysis of deep drawing process on perforated sheet metal (PSM). In this FEA package, input parameter were blank thickness, punch velocity and blank material. Whereas output parameter was stress on the basis of outcome stress value studies and optimizing best suitable parameter for perforated sheet metal (PSM).

OPTIMIZATION

Optimization technique is used to find out probably suitable maximum or minimum stress value for different experiment process. There are many technique use for optimization such as Taguchi method, response surface methodology and weighted principal component method. Weighted principal component method is more accurate and provides approx. solution as compare to Taguchi and response surface methodology.[5]

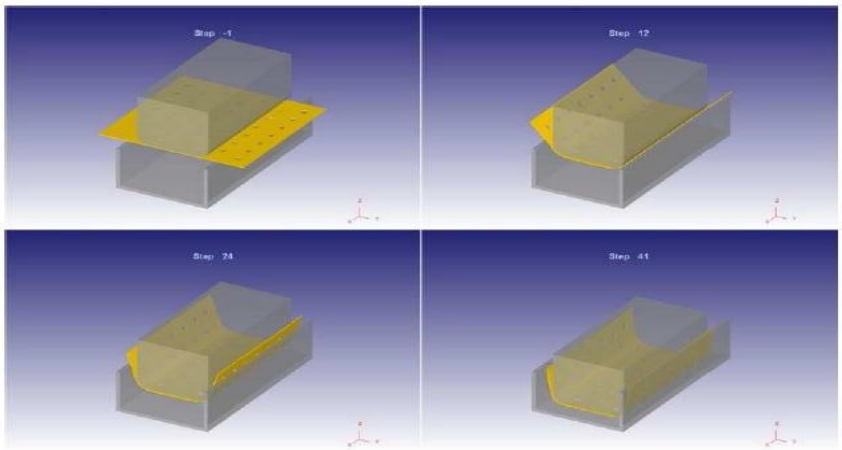


Figure 8: Simulation work in DEFORM-3D [1]

Dr. Kartik D. Kothari and Dr. R. L. Jhala, [1] use weighted principal component method for optimization in their experimental work. Weighted principal component method was investigated in 1901 by Karl Pearson. In this technique several steps need to follow for archiving optimum solution. Steps shown below,

1. A. for minimization of response lower the best principal is used formula,

$$\frac{S}{N} = -10 \log(\frac{1}{n}\sum_{i=1}^{n} y_i^2)$$

B. for maximization of response, higher the better principal is used formula,

$$\frac{S}{N} = -10 \log(\frac{1}{n}\sum_{i=1}^{n} \frac{1}{y_i^2})$$

Where,

$y_i = Measured\ value\ of\ responce$

n. = No. of observation

2. The original multi response array form no of test trials and n no. of response is expressed as,

$$X = \begin{bmatrix} x_1(1) & x_1(2)\cdots\cdots & x_1(n) \\ x_2(1) & x_2(2)\cdots\cdots & x_2(n) \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ x_m(1) & x_m(2) & x_m(n) \end{bmatrix}$$

3 The S/N ratio is normalized using following formula

$$x^*_i\,(j) = \frac{x_i(j) - x_i(j)min}{x_i(j)max - x_i(j)min}$$

4 The Eigen value and Eigen vectors are evaluated from the covariance matrix obtained from the normalized data,

$A = \text{cov}\,[X^*]$

$[A - \lambda I] * [v] = 0$

5 The principal components are obtains using following equation,

$Y\ m,n = [X^*m,n] *[\ V\ n,n]$

$MPI_j = \sum_{i=1}^{n} W_i \times Y_{ij}$

A Max MPI value indicates best min and max parameter for experimental value.

CONCLUSION

For the detail study is carried out, material properties play an important role for forming process of perforated sheet metal. Due to material properties spring back effect also generated. Punch's nose radius is also playing a vital role for good quality product from the forming process. Blank holder Force expands grating and subsequently the required punch load. Subsequently, the clear holder power ought to be sufficient only to avert wrinkling of the spine. The edges of the punch and bite the dust are adjusted for the simple and smooth stream of metal. Leeway amongst pass on and punch is additionally given so sheet metal could be effectively suited. Inadequate or vast freedom may come about into shearing and tearing of the sheet.

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