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Effects of V Ring Pattern in Fine Blanking Process by FEA

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Abstract: **Fine blanking a press working operation which is used to manufacture the parts which needs precision. Special fixtures and specific features like die-clearance, location and dimension of V- ring, force applied on punch and V ring, in manufacturing influences the quality of product in fine blanking process. In this work, instead of providing V ring on blank holder alone, it is provided on blank holder, die and both. The behavior pattern of die-roll width and depth, shear and fracture zone are studied by the considering the parameters of locations of V ring indenter and its clearance for the purpose of analysis.**

Keywords: **Abacus software, Blank holder, Clearance, Die, Finite element analysis, Fine blanking.**

I. INTRODUCTION

Fine blanking a single step unique metal forming specific type of hydraulic press used for high volume manufacturing in several industrial sectors which includes automotive parts replacing many of the more expensive manufacturing options (i.e.) secondary process operations. The fine blanking process involves Tool Closure, shearing of part, Opening of tool, Ejection of slag, pushing and removal of part. The features that make the differences are (a) Blank holder and counter punch force (b) V-ring indenter (c) Die clearance. V ring is a raise crest, usually formed in blank holder. V-ring indenter prevents the lateral movement of blank by gripping it. V ring plays a significant role in building up high hydrostatic pressure in shear zone by achieving rotational material flow suppressing the generation of fracture zones in the shear surface. By providing V-ring indenter i.e., on blank holder as well as die the hydrostatic stress developed can be improved more over it ensures that enough material is packed into the die cavity to create full shearing which is the motive of this work. Many researchers have studied the fine blanking process. However the amount of work done is relatively insufficient and further investigation is still needed.

Kwak et al. [1] did FEA by a FEM code and DEFORM-2D to explore on consequence of clearance in die on shear planes for the safety belts in automotives. Cockcroft–Latham fracture criterion was applied. From the scrutiny, it was established that die-roll width and depth of shear plane raised with rising clearance of the die. Biglari1 et al. [2] studied the sway of elevation and position of V-ring indenter. From their investigation, it is clear that the element dimension beneath V-ring and in shear zone is finely cultured and also they are subjected to the large warp. Kwak et al. [3] studied the result of V ring on sheared surface in shear and fracture zone, die roll width and depth and showed that all these zones and die roll dimensions decreases and burnished zone increases in presence of V ring indenter. Thipprakmas et al. [4] studied Finite element analysis of V-ring on the basis of material flow. It stated that the V-ring indenters on either the blank holder or the die alone made it difficult to achieve rotation of the material flow. Furthermore V-ring indenter resulted in close packed revolution of material flow and also increased hydrostatic compressive stress on shearing zone.

Previous studies have been done on the influence of V-ring indenter on Volume Fraction, sheared surface, formation and propagation of shear band, when the V- ring is formed on the bottom surface of blank holder alone. Hence in this present work it is proposed to explore the upshot of V- ring indenter on shear and fracture zone in fine blanking process, when the

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V- ring is provided in bottom surface of blank holder, on the top surface of die and both in blank holder as well as die. The clearances and distance of V-ring indentation is proposed to be varied to study its influence on the shear zone by FEA on the basis of material flow.

