Finite Element Analysis of a Forging Die Whose Cavity Was Obtained by Reverse Engineering Techniques

Andrew Somrack
Cleveland State University

Abstract

This report documents the results of the finite element analysis of a die whose cavity was designed using reverse engineering techniques. A worn component was provided by RSP Tooling LLC. The geometry of the component was captured using reverse engineering techniques in the Cleveland State University component evaluation and prototyping laboratory using a MicroScribe digitizing arm in conjunction with the SolidWorks 3-D CAD system, and the RevWorks reverse engineering add-on to SolidWorks. A die was designed in SolidWorks by sinking cavity into the block while applying appropriate shrink factors. A finite element stress analysis was performed on this die geometry, and it was found to be overstressed. Two different approaches were applied in this study to obtain appropriate die-increasing the wall thickness of the die and applying a shrink ring.

1.0 Introduction

This report consists of several designs of a die and the part FEA analyzed using the computer program ALGOR. In the process we began with the original design that was developed as a part of a program with the Forging Industry and Educational Research Foundation by Cleveland State University. Two approaches were used to design the die. First the wall thickness was increased until the effective stress from the von Mises criteria reached an acceptable level. The second approach was to put a shrink ring around the die and select appropriate parameters for the von Mises criteria.

For this study, a ceramic part shown in Figure 1that was provided by RSP Tooling, LLC was used. It may be assumed to be a broken or worn component that has to be replaced. It is chipped in several places and one of the larger chipped areas is shown to the right in the figure. The subject was selected to demonstrate the component evaluation procedure.

Figure 1 – A Worn or Broken Part Showing Chipped Region

The part was digitized in the Cleveland State University Component Evaluation and Prototyping Laboratory using a MicroScribe 3D Digitizing Arm, the SolidWorks 3D CAD system and RevWorks, a reverse engineering software package that links with SolidWorks. Accurate numerical methods, based on geometric triangulation, calculate coordinates and the software transforms this on the surface of the models. The CAD model of the reconstructed part is shown in Figure 2.

Shrink factors were applied to account for shrinkage of the forging as well as the ceramic pattern. This is illustrated in Figure 3.

After the model is designed, a prototype can be built using a rapid prototyping procedure such as Stereolithography or CNC machining. This model would be used to make the ceramic target that is to be used in the RSP Tooling machine.

The finished CAD model of the die is then modeled in Solid Works. Figure 4 shows the finished model of the die and the die that was fabricated by the Rapid Solidification Process. Since the RSP Tooling die for this case was fabricated before the CAD model was made (this is not the normal procedure) it can be seen that the component evaluation steps were performed correctly.

