Topology Optimization of a Stamping Die Structure using LS-DYNA® and LS-TaSC™

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Abstract

Cost of Stamping Dies accounts for about 45% of total cost of a vehicle program. The construction cost of these dies is used as benchmark by the automotive companies to evaluate the cost of any new vehicle program and also to determine where they stand compared to their competitions. The cascading effect goes down to the TIER-1 suppliers to optimize their die structure designs in order to stay afloat in the business. FE Simulation tools like LS-DYNA along with optimization tools like LS-TaSC to predict come out with the lighter and optimal die structure designs. In this paper we used LS-DYNA & LS-TaSC to optimize a die structure under loads due to stamping.

Introduction

Stamping Dies are a used to produce sheet metal component that will be used in an assembly of a structure. These Dies are used to form, pierce, trim the sheet metal components into a desired shape. Normally these die structures are built using a thumb rule (based on design hand books). These die structure will also undergo repeated loadings throughout its operating cycle. These die structures can be very bulky and are too expensive. Tool rooms look forward to optimizing this die structure as light and robust as possible to stay afloat in a highly competitive market.

In this paper we are talk about optimization of a die structure based on stamping loads. The optimization of die structure should be in association with the design standards as per the design hand books. Hence only some critical portions of die Structures only have to be optimized. In this paper we present about optimization of ribs in a die structure.

Stamping Dies – Over view

The 3D CAD model of the entire die assembly is divided into three different groups, viz, The die assembly, binder assembly & punch assembly respectively as given in the (Fig: 1.0). A geometry cleanup operation has been carried out to remove the unwanted components to make the model more lean and clean (Fig:1.1). The mass of each assembly is calculated and the tonnage of the press on which this tool can be loaded also is calculated.