II. ANALYSIS OF FINE BLANKING

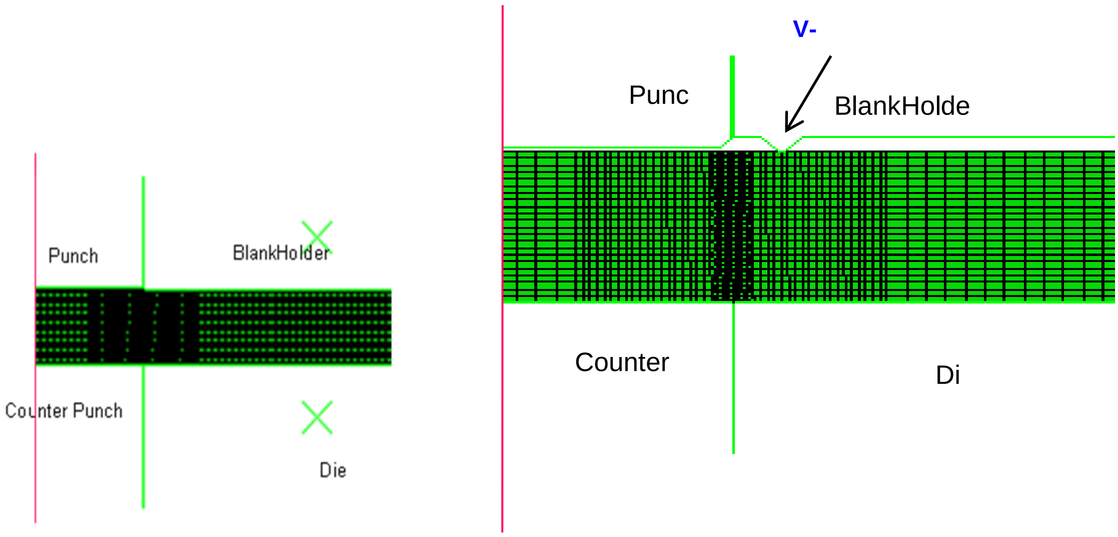
The study of this analysis is to investigate, how shear zone, fracture zone and die roll behave in the following four cases as in figure 1.

Model I: No V- ring indenter

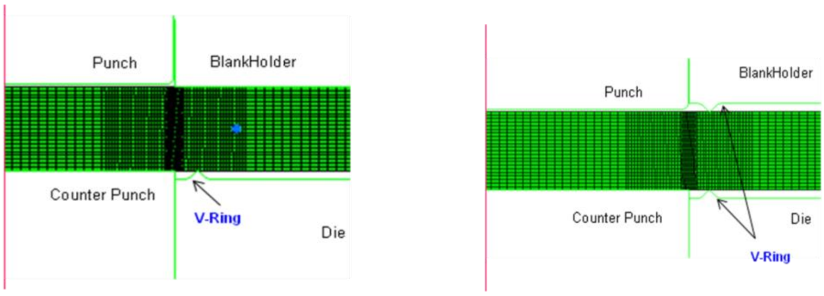
Model II: V- ring indenter formed on bottom surface of blank holder

Model III: V- ring indenter formed on top surface of die

Model IV: V- ring indenter formed on both blank holder as well as die



Model I: No V ring. **Model II: V ring on blank holder only**



Model III: V ring on die only **Model IV: V- ring indenter on blank holder & on die**

Fig.1: Models developed for studying.

For simulating the fine blanking process, four finite element models as specified previously have been developed for the analysis, using ABAQUS code. The component to be analyzed is assumed to be circular with diameter of 100mm and the thickness 5mm and the material is assumed as En 2E steel. The die diameter is assumed as 50mm and punch diameter, 49.98mm, 49.9mm, 49.8mm, 49.7mm for the clearances 0.4%, 2%, 4% and 6% of blank thickness respectively. Punch corner radius is taken as 0.01mm and that in die is 0.4mm. The co-efficient of friction between blank and other tools has been taken as 0.1. Fig. 2 gives the dimensions of Model II with clearance 2% of blank thickness. Punch displacement given is 7mm, Counter force as 75kN, blank holder force as 600kN. Since the fine blanking progression is symmetric with reference to a plane alongside the center of the blank, solitary partly of the blank was designed for intended purpose. The tools, punch, counter punch, die and blank holder are modeled with rigid surfaces.

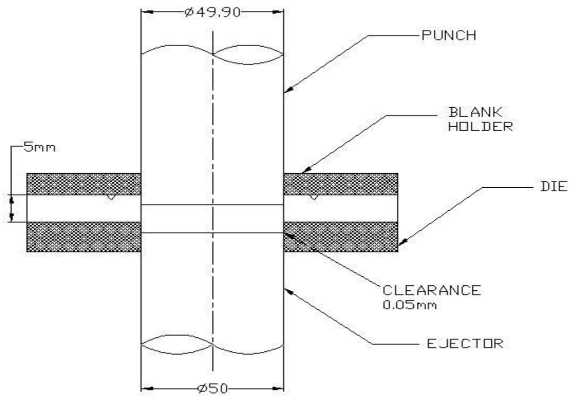


Fig.2: Dimensions of the Component.

