Formability Analysis of Front Lower Control Arm Using Hyper Form

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Abstract-Finite element analysis for the metal forming of lower arm is performed using hyper form. Metal forming simulation is also helpful at the product and tool design stage to decide various parameters. Optimization of process parameters in sheet metal forming is an important task to reduce the manufacturing cost. The main work of the formability analysis is to analyze the blank shape, forming load, formability, spring back, thinning percentage and prediction of strain. The effects of these parameters on sheet metal are studied and spring back is investigated .These results provide significant guidance to the manufacturing of sheet metal parts in forming process.

Keywords: Finite Element Analysis, Simulation, Metal Forming, Hyper Form

Introduction

The lower suspension arms are connected to the vehicle frame with bushing and permits the wheel to go up and down in response to the road surface. Control arm is the most crucial part of the suspensions system. It is made from materials like steel, iron or aluminum. Suspension arm is very important for the all vehicles on the road, if there is no suspension arm in suspension system, then it is expected that it can result in annoying vibrations and unwanted driving irregularities that could sometimes lead to road accidents like collisions with another car or obstruction on the road. Suspension arm is one of the most important components in the suspension system. It is fitted in various types of the suspensions like Macpherson, wishbone or double wishbone suspensions. During actual working conditions the maximum load is transferred from tire to the ball joint in Macpherson strut system and in double wishbone maximum load is transferred from upper arm to the lower arm which is responsible for the failure and twisting of lower suspension arm at the ball joint locations as well as control arm because of more impact load. Jong-kyu Kim et al. [1] optimized the upper control arm so as to minimize the weight. By performing the kriging interpolation method, the weight of control arm is reduced by 16% from the initial design. Optimum design of static strength is also obtained by the in-house program. Kwon Hee Lee et al. [2] Performed FEM analysis which shows the stress distribution and maximum stress on the lower control arm under a very severe loading condition. By virtue of the result of FEM analyses, fifty simulations with six design variables were performed for RSM and kriging model to construct the approximation of the weight and maximum stress to obtain the optimum result. M. M. Rahman et al. [3] developed Three-dimensional model of suspension arm using Solid Works software. 10 node tetrahedral element (TET10) was used for the solid mesh. Sensitivity analysis was performed to determine the optimum element size. These analyses were preformed iteratively at different mesh global length until the appropriate accuracy obtained. Dae Sung Joo et al. [4] Carried out Simulations of the nonlinear suspension system and compared with the linear suspension model and linearized suspension system. Numerical integration is performed by a fourth order Runge-Kutta method, integration step size is 0.007 sec. Youngsuk Kim et al. [5] performed Finite element simulations for the press forming of a lower arm using the dynamic finite element method (FEM) code PAM-STAMP. To optimize the press-forming conditions and secure a safe product without any failure, such as fractures and wrinkling, the FEM simulations are coupled with Taguchi's orthogonal array experiment. Three design variables—the friction coefficient, plastic anisotropy parameter, and blank shape—are selected to be optimized. Dong-Chan Lee and Jeong-Ick Lee [6] in this paper, optimization design methodologies in the design stages of an aluminium control arm for a suspension are presented. First, using topology optimization, the optimal layout and the reinforcement structure are obtained. B-C Song et al. [7] Performed optimal structural design of an upper control arm. The four loading conditions were considered to be the service loads. The inertia relief method for finite element analysis was utilized to simulate the static loading conditions. Hiten kumar Patel [8] observed that achieving high standard quality products in almost no time with great economy in aerospace industry demands for a high technology that helps exceed the engineering requirement of products. This paper tells about use of hyper form, hyper form helped reducing the complete product development cycle to almost less than 40% of what it usually took using conventional methods. Hardial Singh and Gian bhushan [9] linear static structural analysis has been carried out of a lower control arm to determine the maximum deflection, stress distribution and its location in the front lower control arm. It has been observed that stresses, displacements found well within safe limits and structure could withstand the given load. Krup Kumar and Hardial singh [10] performed the analysis to verify the effect of fillet radius on strength of spur gear; stress, strain and deformation was found by increasing the load up to yielding limit of the material. Om parkash and Hardial singh [11] worked was carried out the optimization of connecting rod, which was obtained by changing the design variable in the existing connecting rod design. The component was optimized for weight subject to fatigue life and manufacturability.

