Supplementary Material

Experimental and Numerical Studies of Sheet Metal Forming Using Gas Detonation Process

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Mesh convergence study

Applying the finite element method, the mesh plays a crucial role in the numerical simulation. In general, a finer finite element discretisation yields a better approximation and more accurate calculation result. However, it has always been a question: what is the resolution of the finite element mesh that provides reasonably accurate results? Therefore, it is very important to check the mesh independency of the numerical simulation model.

In the present work, the mesh refinement is obtained by h-refinement. Figure S1 shows that as number of degrees of freedom increases internal energy also increases. The snapshots of meshed assemblies shown in figure from very coarse to very fine model (A to F). Finally, the finite element model of 7e+4 number of degrees of freedom considered for all the analysis.
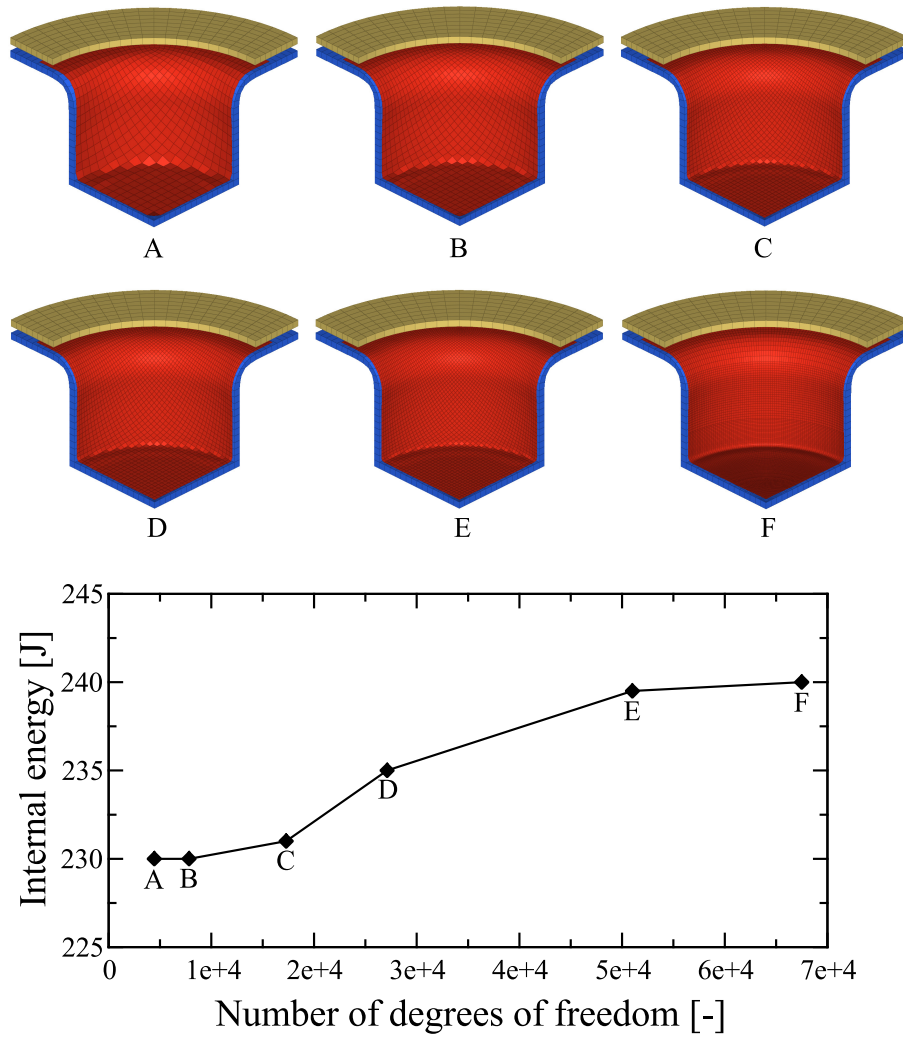
**Figure S1.** Mesh convergence study.

Influence of friction parameters

In order to model the contact friction, different static and dynamic friction coefficients were taken between the workpiece and the top plate as well as between the workpiece and the die. Figure S2 shows the influence of friction parameters on the outer diameter as well as the bottom corners of the formed cup.