Fig.3 gives the dimensions of V-ring indenter, V- height has been taken as 0.5 and it is located at a distance of 25% and 50% of blank thickness, i.e., at 1.25mm and 2.5mm from blank holder corner on punch side. The included angle between two faces is 90^0.

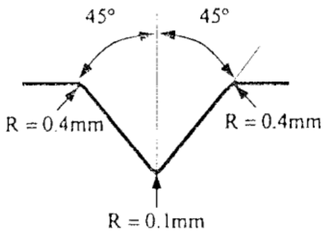


Fig.3: Dimensions of V- ring indenter.

In the region of shearing, very dense and fine mesh is defined, with 44 elements and in other areas relatively larger elements are used for analysis. The element used is Four Noded, Axi-symmetric elements, defined as CAX4R. The number of elements in thickness direction is 22 and the damage initiation criteria used are ductile and shear criterion. The four models with different clearances like 0.4%, 2%, 4% and 6% of blank thickness have been taken for analysis and with the clearance which gives best results has been taken for further analysis. With that clearance the V-ring indenter has been located at distance of 25% and 50% of blank thickness in different points and that process has been analyzed for optimality in shear zone, fracture zone and for die roll width and height.

III. RESULTS AND DISCUSSION

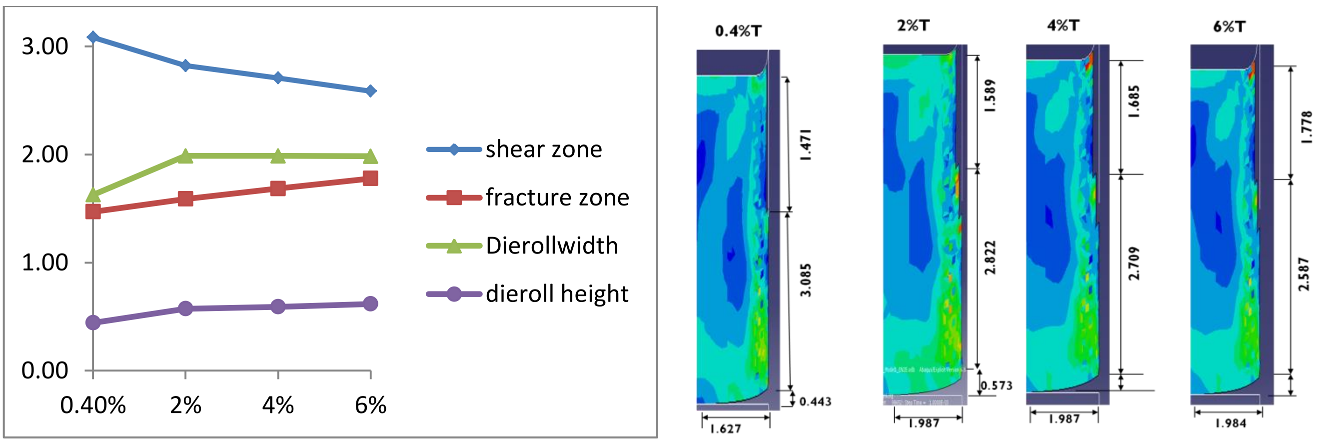


Fig.4: Results and plots for Model I with clearances 0.4%, 2%, 4% and 6% t.

Figure 4 shows Model I (i.e.) without V-ring indenter gives shear zone from 51% to 62% around 1/3rd of blank thickness and also fracture zone vary between 29% and 36%. Die roll width also lesser, due to the counter force. But this does not meet the objective, i.e. full shear zone and zero fracture zone.

