Performance measurement and modeling of Fine Blanking process using Simulation Technique to Reduce Burr Height

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ABSTRACT: During the past decade, two clear trends have been observed in the production of metal components. Firstly, time-to-market needs to be shortened in order to introduce new products competitively. Secondly, ongoing miniaturization forces product dimensions to decrease. Of all forming processes employed in high volume production, blanking is one of the most widely used separation techniques.

In blanking processes, tolerances on the machined parts become tighter, the focus shifted on analysis of factors that will affect in blanking process. Metal blanking is a widely used process in high volume production of sheet metal components but after blanking, burr formation at edges of the product is observed and hence it is need to do the deburring process due to this there is increasing the cost of production and time. Fine blanking is process which helps us to minimize the burr size.

The main objective of this work is to present the development of a model to predict optimum value of parameter for fine blanking process. The model investigates the effect of potential parameters influencing the blanking process and their interactions. This helped in choosing the process leading parameters for two identical products manufactured from two different materials blanked with a reasonable quality on the same mold. Finite Element Method (FEM) and Design of Experiments (DOE) approach are used in order to achieve the intended objectives. It can be stated that the FEM coupled with a DOE approach provide a good contribution towards the optimization of sheet metal blanking process.

In this work we study the effect of four factors on Burr height of the product i.e. Thickness, clearance, Blank holding force and material in which we get the minimum burr height of 6.818181818% of metal sheet thickness for aluminum with maximum stress 290Mpa and maximum burr height of 25% of metal sheet thickness for SS304 with maximum stress 1148.7Mpa. Minimum burr height is observer at 0.5mm thickness, 0.05 clearances and 2000 BHF shows us that the four factors directly influence the burr height of the final product.

Index Terms **– Fine blanking, Blanking Simulation, Reduce Burr Height, Modeling of Fine blanking**

I. INTRODUCTION:

As we know that fine blanking is one of the mostly used methods for manufacturing process. This process includes deformation, hardening and crack initiation and propagation of raw material to produce a final product. As discussed earlier, it consists of number of sub processes as per the final product required by the manufacturer. And also these sub process are hard to design and to sequence it according to product. The theoretical modeling of such processes is very difficult due to the complexity in describing the different stages of the whole shearing process starting with the elastic stage and ending with the total separation of the sheet metal. This will require each time a heavy experimental set up to perform blanking and for each time we have to consider each and every aspect of parameters. So this makes manufacturer a cumbersome task however the solution can be a simulation technique to perform this. This paper consists of modeling of a fine blanking process using simulation technique. By which we can save our energy, efforts and large experimental set up by doing so. Fine blanking can achieve flatness and cut edge characteristics that are unobtainable by conventional stamping and punching methods. Fine blanking is described in relation to conventional methods to encourage a better understanding of its benefits and limitations.[1] The part edge quality also depends on the material being blanked. Various material coefficients and process factors affect the quality of the blanked part. Materials with large ductility, low yield strength, and homogeneity will have better blanked edge quality, dimensional tolerances, and longer tool life. The section II describes what are the factors are responsible for affecting in the blanking process, section III explains actual simulation technique scenario studied under Ansys Software, section IV describes actual result in table and data format and steps in simulation of blanking process and at last the section V concludes the objective of the paper.

II. FACTORS AFFECTING IN THE BLANKING PROCESS:

The blanking is not just a single process instead it consists of various sub phases according to the manufacturing phases of production. And so that, to produce a fine product or to perform a fine blanking we have to consider each and every small factor affecting it. Mechanical and geometrical aspects of the sheared edge during the blanking operation are the main concern of many researchers. It is affected by several parameters such as the clearance, material properties/ work hardening/microstructure, thickness of material, wear state of the tool/tool radius, punch/ die size/geometry, friction, layout, blank holder force, punch speed, punch-die alignment and cutting angle.[2]

The accuracy of work pieces can be characterized by the following errors: dimensional error, positional error, and form or shape error. The errors on blanks are influenced by material, tool shape, process variations and machine.[3] Some of the important factors are discussed as follows:

1. Clearance:

In blanking processes, the clearance can be expressed as a percentage of the sheet thickness. Clearance is the space between the punch and the die tool. And for optimum finishing of cut edge correct clearance is necessary and that is also depends on kind, thickness and temper of the material. Correct clearance is necessary for a clean break whereas excessive clearance will result in tapered edge.