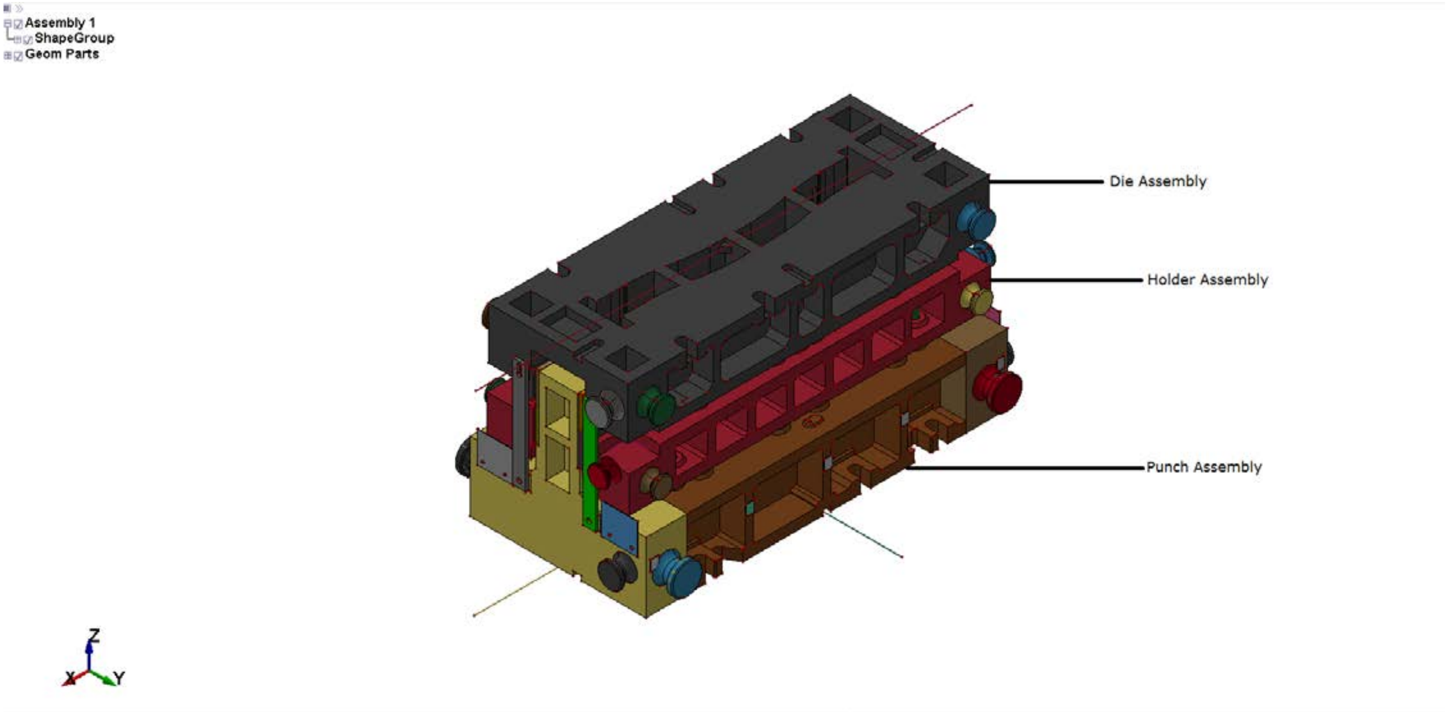


Fig 1.0

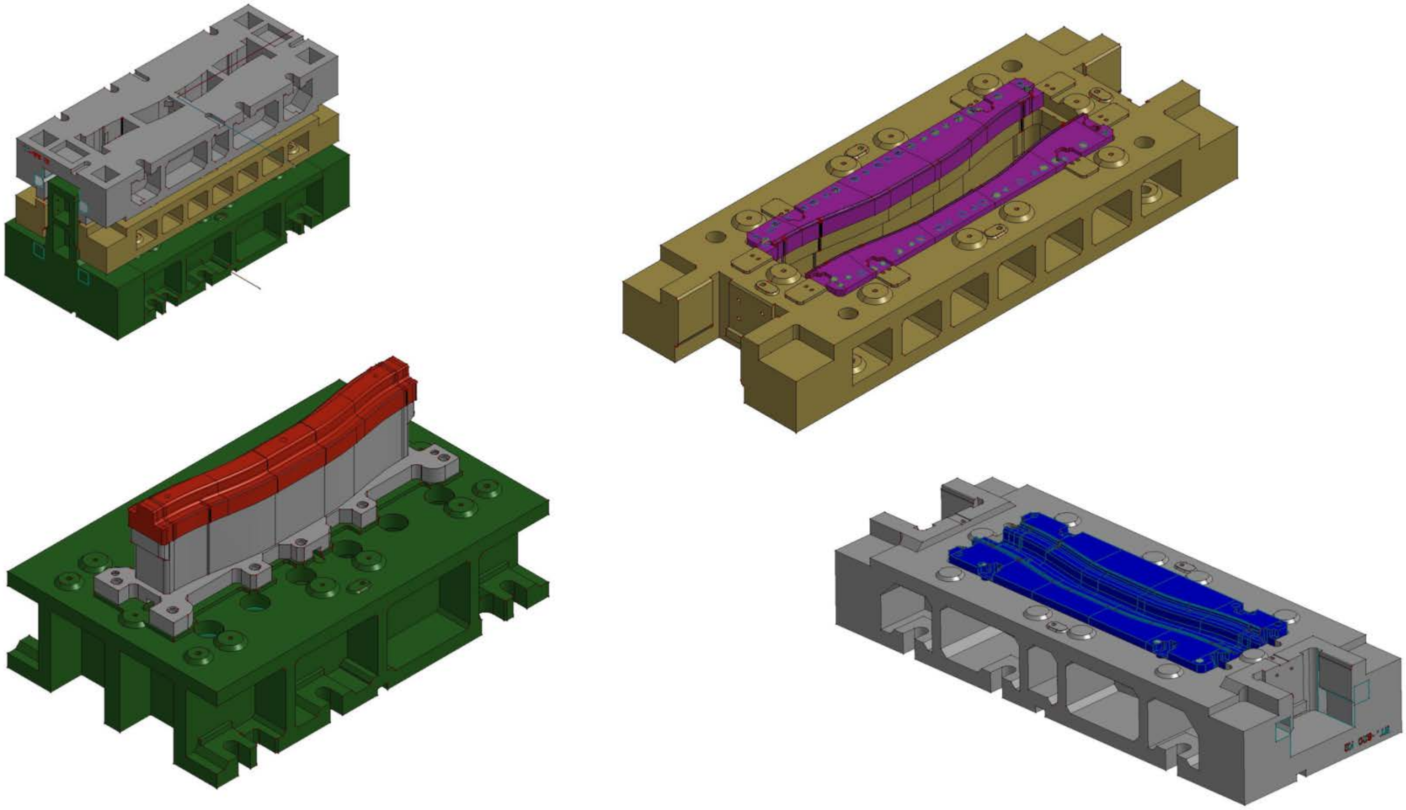


Fig 1.1

Every such assembly has two parts to it. Firstly, the tool inserts, which are made from die steels. These inserts are the key parts in any stamping tool. These are carefully machined to arrive at the desired profile (die face) such that once the stamping operation is over the sheet which is kept between the dies should deform and take the profile of inserts. The other major part in the assembly is the casting. The sand castings build to keep the inserts. These are very bulky structures which are build not only to with stand the shock loads during the stamping operations, but also have options to chain the tools for transferring from one location to another.

Sand castings are designed based on thumb rules. These thumb rules can vary from company to company. Due to this the design rules remains identical irrespective of the type of sheet metal is used for forming. For example, the load generated on the casting are different, when a UHSS steel is used and when compared to normal CRCA