   In case of the friction parameters were zeros, the outer diameter was nearly matched to the experimental diameter. Moreover, the bottom corners were sharp as like experimentally formed cup.
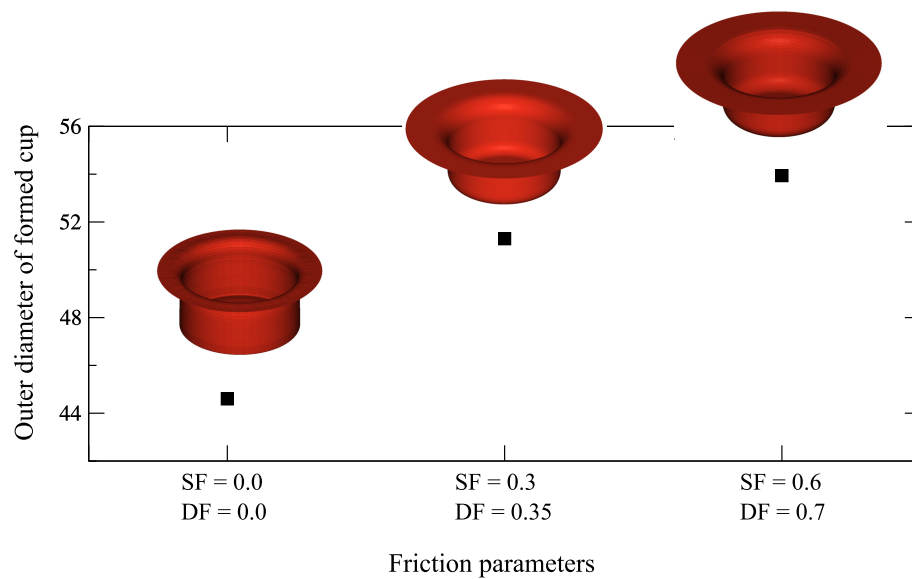

Figure S2. Influence of friction parameters.

Variations of the geometrical parameters

The main aim of this work was to study the cup formation of sheet metal. In our Shock Wave Laboratory, we have the small gas detonation forming apparatus. Therefore, in order to glide over the top corner (R5), we have not considered the sharp corners, however, we wanted have sharp corners at the bottom of the cup (R0). Following the reviewer's recommendation, we have changed the die with changing the corner radii (R0 and R5) and performed simulations. We considered following two cases,

1. R0 at the bottom as well as the top corners, and

2. R5 at the bottom as well as the top corners.

Figure S3 shows the variations of the geometrical parameters. As the bottom and top corners are set to R5 there was no damage occurred because of smooth corners. However, in case of R0 at bottom as well as top corners, damage has occurred earlier (see Figure S3c)
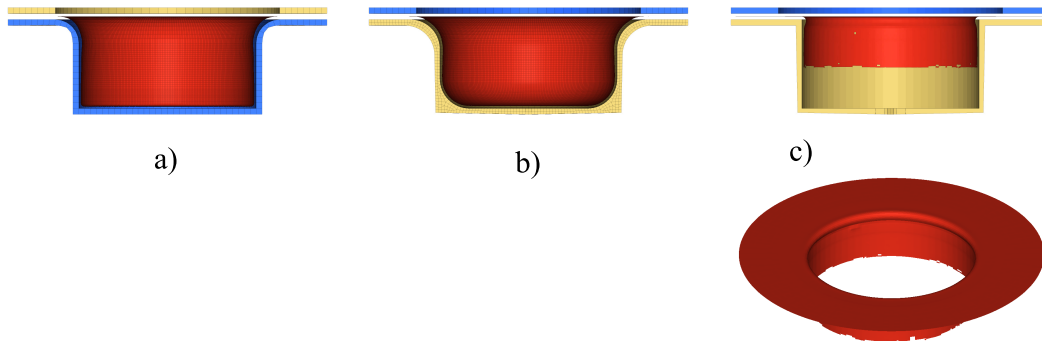
Figure S3. Variations of the geometrical parameters: a) top corner - R5 and bottom corner - R0; b) R5 at bottom as well as top; and c) R0 at bottom as well as top.