2. Punch geometry:

Punch geometry affects the punch stresses and temperature as well as punch life. Figure shows the maximum forces by using different punch shapes when blanking a round part. The punch forces differ because the area of contact with the sheet at given instant in the penetration length is not the same.[4]

3. Tool wear

It is necessary to study the effects of tool wear on the blanking force and the sheared profile. Variations as there is slow degradation of the blanking tool caused by the friction involved between tool and sheet metal. The rate of wear is affected by parameters such as tool material, blanked part material, punch–die clearance, punch velocity, lubrication, and material thickness.

The effect of tool wear leads to the Formation of burrs and increases burr length. Burr length is generally an important criterion in the industry to evaluate part quality. Burr length indicates when the tool should be reground to obtain the sharp die-and-punch radius. It has also been observed that the effect of tool wear is more pronounced at higher blanking clearances. The effect of tool wear on part edge quality is significant. Tool wear leads to the formation of buns and increases burr where the effect of tool wear was simulated by assuming different punch corner radii in simulations.

4. Sheet Thickness

For a given material, the energy requirement in blanking is influenced by the sheet thickness. It has been observed that:

1. The blanking energy decreases with increasing clearance-to-sheet thickness ratio c/t and increases with increasing sheet thickness.

2. The proportions of the different depth characteristics of the sheared profile are affected by the thickness.

5. Material

The part edge quality also depends on the material being blanked. Materials with large ductility, low yield strength, and homogeneity will have better blanked edge quality, dimensional tolerances, and longer tool life.

III. SIMULATION OF BLANKING PROCESS

3.1 Geometry of blanking process

We take the metal sheet of 12 mm radius for punching the hole of 10 mm in this we fix the support at a distance of 2 mm from the edges of the sheet metal. We alter the radius of the punch so that to adjust the punch to die clearance value in this we use the asymmetry type of meshing as width of sheet metal is very large as compare to thickness of the sheet hence stress along with width can be neglected and modeling is done in 2D only.

For simulation we use the 0.035mm mesh size. With the multi zone quad/tri method, edge sizing and mapped face finishing type of meshing with uniform surface, after successfully meshing we get 5545 nodes and 5177 elements for of 0.5 mm thick sheet.