steel. So, these sand castings fail in such scenarios, especially those areas where the ribs are weaker. Also, when the costing of a die is calculated, the castings are priced based on their weight. Hence, it is always advantageous to work on casting optimization to produce a lighter and robust casting.

LS-DYNA is a proven tool to validate the die face designs. This paper will talk about how LS-DYNA can be used with LS-TaSC to optimize the sand casting ribs.

Modelling Approach

A forming simulation is initially performed by keeping tool inserts & blank. This is setup using the Ez-Setup in LS-PrePost®. This trial run is to ensure that the kinematics are correct, and the reactions forces computed are correct. (Fig 2.1)

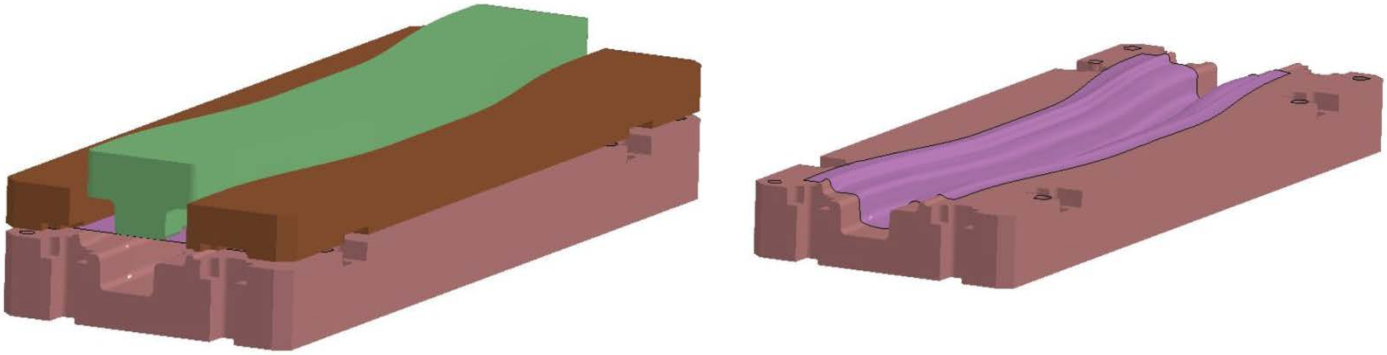


Fig 2.1

The next step is to incorporate the castings in the forming simulation model. In this paper, casting (die side) is chosen for optimization. The same approach can be applied to other casting as well. The casting mesh is divided into design and non-design part. Design part is the region which needs to be optimized. (Fig 2.2)

