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Design and analysis of draw die for the tail gate skirt panel

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Abstract*— This work aims to design and analysis of sheet metal dies of automobile Penguin commercial and passenger vehicle. The component tail gate skirt panel has to be produced by incorporating stage wise operations i.e. Draw (S/A) Die, trim and pierce, Flange, Restrike etc . The die is designed using CATIA V5 R19 as modeling tool. First method plan is prepared by the designer which consists of sequence of operation to produce the component economically. After that die is designed according to method plan, this is modified & approved by the project head & customer. The results obtained from simulation tool-PAMSTAMP 2G software. Results like FLD/FLC, major, minor strains and thinning etc.,. A tensile test was carried out to get exact physical properties of material which were the input to the simulation software.

***Keywords*— Design, Draw Die, Sheet metal**

INTRODUCTION

In the iincreasing competition in automotive industry demands productivity engineers and production managers of car body panels are changing their strategy of operation. To increase the productivity there is need to combine the operation in same tooling if feasible. An automotive plant today produces some 40~50 critical panels per model of car in-house, that require some 100-150 dies. Criteria for taking decision about the panels to be manufactured in-house vary from company to company. Higher Strength Low Alloy (HSLA) steels of thinner gauges are getting preference for weight reduction and the resulting better fuel economy. Other quality characteristics under demand are higher yield stress (strength), toughness, fatigue strength, improved dent resistance as well as corrosion resistance in materials used for body panels for improved durability and reliability. Press tools are special tools custom built to produce a particular component mainly out of sheet metal. The sheet metal components are being used increasingly in the automobile, aerospace, electronic & other industries because of their premium quality, low cost. Stamping process was originated from the aerospace industry towards the end of 18th century by K. R. Andrews on since then there is a significant change in the process of sheet metal stampings. A number of parameters affect the formability of sheet metal. Most of metal sheet forming processes may be characterized by nonlinear problem in geometry, material behavior, and extensive sliding friction contact phenomena. Knowledge of the deformation mechanism and the influence of the process parameters are important in the design of sheet metal forming processes. Numerical simulation of sheet metal forming processes is generally carried out by the finite element method (FEM). Generally it is very difficult to determine the optimum parameters for satisfying the design specification without any problem during the forming process. Now, many researchers have been being carried out with the FEA and the optimization techniques.

LITERATURE REVIEW

Yuji Yamasaki et al., concluded that the we can use the press forming process in the closed profile structure components. Spot welding requires flanges to hold. He studied about the weight reduction and collision strength on having flanges and without flange and came to know that we can obtain up to 12% of lighter and high stiffness using hexogonal shape pofiles. A front side member was produced and analysed.The weight effected ratio was estimated 39% of front side member.Ming-Fu Li et al,illustrated the car door impact beam by hot stamping.Structure design is composed of one or two tubes and two brackets.Pam-Stamp software was adopted for the simlation.Stamping implemented for front door beam.Micro hardness test was conducted max HRC48 and mini HRC42. In this paper the movable pad plays importent role,from three point bending test the energy absorption is below the lower level compared to baseline.Liliang Wang et al., stated that by reducing the weight we may reduce the emmision of co2 and improves the fuel efficiency. Gleeble 3800 thermo-mechanical simulator was designed and manufactured as a test rigid, using QuickSim2 software thermal and mechanical tests were controlled. The temperature history curves of experimental and stimulation data are compared at 100MPa pressure. By using reverse modelling technique heat transfer coefficient increases with increasing the constant pressure and the values obtained are 12KW/m2K for above 100MPa pressure of AA5754 sheet material.