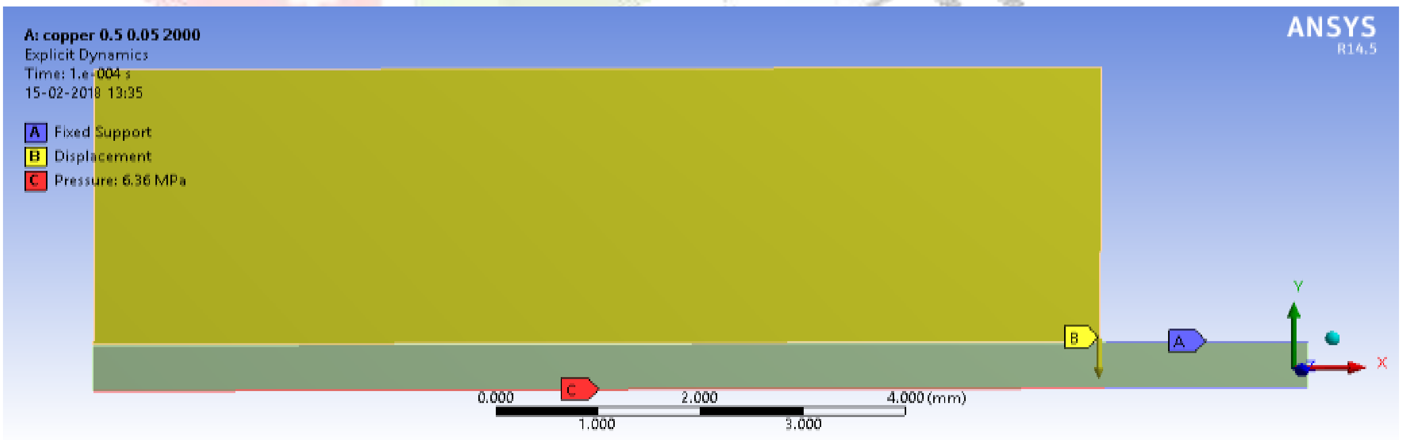


Fig. 1 Model design for explicit dynamic

3.2 Meshing:

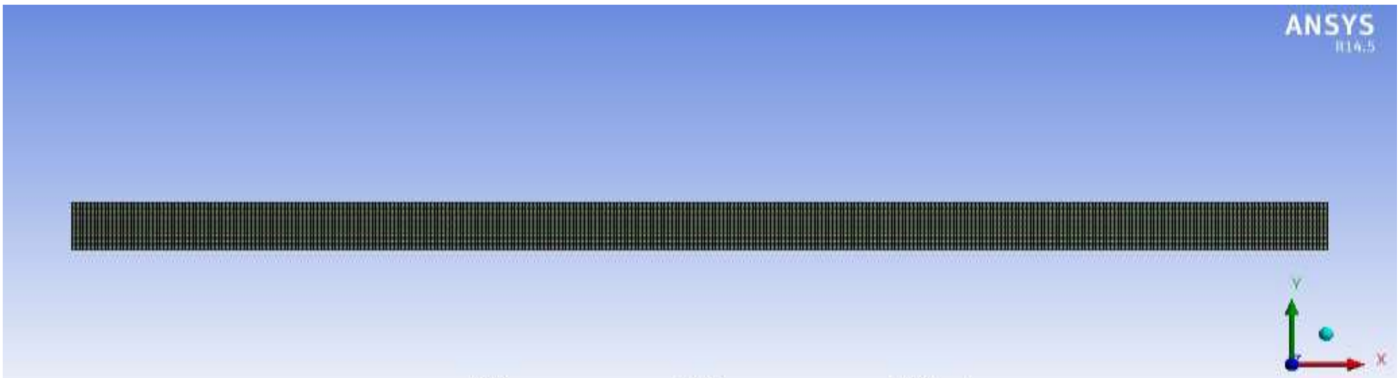


Fig. 2 Meshing of Sheet

3.3 Boundary conditions and simulation parameters

we had taken the a punch of radius 9.95mm,9.90mm,9.85mm for clearance 0.05mm, 0.1mm, 0.15mm respectively. The sheet which has to be blank is taken as 0.5mm, 0.6mm and 0.7mm thickness. We use the three type of material for iteration that is ss304, aluminum and copper. We use punch displacement for the cutting purpose instead of applying the pressure we use fix support for the holdings the sheet for analysis process Initially we apply the 0 back pressure so to evaluate burr height in conventional blanking later on we increase the back pressure from 0 to 1000 BHN and then 2000BHN and other parameter to optimizing the process. Instead of applying the force we applying the Back pressure which can be mathematically converted in to Force. By using formula

Pressure = Force / Area of sheet metal

3.4 Material properties

We used three for the simulation that is SS304, Copper and aluminium the properties of this material are as follows

Density	7.9e-006 kg mm^-3
Specific Heat	4.23e+005 mJ kg^-1 C^-1
Initial Yield Stress Y MPa	340
Maximum Yield Stress Y_{max} MPa	2500
Hardening Constant b	43
Hardening Exponent n	0.35
Melting Temperature T_{melt} C	2106.8
Shear Modulus MPa	77000

So by combining these four parameter we get 81 combination of parameter for simulation.

3.5 Response parameters

In this experiment we have selected four parameter that affecting the burr height are as follows:

1. Punch to die clearance
2. Material thickness
3. Material of sheet
4. Blank holding force

This parameter makes a direct impact on burr height so we study the effect of this parameter on the burr height. After performing the simulation successfully we get numerous data by using met lab software we analyze this data and study the effect of above mentioned parameter on burr height.

IV. RESULTS ANALYSIS

For observation in detail we have used Finite Element Method (FEM) and Design of Experiments (DOE) techniques. The combination of both techniques is proposed to result in a reduction of the necessary experimental cost and effort in addition to receiving a higher level of verification. Design of Experiments provides the guidance in the selection of the proper combination of the process parameters at their specified levels, in such a way that costly dies will not be manufactured until the finite element simulations show the best set of process parameters. The methodology that is followed to attain the research objectives is divided into the following work phases:

Some of the blanking parameters can be classified into controllable and uncountable parameters as per the nature. The identified controllable parameters can be clearance, blank holder force, sheet metal thickness, and material. Whereas, the uncountable parameters are material properties inconsistency and conditions (shape, defects and internal stresses), friction and wear state of the tool, stroke rate or blanking speed, and punch-die alignment. After completing the simulation we are going to perform the iteration to get optimize value.[5]