Process Methodology

The formability of blank sheet depends on the process parameters such as pressure, punch speed, friction coefficient, and blank holder force. Fracture and wrinkle are the major modes of failure in sheet metal parts. Hence, using proper process parameters are essential to restrict wrinkling tendency and avoid tearing. One of the quality criterions in sheet metal formed parts is thickness distribution. In this study, a lower control arm with JSH590B steel and blank thick of 3.2 mm is simulated by using Altair's Hyper Form radioss to study the effect of these parameters on failure modes and thickness distribution shows in figure 3.The FEM simulation was performed on the die face, like a real die, and the gravity of the blank was ignored. The friction behavior of the blank die /blank blank holder and blank punch was modeled after coulomb friction law.

Material properties

The material is used for JSH 590B steel for lower control arm. The material is used with a thickness of 3.2 mm. The mechanical properties are shown in table 1.

Sr.No.	Properties	values
1.	Yield strength	440 MPa
2.	Tensile strength	590 Mpa
3.	Young modulus	2.1E^5
4.	Strain hardening parameter (K)	1025
5.	Strain hardening exponent (n)	0.22
6.	Poisson's ratio (ν)	0.3

Figure 1. Blank size estimation

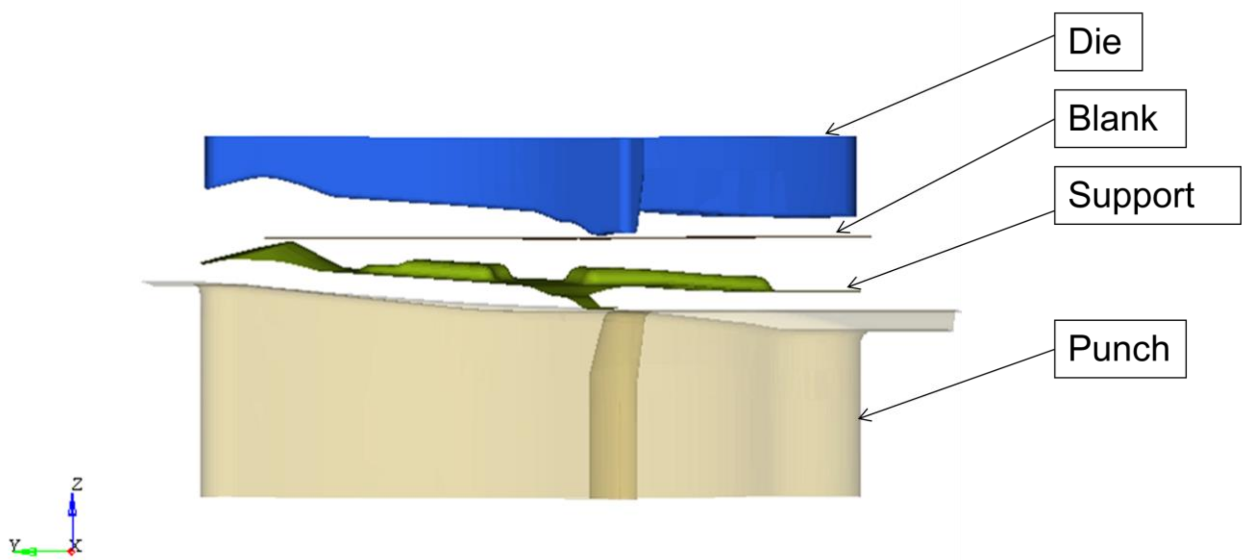

Figure 2. Die set up

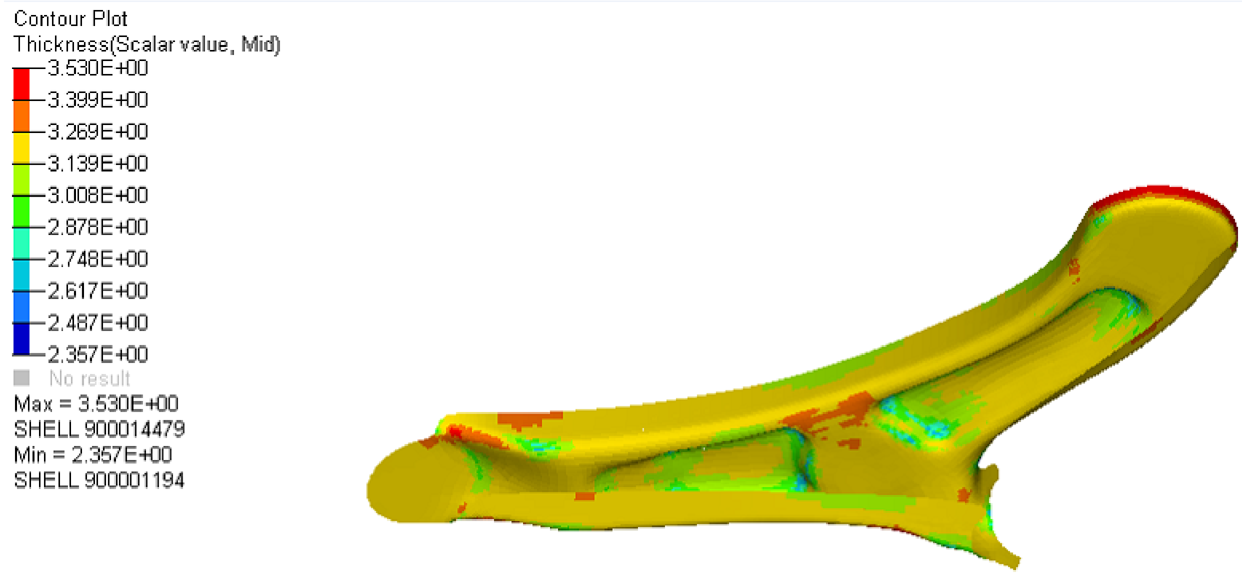

Figure 3. Thickness plot

Thickness contour plot shown in figure 3, red region shows thicker portion and blue region shown thin portion in the control arm. The maximum thickness is 3.5 observed in outer surface of the control arm.