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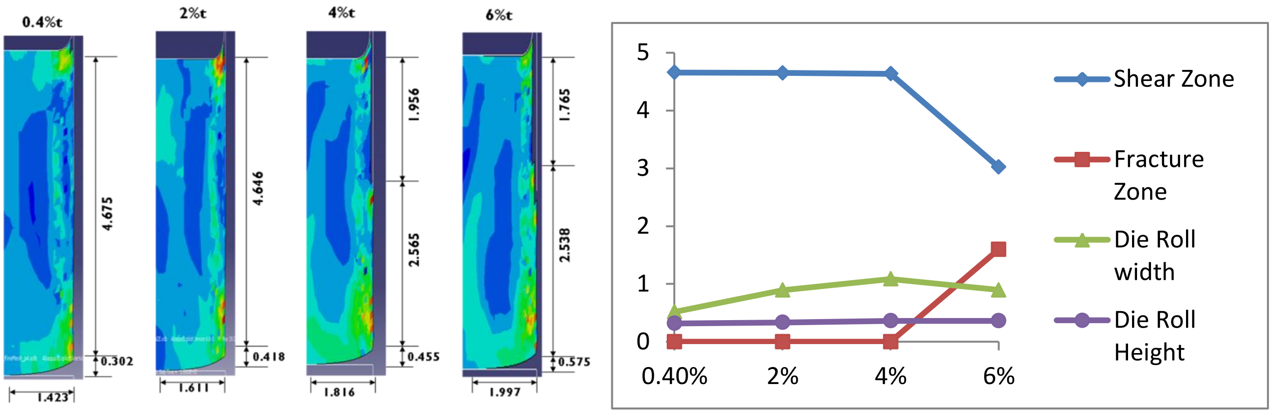

Fig. 5: Results and plots for Model II with clearances 0.4%, 2%, 4% and 6% t.

Figure 5 shows Model II, (i.e.) V-ring on blank holder alone, when the punch clearance is higher, gives 60.44% shear zone and 32% fracture zone. But with lower punch clearances, it gives zero fracture zone and shear zone around 93%. In this case the die roll width and height is also minimum. Figure 6 shows Model III, (i.e.) V-ring on die alone, when the punch clearance is minimum, gives 89.25% shear zone and fracture zone. With higher clearances this model gives poor results.

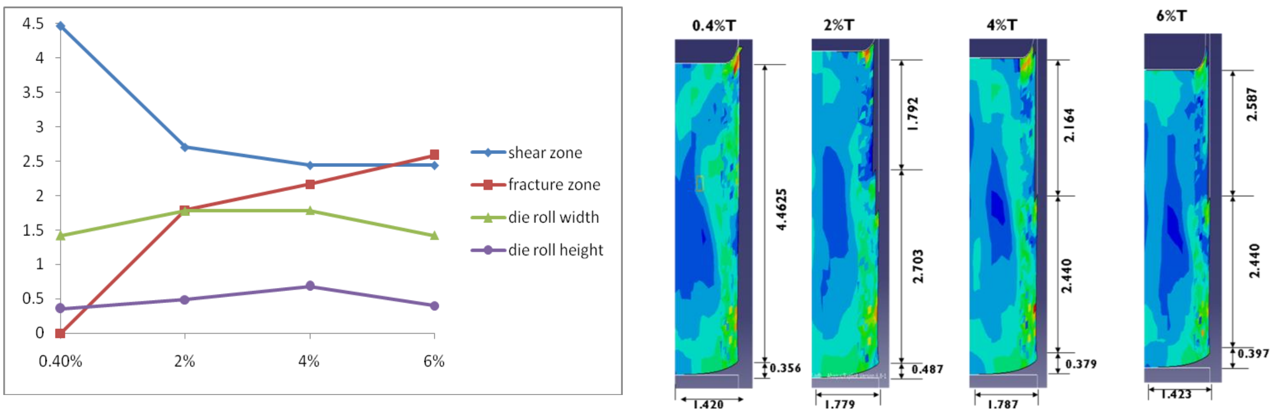

Fig. 6: Results and plots for Model III with clearances 0.4%, 2%, 4% and 6% t.