Paul Hippchen et al., described an approach to calculating mechanical properties and geometry of indirect hot stamping car body parts with tailored properties by coupling the diffusion controlled kinematics of phase transformation. The time dependent temperature curve are measured in dilatometric testing, results shows average cooling rate >70k/s (upper cooling critical rate).A new modelling for industrial application were implemented in the FE-code LS-

DYNA971.An approach for calculating volume fractions and transformations includes strain for every phase transformations.Sin-Liang Lin et al., studied targets on front suspension system by modifying the sub frame design from stamping welding to one-piece hydro formed parts. Expansion ratio considered in stamping and hydro forming is 72% and 29.36% respectively. Simulation results of static strength says tube-hydro forming type maximum stress is smaller than stamping type, maximum displacement is little larger. The results are compared between tube-hydro forming and stamping process.Mark Vrolijk et al., stated that by using tailoring properties the thickness of the automobile parts are reduced smoothly due to lightweight. In this paper the aluminium is forged at warm and hot conditions to achieve light weight and to overcome the conventional Al forming at room temperature.ESI PAM-STAMP is the reliable tool for simulation process, analyse and improve warm and hot forming process. Virtual engineering of forming help further optimize weight saving using tailoring properties and even lighter materials(Al).Xianhong Xan et al., in this paper the mechanical properties of hot stamping are improved the ductility of components. Elongation of hot stamping is small which decreases the energy absorption while crashing. By taking one step quenching and partitioning time strength and plasticity reaches to 21.2GPa% and two step quenching and partitioning time reaches much lower. Tensile strength and plasticity is 24% higher than the traditional full martensite transformation. Both cooling and heating devices are designed.

FORMABILITY ANALYSIS

The ability of sheet metal to undergo lateral and transverse deformation to gain desired shape. The formability analysis for the component is carried out using PAM-STAMP 2G software. Before that inputs for formability analysis e.g. die surface, punch, blank holder are developed in CATIA V5 software. By simulation 80% of the die is proved before manufacturing, the other 20% can be obtained at try out. This analysis report is benefits before designing the draw die.

Majority of automobile components are produced from sheet metal, and hence sheet metal forming plays a vital role for the automobile industry. Development of tooling for sheet metal parts has been ruled by experience, thumb rules and some empirical formulae‘s for the years. With development of finite element technology many commercial packages have been developed for analysis sheet metal forming. FEA is being widely used to validate stamping tool designs and processes in virtual tryout space before putting them in manufacturing to reduce time and cost in tool tryouts.

A. Surface Development

1) First bring the component into the draw setup; there is no any undercut present in the component.
2) Die Radius generally from 6t to 10t. More die radius imparts more material flow in the cavity and better thinning control on the part.
3) Plan corner radius should be more and has direct relation with corner draw height.
4) Bead line should have 6t radius in corner
5) Taper of 10 degree is provided on the punch wall. Angle should be increased when draw height is more
6) Ring line should not be sharp
7) Blank holder minimum 20mm bigger on all sides than blank
8) Draw bead position should be decided according to whether trim line is on punch or on blank holder.
9) Before importing die surface into FEA software check the quality of the die surface e.g. overlapping patches, intersected patches etc.
10) For this project Surface Development is done using CATIA V5R17.

a) Die surface:

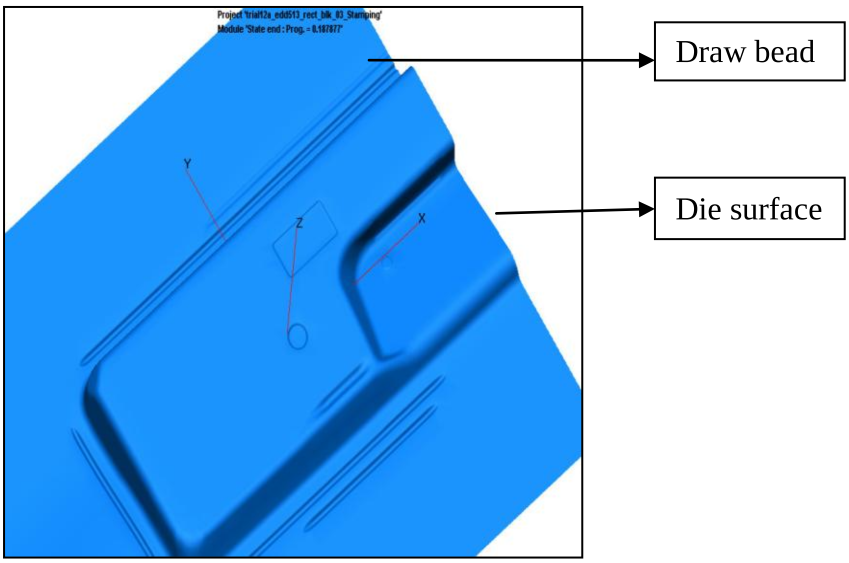

Fig:1 Die surface

b) Punch and Blank holder surfaces:

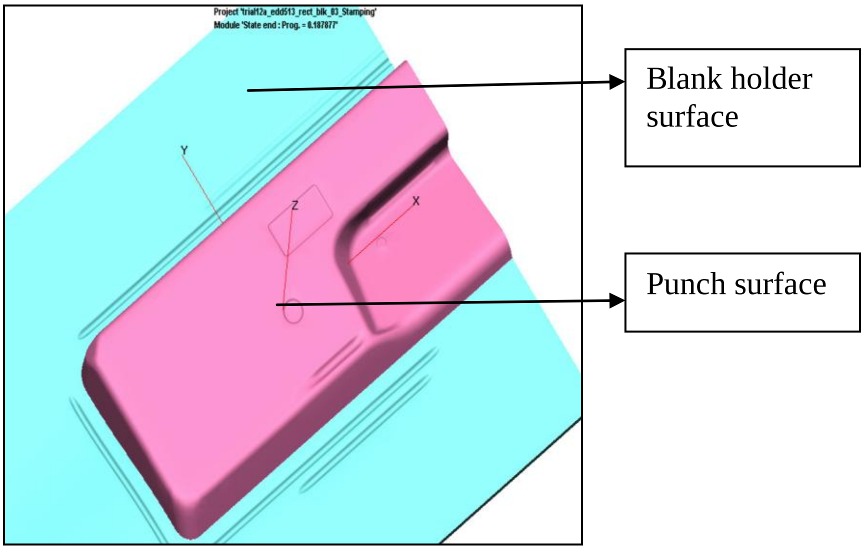

Fig: 2 Punch and Blank holder face

B. Formability analysis:

Material and section properties are assigned to all components. Tool motion is applied to die and load is applied to binder. The contact definitions between different components and constraints are defined. In this stage we supposed to give all inputs for simulation.

1.Drawing force[9]:

Draw Force=ultimate stress X Perimeter Area

Perimeter area=Ring line Length X Thickness of the sheet

f=Ultimate Strength of the material= 310 N/mm2

t=Thickness of the sheet = 1mm

L=Length of the material=Ring line length =3844mm

Drawing force F = 310*3844*1

= 123008Kgs

= 123 Tonnes

2. Blank Holder Force [9]:

Blank Holder Force is equal to the 30% of the Drawing Force

0.3 X 123= 36.9Tonnes

The total drawing force is equal to the sum of the Drawing force + Blank holding force

123+ 36.9=159.9T

The drawing force is159.9 T hence a press of more than 159.9T capacities has to use.

3. Cushion pin pressure [9]:

The cushion pin force must be equal to the 20%-30% of the Drawing Force.

The travel of the cushion pin must be equal to the Travel+10mm+20mm (Allowance).

C. *Inputs for Simulation and Boundary Conditions*

1. SHEET THICKNESS = 1 mm
2. DRAWING FORCE =123 Tonnes
3. BLANK HOLDER FORCE = 36.9 T
4. TOTAL DRAWING FORCE=159.9T
5. BLANK SIZE = 1750mm *540mm * 1mm
6. MATERIAL = EDD 513
7. FRICTION = 0.12
8. BEADS RADIUS = 6 (BASIC CASE)
9. RAM DIRECTUION = Z DIR (-1)
10. SLIDING RADIUS = MAX (2.5), MIN(2)
11. GRAVITATION FORCE = 9.8 m/s

1) Blank size estimation is done by formula d <= 0.25 (Rmin + 0.5 t) where Rmin is the smallest fillet radius on which blank slides whereas d is the minimum size of blank element coming after forming stage.
2) Mass scaling criteria is important and it comes in holding and forming stage only. For holding mass scaling should be 2x min element size while for forming it should be equal to min blank element size.
3) For all analysis work use coefficient of friction value as 0.125 only.