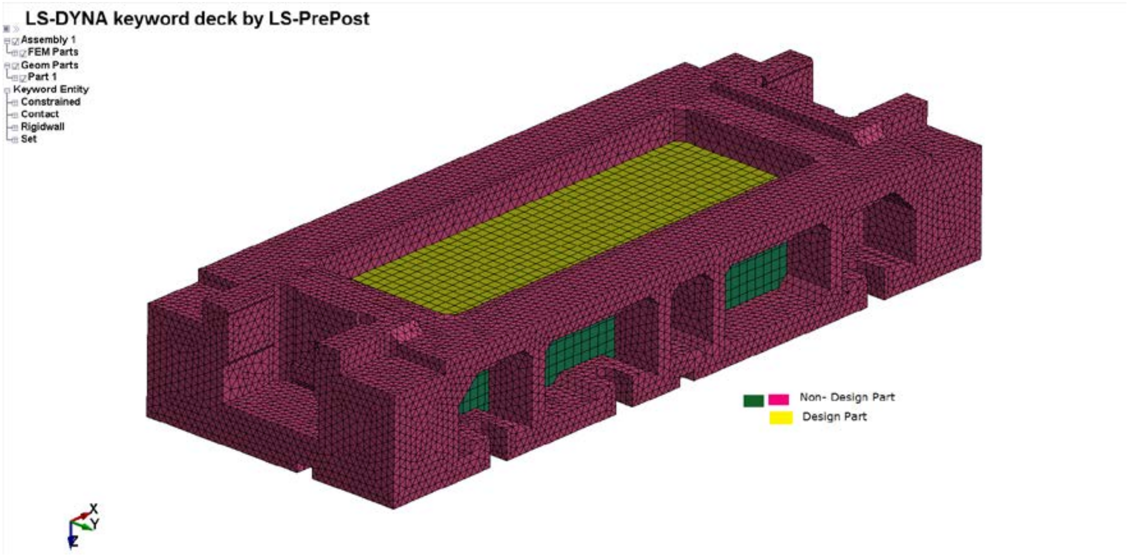


Fig 2.2

The shell mesh is generated on the die insert and that mass is matched based on the original assembly. The same is applied to blank holder & punch inserts based on the upper half assembly mass. A contact (*CONTACT_AUTOMATIC_SURFACE_TO_SURFACE) is defined between die inserts and casting that holds it. A tied contact is defined between Tetrahedron and Hexahedron meshes in the casting. *BOUNDARY_SPC_SET were defined at the slot locations where the casting is going to be clamped on to the press bed. (Fig2.3). A baseline run is executed to understand the loading on casting parts.