4.2 Effect of clearance:

As we see in the graph as the clearance increase from 0.05mm to 0.15mm the height of the burr is also increase this because as the clearance increases it gives more space for the material to flow. Hence we get minimum burr height on the 0.05 mm clearance.[5]

4.3. Effect of Thickness:

In the graph we can see as the thickness of sheet metal increases from 0.5 to 0.6 the burr height increases but as thickness increases from 0.6 to 0.7 it increases marginally so we can conclude that burr height increases with sheet thickness and we get minimum value at 0.5mm thickness.[5]

4.4 Effect of Blank Holding Force:

BHN is a very important factor in this simulation technique as we see in the chart it is clearly seen that as the BHN changes from the 0 to 1000N the burr height reduced drastically this is just because of the blank holding force which is opposite in punch force do not allow the metal sheet to bucking during the punching process leading to smaller burr height.

4.5 Effect of the Material:

Among all those, this is not an important factor among other because selection of material is mainly depend upon the type of use still we are studding the effect of material on burr height. As we see in the graph it is clearly seen that burr height is minimum for the ductile material like cooper and it is higher for SS304. As we see in the graph the effect of punch clearance, thickness of sheet metal and BHN on burr for SS304, Copper and Aluminium respectively.

After successfully Simulating 81 simulation and we get the following result for SS304:

Table 4.1- Burr Height for SS304

Sr. No.	Clearance	Thickness	BHF IN N	Burr height	%	Max. stress
1	5	0.5	0	0.095238095	19.04761905	1167
2	5	0.5	1000	0.076086957	15.2173913	1167.9
3	5	0.5	2000	0.076923077	15.38461538	1174
4	5	0.6	0	0.12	20	1162.1
5	5	0.6	1000	0.114705882	19.11764706	1165.6
6	5	0.6	2000	0.096774194	16.12903226	1172
7	5	0.7	0	0.143181818	20.45454545	1171.4
8	5	0.7	1000	0.12962963	18.51851852	1170.5
9	5	0.7	2000	0.116666667	16.66666667	1164
10	10	0.5	0	0.108695652	21.73913043	1148.9
11	10	0.5	1000	0.097826087	19.56521739	1138.3
12	10	0.5	2000	0.089285714	17.85714286	1147.2
13	10	0.6	0	0.109090909	18.18181818	1155.2
14	10	0.6	1000	0.104347826	17.39130435	1168
15	10	0.6	2000	0.103846154	17.30769231	1152.2
16	10	0.7	0	0.143478261	20.49689441	1149
17	10	0.7	1000	0.134615385	19.23076923	1152.5
18	10	0.7	2000	0.125	17.85714286	1160
19	15	0.5	0	0.095238095	19.04761905	1151.1
20	15	0.5	1000	0.089285714	17.85714286	1151.8
21	15	0.5	2000	0.086538462	17.30769231	1144
22	15	0.6	0	0.116666667	19.44444444	1141.7
23	15	0.6	1000	0.111111111	18.51851852	1146
24	15	0.6	2000	0.108	18	1155
25	15	0.7	0	0.175	25	25
26	15	0.7	1000	0.145833333	20.83333333	20.83333333
27	15	0.7	2000	0.128333333	18.33333333	18.33333333