Figure 7 shows Model IV, (i.e.) V-ring on blank holder as well as die, when the punch clearance is on lower, gives maximum shear zone and minimum fracture zone, 93.5% and zero. But with higher clearance it gives approximately ½ of the blank thickness as shear zone.

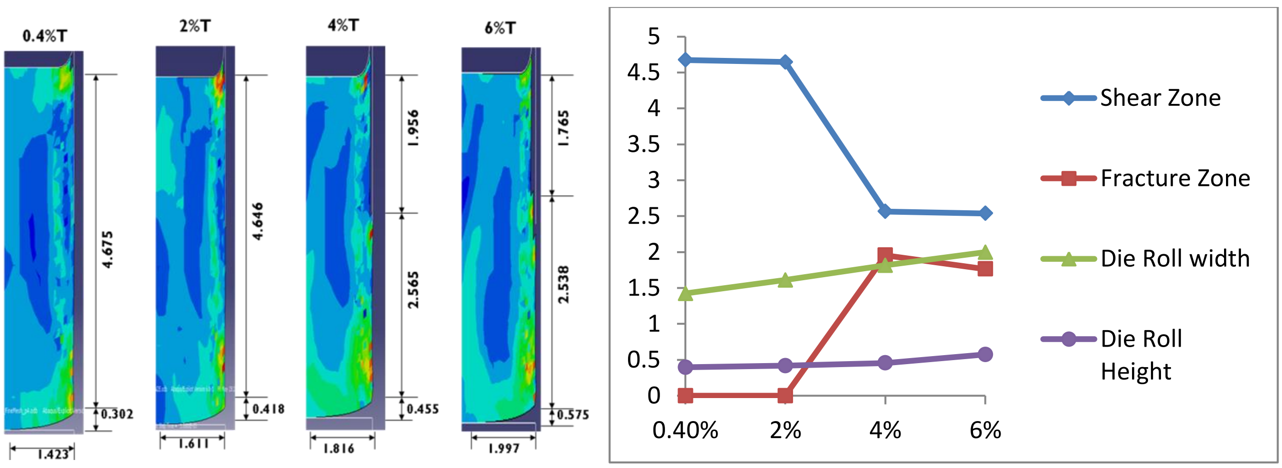

Fig.7: Results and plots for Model IV with clearances 0.4%, 2%, 4% and 6% t.

Table 1: Percentage of Shear, Fracture Zone, and Die Roll with various clearances for all models

MODEL I				
Clearance	Shear Zone%	Fracture Zone%	Die Roll width%	Die Roll Height%
0.40%	61.70	29.42	3.25	8.86
2%	56.44	31.78	3.97	11.46
4%	54.18	33.70	3.97	11.82
6%	51.74	35.56	3.96	12.34
MODEL II				
Clearance	Shear Zone%	Fracture Zone%	Die Roll width%	Die Roll Height%
0.40%	93.10	0	1.03	6.40
2%	92.98	0	1.78	6.72
4%	92.66	0	2.17	7.28
6%	60.44	31.94	1.79	7.26
MODEL III				
Clearance	Shear Zone%	Fracture Zone%	Die Roll width%	Die Roll Height%
0.40%	89.25	0	2.84	7.12
2%	54.06	35.84	3.55	9.74
4%	48.80	43.28	3.57	13.58
6%	48.80	51.74	2.84	7.94
MODEL IV				
Clearance	Shear Zone %	Fracture Zone%	Die Roll width%	Die Roll Height%
0.40%	93.50	0	2.84	6.04
2%	92.92	0	3.22	7.36
4%	51.30	39.12	3.63	9.10
6%	50.76	35.30	3.99	11.5

Table 1 shows Shear, Fracture Zone, and Die Roll with various clearances for all models. Furthermore, from the table minimum clearance (0.4%) is taken as an optimal clearance and the v ring locations are varied as 25%t and 50%t for optimality in positioning the v-rings for fine blanking process and the results are shown in figure 8 & 9. Also Table 2 compares the 0.4% clearance with 25% t and 50% t for various zones to set optimality in the process of fine blanking.