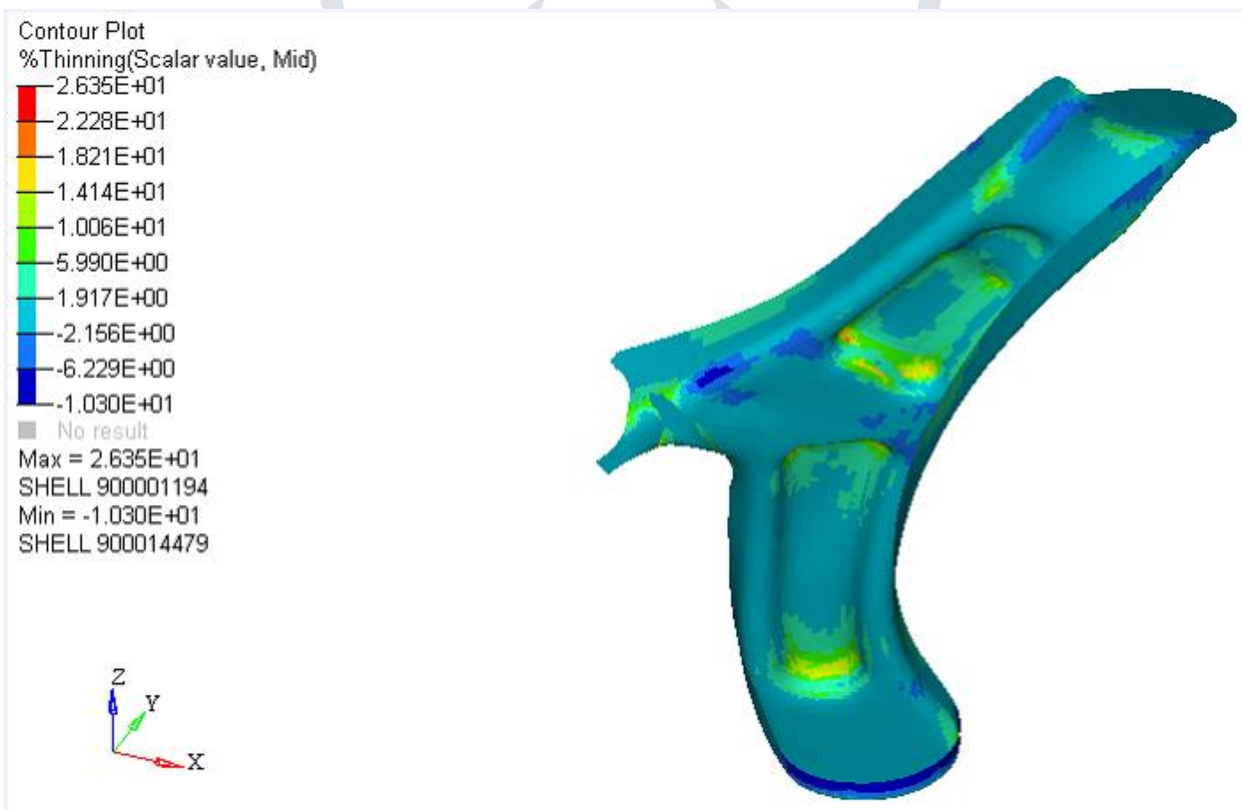

Figure 4. Thinning %distribution

The maximum percentage of thinning 26.35% at element number 900001194 and minimum percentage of thinning is -10.30 at element number 900014479. Metal flow in the volume elements at the periphery of the blank is extensive and inwards as increases in metal thickness caused by severe circumferential compression, this increase in the wall thickness at the open end of the wall. The changes in percentage of thickness are shown in figure 4.