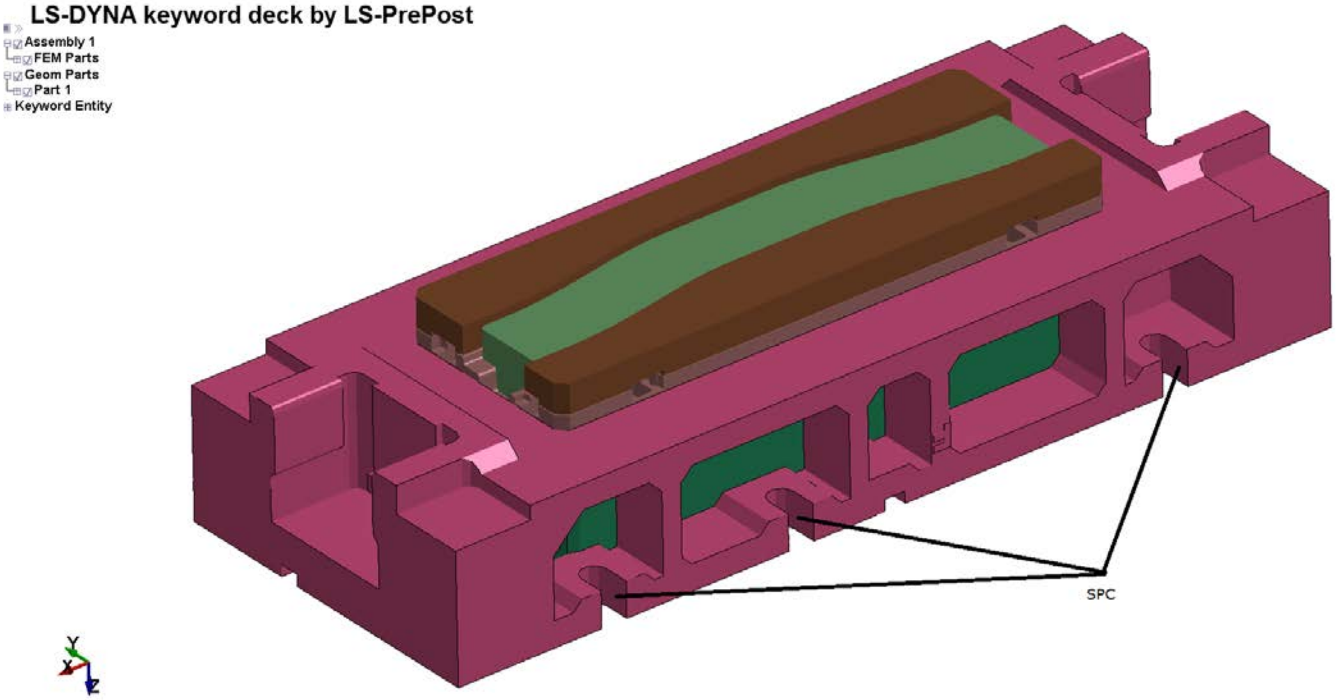
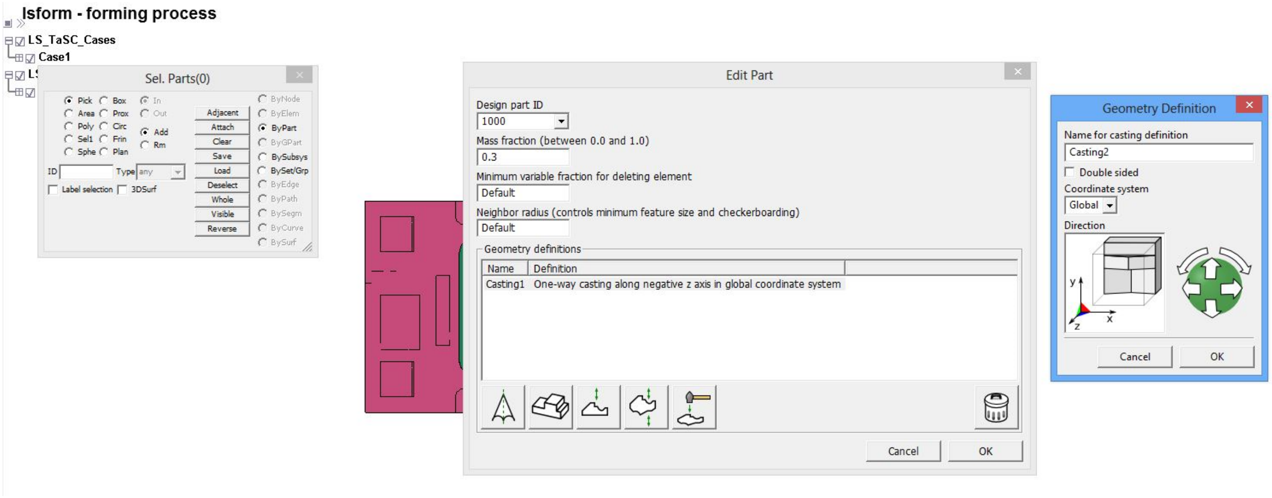


Fig 2.3

The FE model prepared in LS-PrePost is imported into LS-TaSC. A mass reduction target of 30% has been set in such a way to arrive at the stiffest structure possible with that. A constraint of 0.001mm displacement is defined. Also, manufacturing constraints has been chosen as casting and appropriate directions are given (Fig2.4 & 2.5).



lsform - forming process
☑ LS_TaSC_Cases
☑ Case1
☑ L

Edit Part

Design part ID: 1000

Mass fraction (between 0.0 and 1.0): 0.3

Minimum variable fraction for deleting element: Default

Neighbor radius (controls minimum feature size and checkerboarding): Default

Geometry definitions

Name	Definition
Casting1	One-way casting along negative z axis in global coordinate system