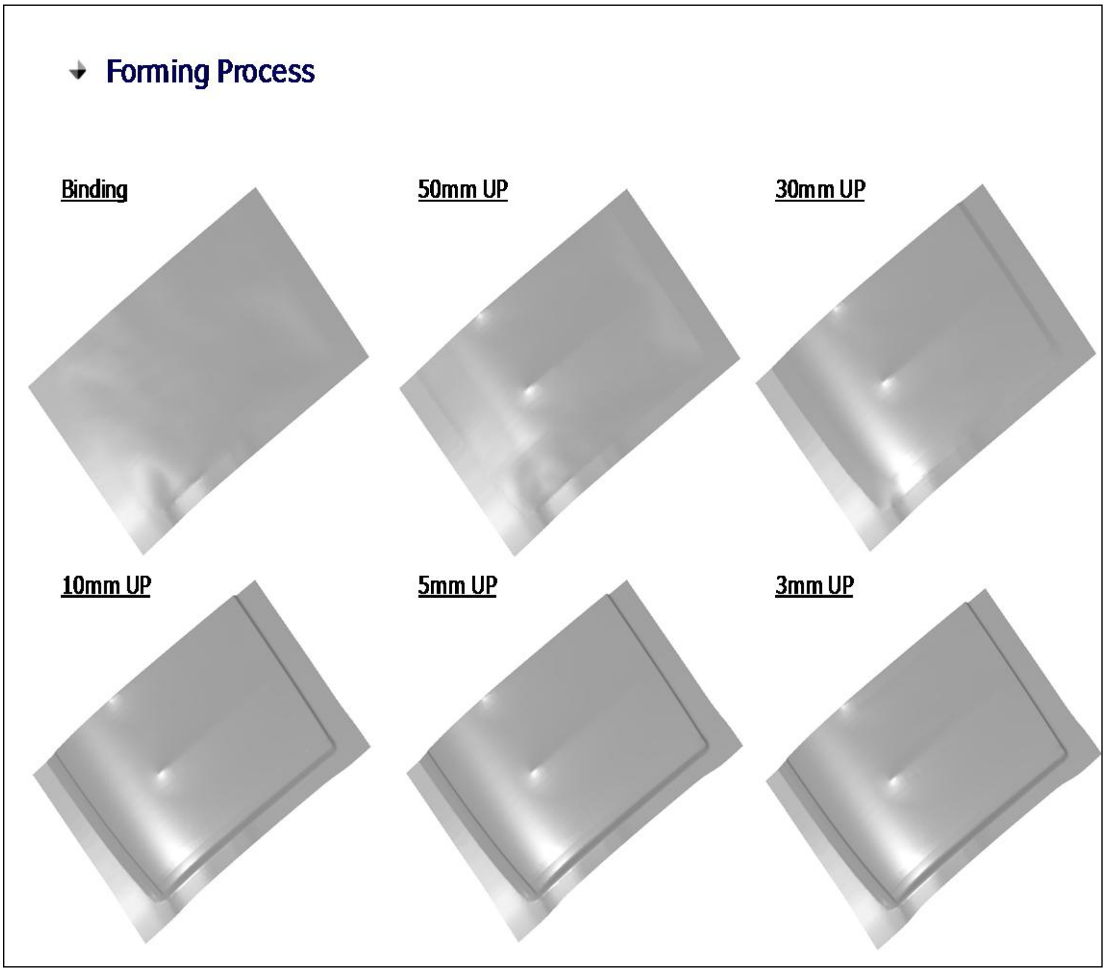

Fig: 3 Forming Process

Material behavior at the instant when the blank sheet is hold between upper die and blank holder with cushion pressure applied. This stage punch has not made any contact with the sheet metal. Blank Holder Force 36.9 Tonnes.