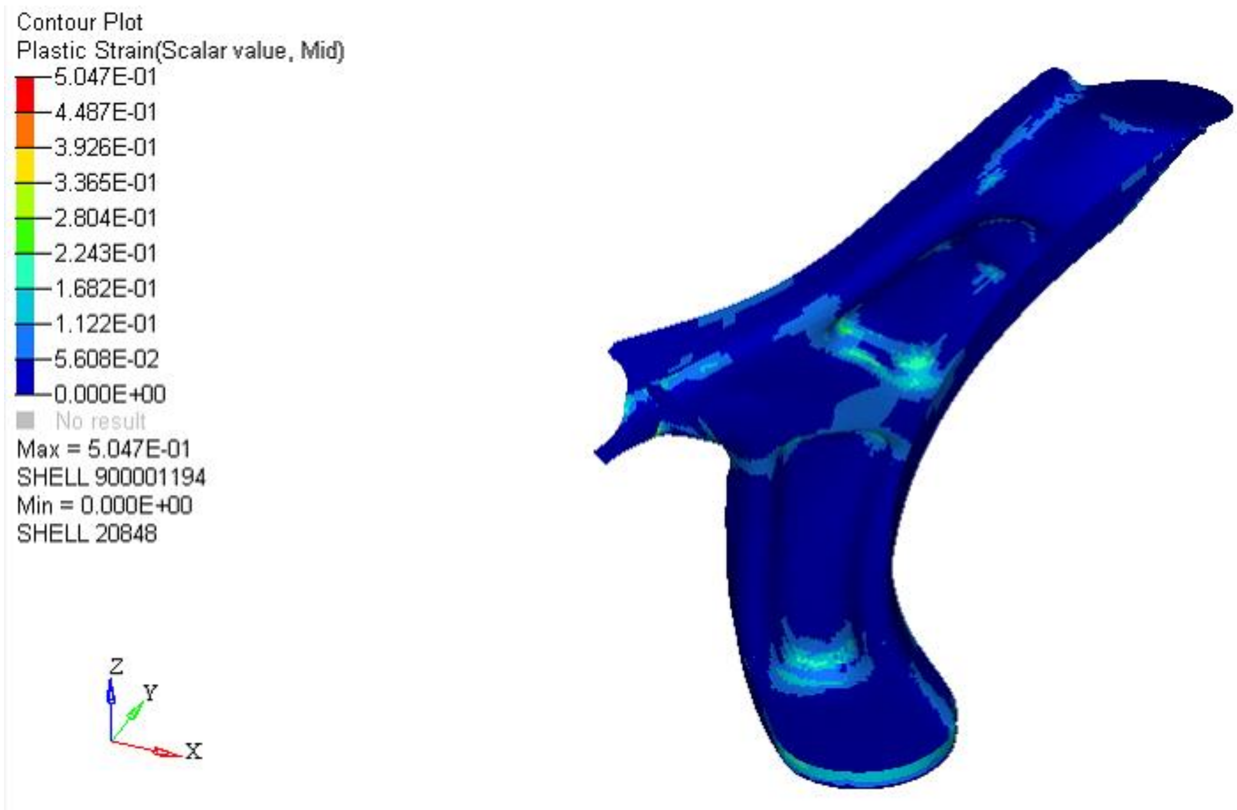

Figure 5.Plastic strain distribution

Plastic stain distribution has shown in figure. 5 most of the blue region shown in control arm.

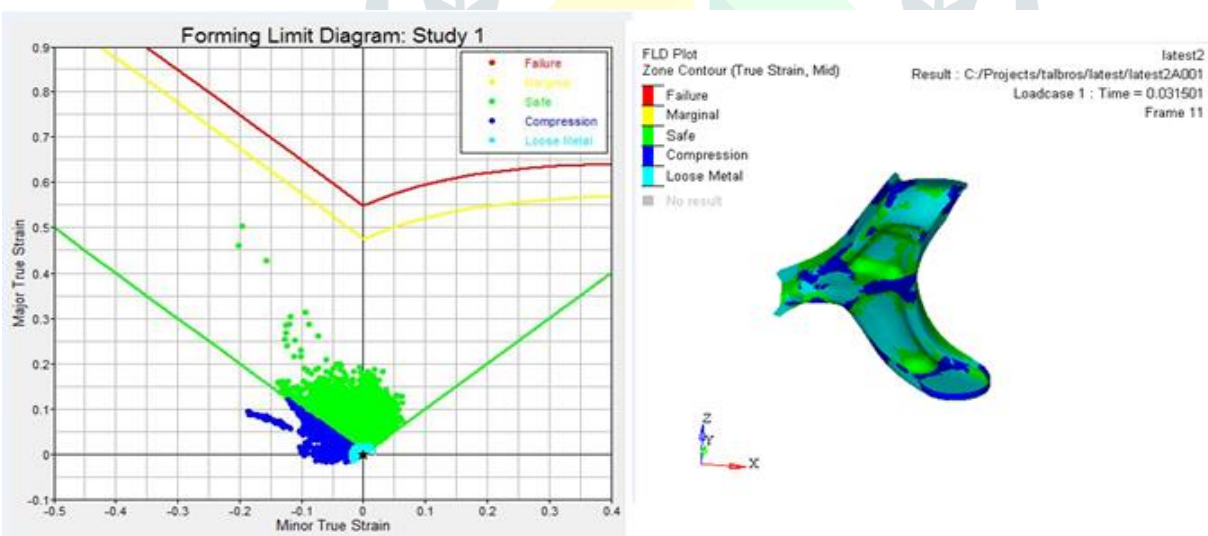

Figure 6. Formability with FLD curve

Forming limit diagram Figure.6 represents that blue zone having maximum compression resulted in increased thickness , red zone having Failure zone results in cracks, parret zone having safe results no failures and same as blank thickness. In figure.6 no failure zone is observed due normal percentage of thinning so these process parameter values are accepted.