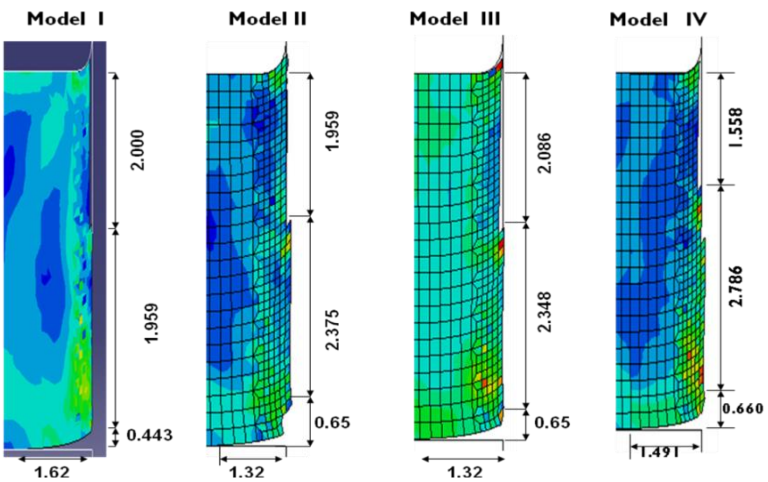

Fig. 8: Models with clearance 0.4% t and V –ring located at 50% t.

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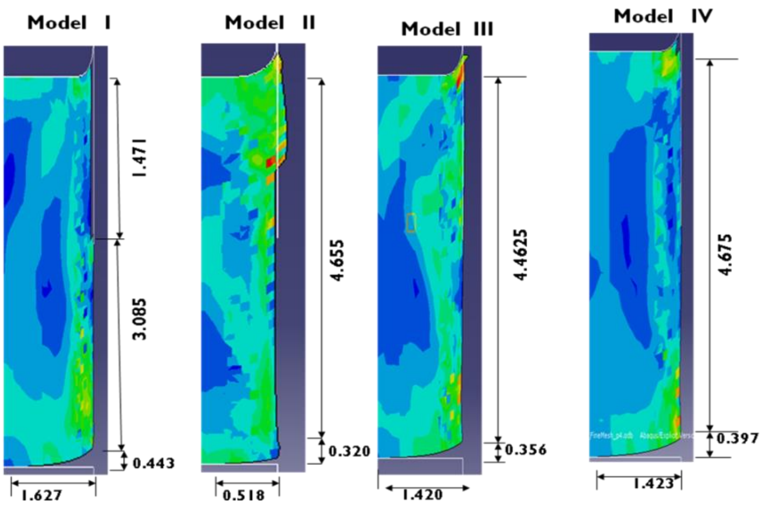

Fig. 9: Models with clearance 0.4%T and V –ring located at 25%t.

Table 2: Percentage of Shear, Fracture Zone, and Die Roll with various V-ring locations at 25% t and 50% t with the clearance of 0.4% t

For Punch Clearance 0.4% of blank thickness(t)								
	shear zone		fracture zone		Die Roll Height		Die Roll Width	
V - ring location	25% t	50% t	25% t	50% t	25% t	50% t	25% t	50% t
Model I	3.085	1.959	1.471	2.000	0.443	0.443	1.627	1.62
Model II	4.655	2.375	0.000	1.959	0.32	0.65	0.518	1.32
Model III	4.462	2.348	0.000	2.086	0.356	0.65	1.42	1.32
Model IV	4.675	2.786	0.000	1.558	0.3	0.66	1.423	1.491

IV. CONCLUSIONS

Solitary exceptional feature, like V ring indentation is fashioned on both blank holder and die. In this work FEA is carried out to probe the outcome of V ring when provided both in die as well as blank holder.

(i) Shear zone is improved, when the V ring is moved towards punch side.

(ii) When the V-ring is on die and on blank holder and punch clearance is reduced, best shear zone, more than 93% and zero fracture is obtained

(iii) V-ring on blank holder (Model II) and V-ring in die and blank holder (Model IV) gives better results than proving it on die (Model III) alone.

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