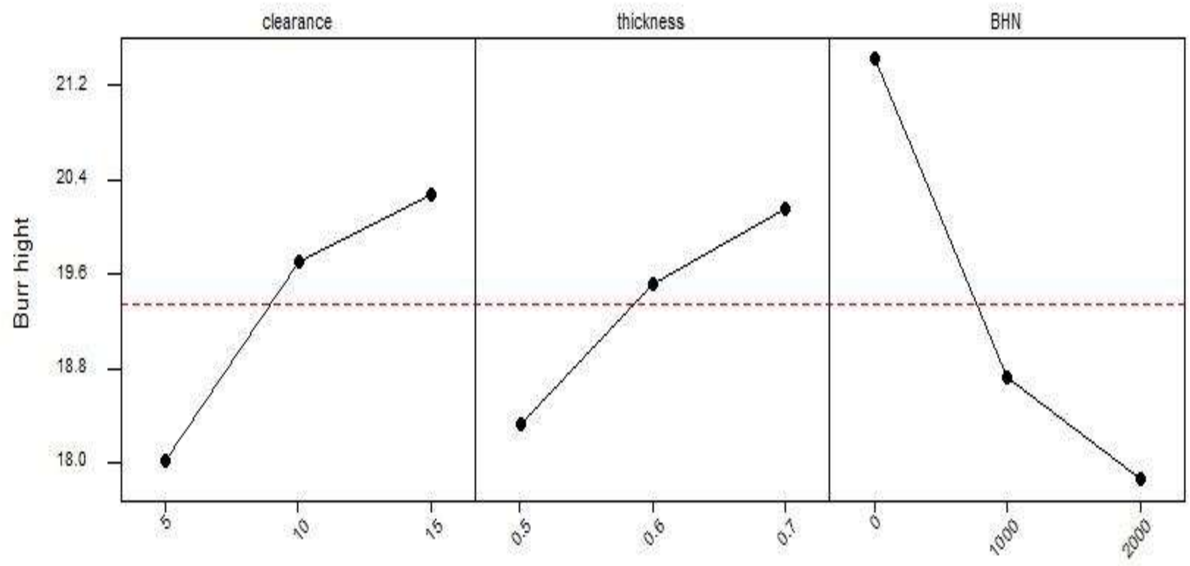


Fig. 3 Main effect plot for SS304

Table 4.2 Analysis of Variance for Burr height, using Adjusted SS for Tests

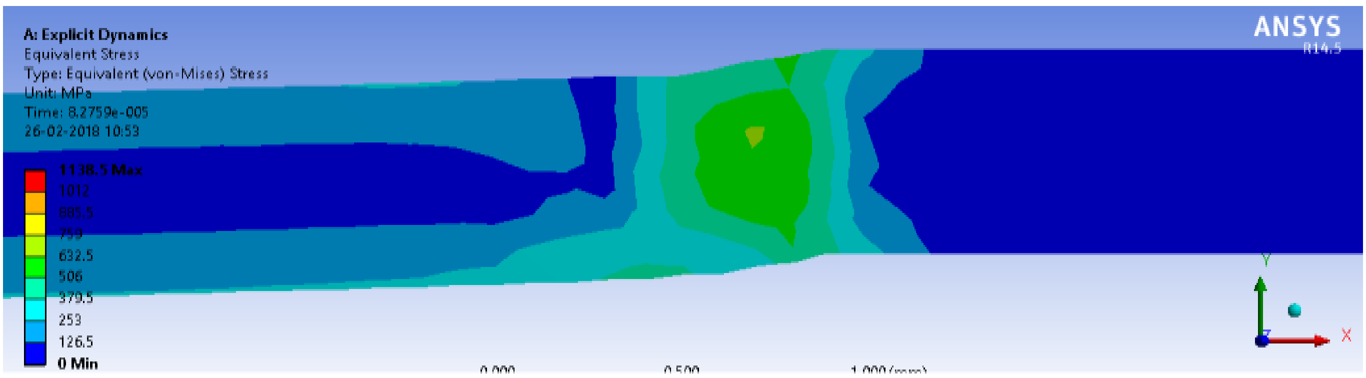
Factor	Type	Levels	Values
Thickness	Fixed	3	0.5 0.6 0.7
BHN	Fixed	3	0 1000 2000
Clearance	Fixed	3	5 10 15

Table 4.3 Analysis Results for SS304

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Thickness	2	30.941	30.941	15.470	4.80	0.003
BHN	2	24.212	24.212	62.106	19.27	0.000
clearance	2	49.680	49.680	24.840	7.71	0.001
Error	47	151.487	151.487	3.223		
Total	53	356.320				

For SS304 optimum burr height is obtained at 0.05mmclearance with 0.5mm thickness of sheet with 2000N BHF i.e. 0.076923077 (15.38461538% of thickness).

From above graph we can easily concluded that optimum burr height for above simulation is obtained at 0.05mm punch clearance, 0.5mm thickness of sheet metal with 2000 BHF and it can be predicted by simulating.