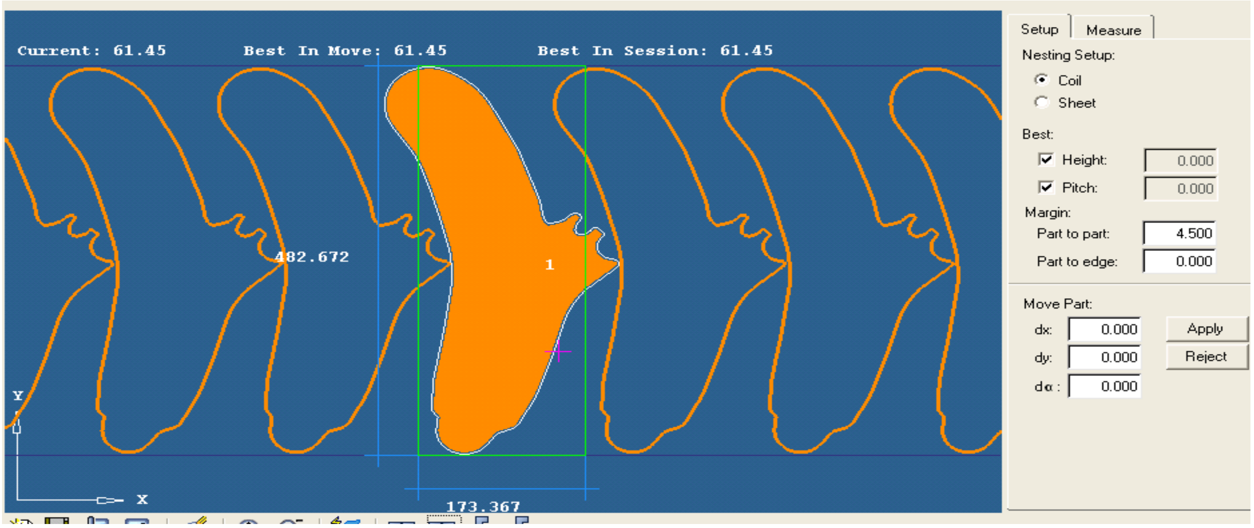

Figure 7.Blank nesting single row single pass

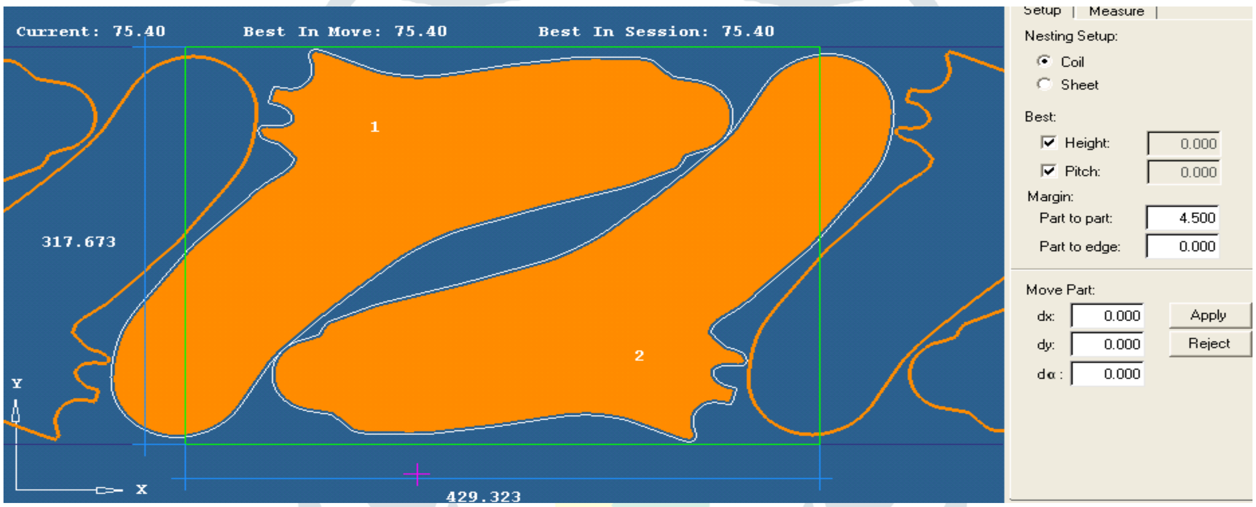

Figure 8.Blank nesting double row double pass

Blank Nesting is one of the most important things in the stamping die design, which determines the optimal material usage through geometric nesting of blanks. If the nesting has been made in manual, there we can only validate the target percentage of material utilization. But we can't able to find whether it is the best optimal nesting. Whereas in Altair Hyper Works we can get the optimal strip layout in a single click and helps us, to reduce input material cost & strip layout design time. In Figure. 7 the layout gives yield percentage of 61.45% single row single pass hence it looks to be a good design. For the same part we have done in blank nesting tool, double row double pass there we got the yield percentage of 75.40% in figure 8.