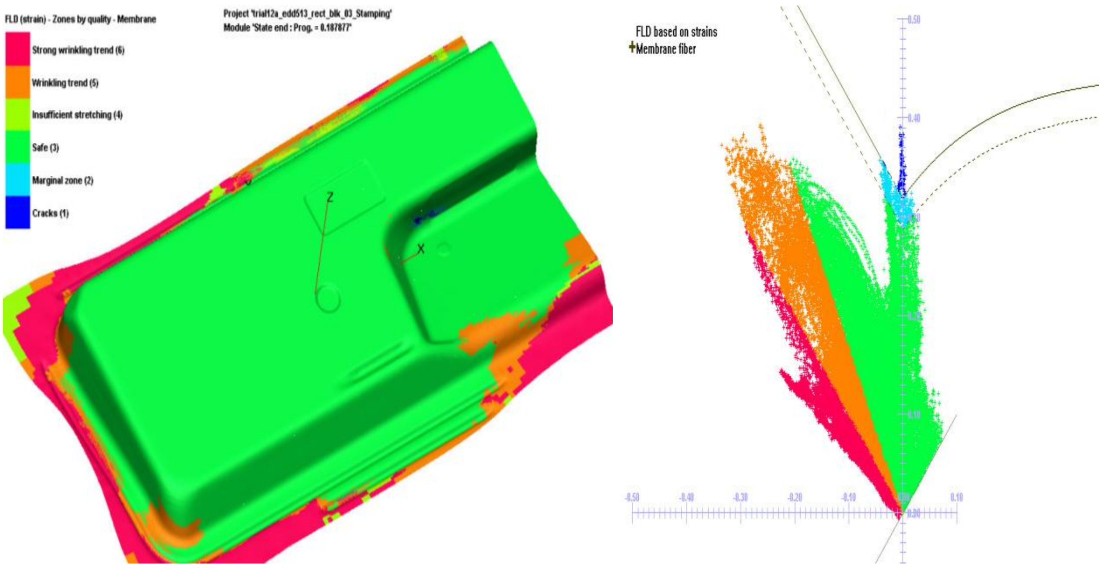

Fig. 4:Final results for tail gate skirt panelSimulative Fld curve for Tail Gate Skirte Panel

Strain Results:

Major Strain

Simulation of the component giventhemajor strain results are maximum major strain obtained as 40.36 %, minimum major strain obtained as-0.5447%.

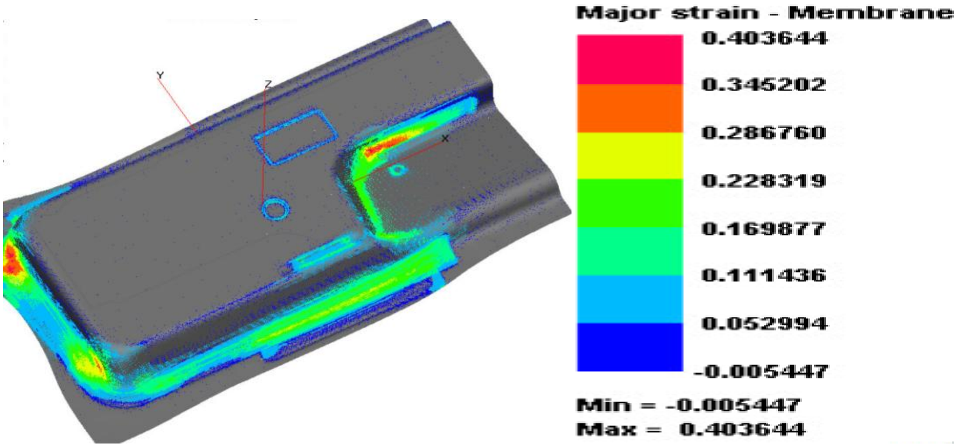

Fig. 5:Major Strain

Simulation of the component giventhe Minor strainresults are maximum minor strain obtained as 40.36 %, minimum minor strain obtained as -0.5447%.