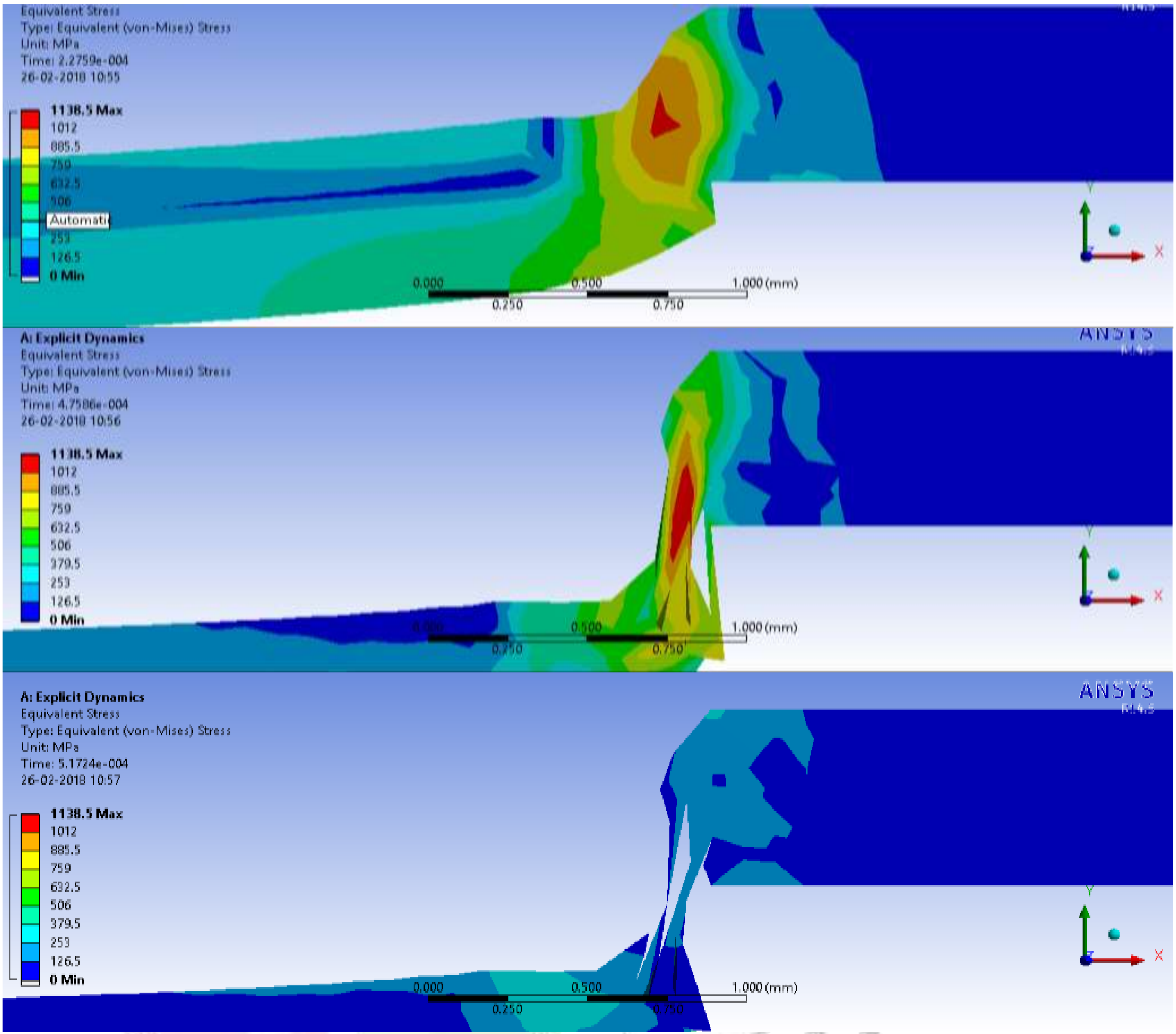


Fig. 4 Steps in blanking process

V. CONCLUSION

From the above discussion we can conclude that the factors affecting in the blanking process are clearance, tool wear, sheet thickness, material and punch geometry. Here we have used three different materials for comparison as stainless steel, copper and Aluminium. And it is observed that the minimum burr height found in Aluminium but for convenience and easy of understanding we have stated data of only SS304.

FEM and Design of Experiments are identified as approaches to study the effects of these parameters on the height of burr formed during punching. After successfully completing the simulation we can conclude that optimum burr height for above simulation is obtained at 0.05mm punch clearance, 0.5mm thickness of sheet metal with 2000 BHF and for aluminum it is minimum.

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