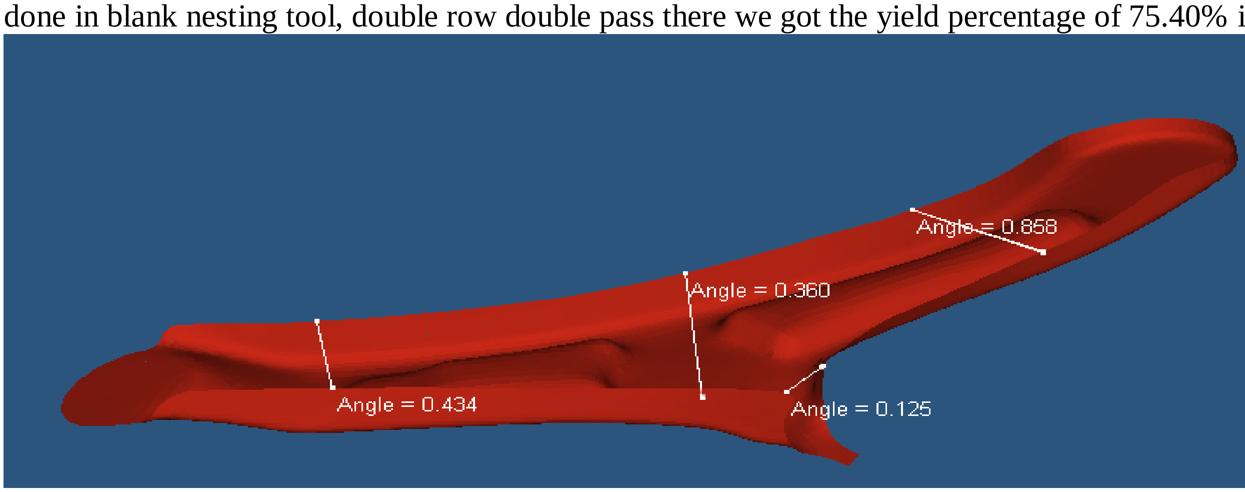

Figure 9.Spring back prediction in Hyper form

Conclusion

The formability analysis of the lower control arm was performed using FEM simulations. Metal forming, product design & Die design industry can be largely benefited to carry the virtual forming simulation and thus reduce the manual tryouts which involves time and money. Lower arm Thickness, Thinning, plastic strain and Formability are predicted in this analysis. Blank optimization resulted in more than 25% material saving & with the help of nesting we got more number of pieces per sheet, which result in higher yield & reduced costing.

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