Geometry Definition

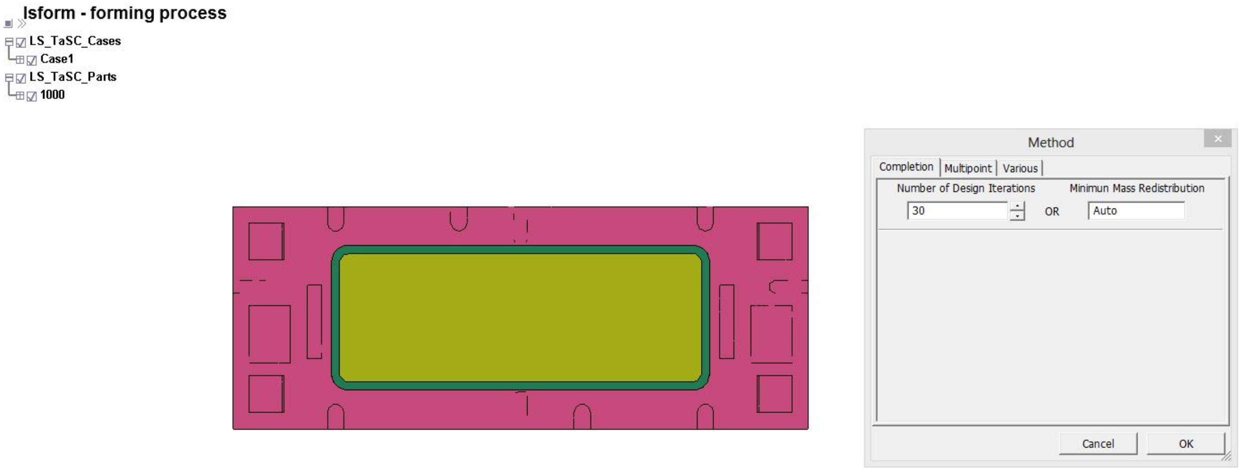
Name for casting definition: Casting2

☐ Double sided

Coordinate system: Global

Direction

Fig 2.4



lsform - forming process
☑ LS_TaSC_Cases
☑ Case1
☑ LS_TaSC_Parts
☑ 1000

Method

Number of Design Iterations: 30 OR Minimun Mass Redistribution: Auto

Fig 2.5

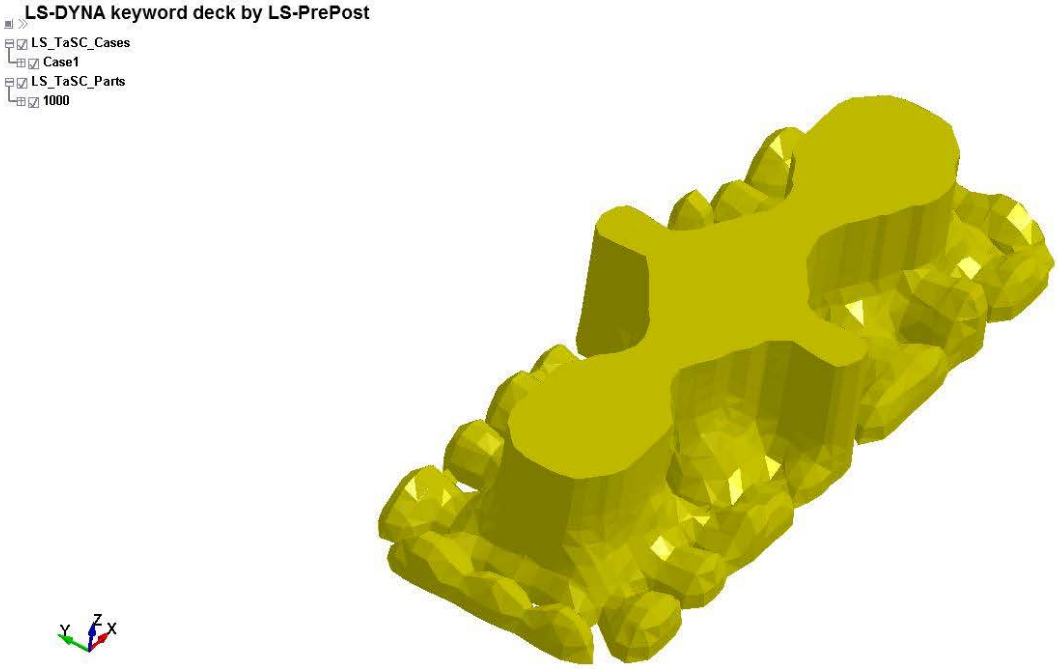


Fig 3.1

Results & Conclusion

LS-TaSC Optimized the casting with a new design (Fig 3.1). This savings in terms of weight was 105 Kg. The displacements were also minimal. Current study was on a major load carrying portion of casting. If the same is applied on punch side, there can be a similar about of saving there as well. This study helps us to understand the possibility of designing a light weighted die structure with LS-TaSC. A fatigue analysis of this design will be carried out in the future studies. Our sincere thanks to Jyoti Toolings, Pune for working with us on this project.

References

1. LS-DYNA Users Manual , Livermore Software Technology Corporation, USA
2. LS-TaSC Users Manual, Livermore Software technology Corporation, USA