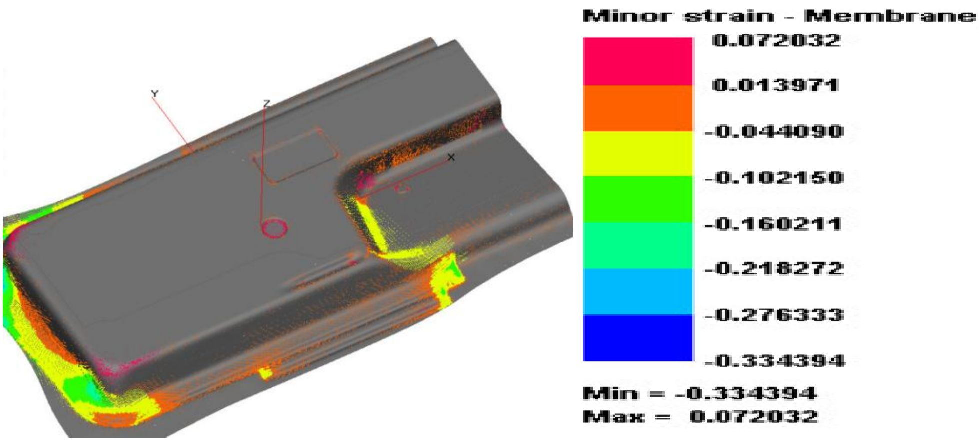

Fig. 6: Minor Strain

Thinning Results:

Simulation of the component given the Thinning Results are , maximum thinning obtained as 1.00864 and minimum thinning obtained as the 0.6806.Considerable Thinning in TATA MOTOR is 20%. In this component maximum % of thinning obtained by 12, which is less than the Allowable % of thinning in TATA.

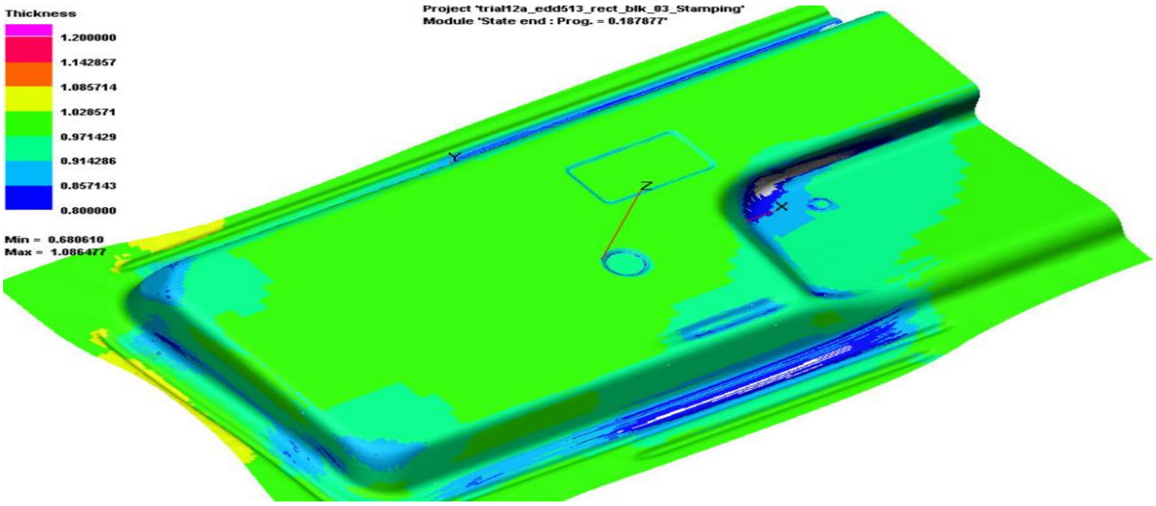

Fig.7: Thinning Results

This set up gives the information about how draw operation is possible for this component

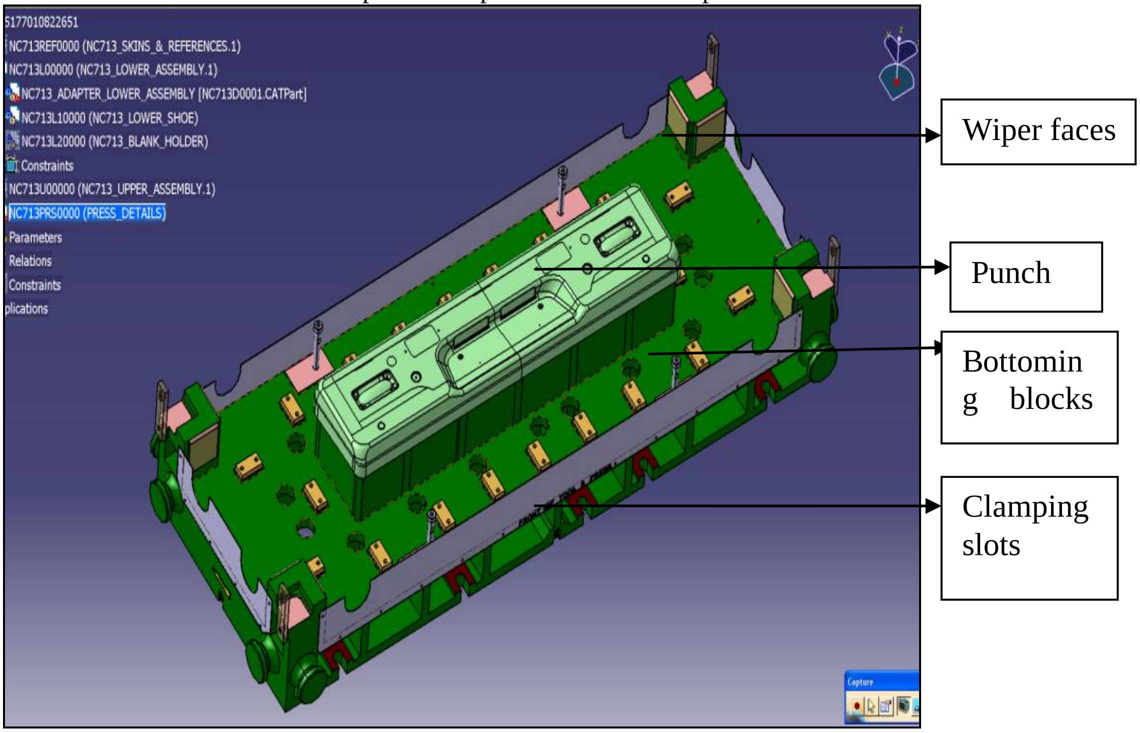

Fig: 6.2 Component with Draw surface draw die set up

The surface is provided by simulation for producing component using draw operation.

6.2 3D DRAW DIE DESIGN: (S/A)

Draw die consist of mainly 3 component

1. Lower die.
2. Blank holder.
3. Upper die.

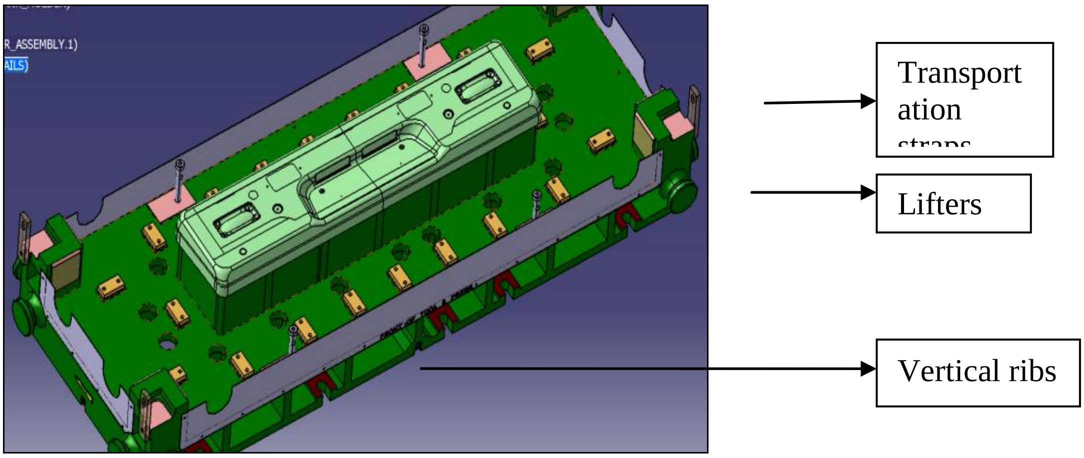

Fig: 6.4 Lower Die

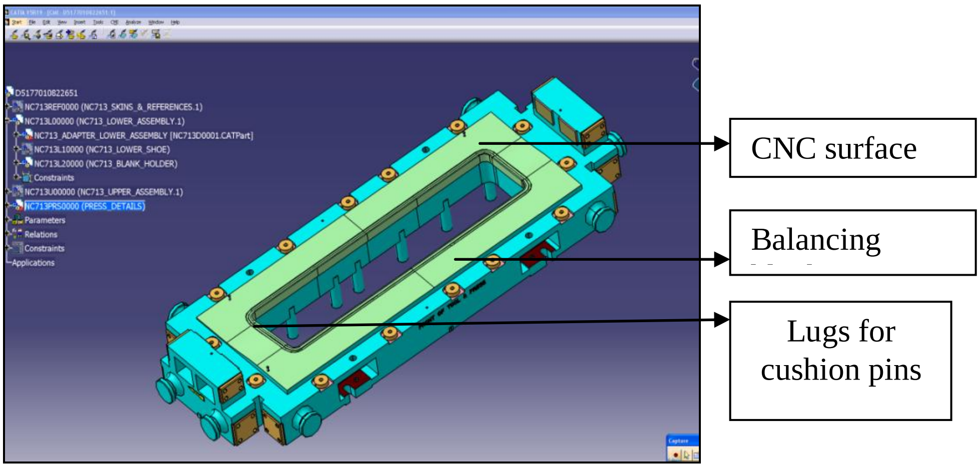

Fig: 6.5 Blank Holder

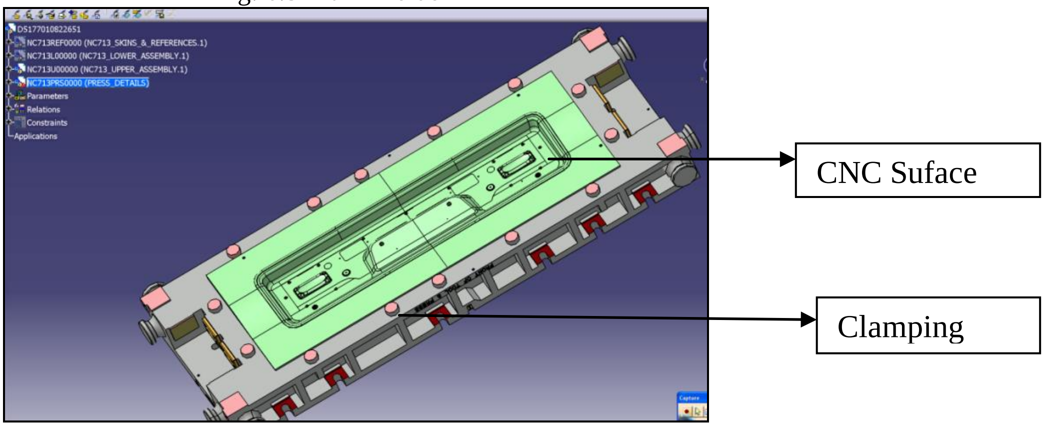

Fig: 6.6 Upper Die

Die also consists of Standard Component such as Balancing Block, Bottoming Plate, Bottoming Marker, Ejection pin, Guide pillar & Bush, Proximity Switch, Loose pin stud & bush, Retaining Screw and Wear plate.

CONCLUSIONS

- Simulation results given wrinkling, safe working and thinning zones. From theoretical calculation we obtained as Drawing force 123 Tonnes and Blank Holder Force 36.9 Tonnes. A tensile test was carried out to get exact physical properties of material which were the input to the simulation software.

- Simulation of the component at Blank Holder Force 36.9 Tonnes and Drawing force 123 Tonnes given the major strain results are maximum major strain = 40.36 %, minimum major strain = -0.5447% and Minor strain results are maximum minor strain = 40.36 %, minimum minor strain = -0.5447%.

- Component maximum % of thinning obtained as 12, which is less than the Allowable % of thinning is 20 in TATA MOTORS. Thinning present in out side of trim line which is trimmed off .Hence component safe.

- The effect of Strain Hardening Coefficient (n-value) of EDD513 Sheet metal it is found to be 0.18253 .It is found that as n-value increases, the formability of sheet metal increases. Evaluation of n-value is carried out by tensile test of EDD513 Test specimen.

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