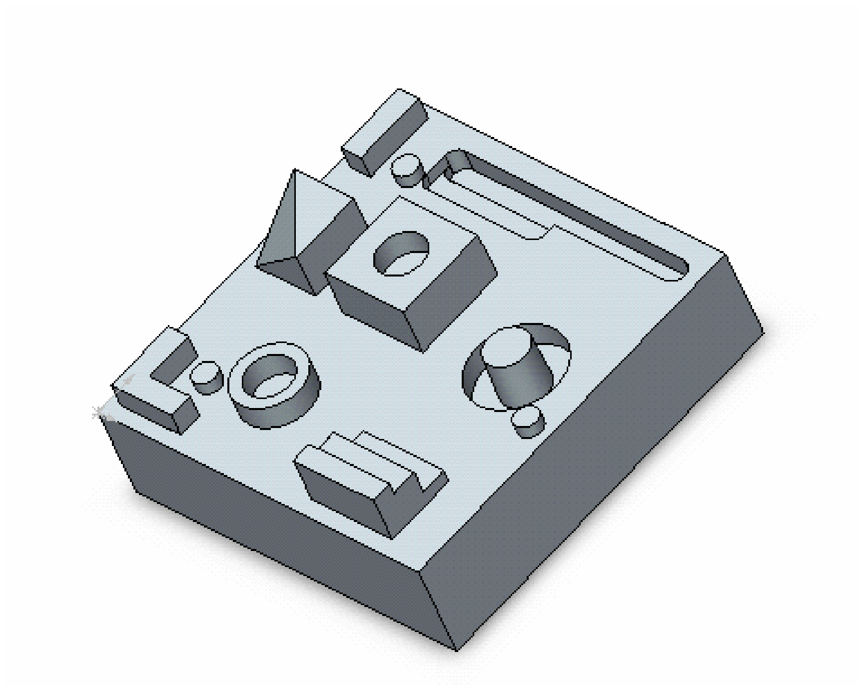


Figure 2 - Solid Model Generated from Scanned Point Data with SolidWorks

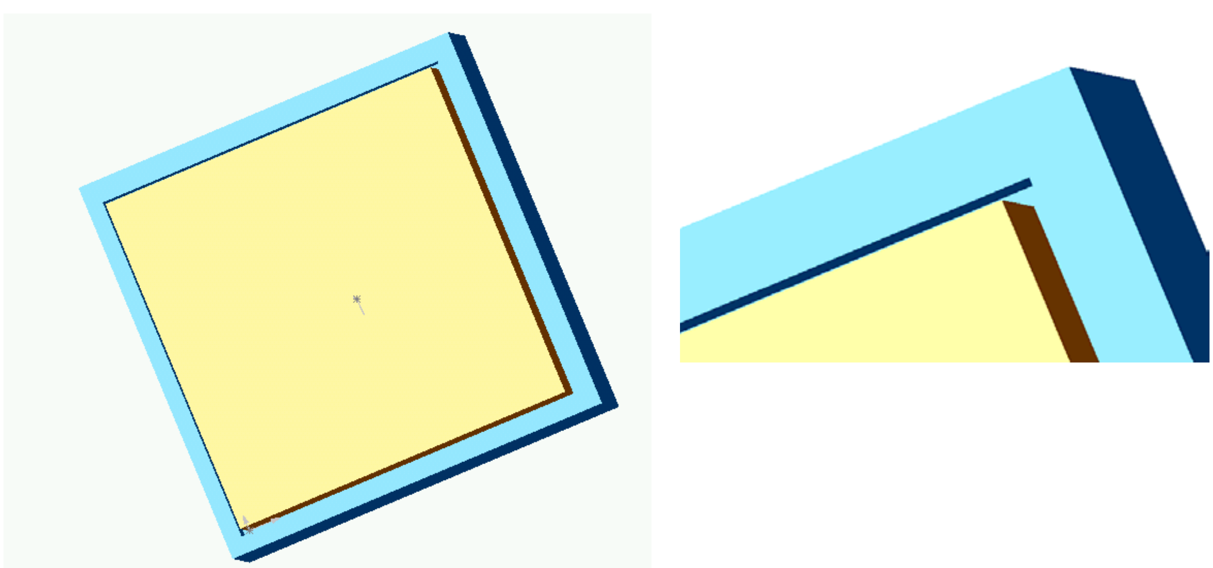
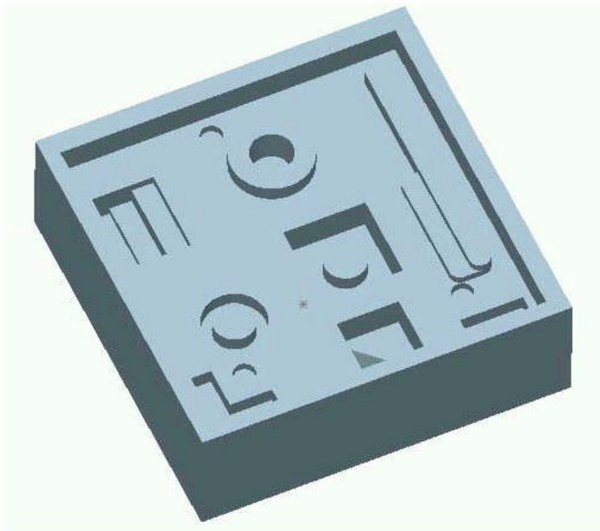


Figure 3 - Part / Die Showing Applied Shrink Factors



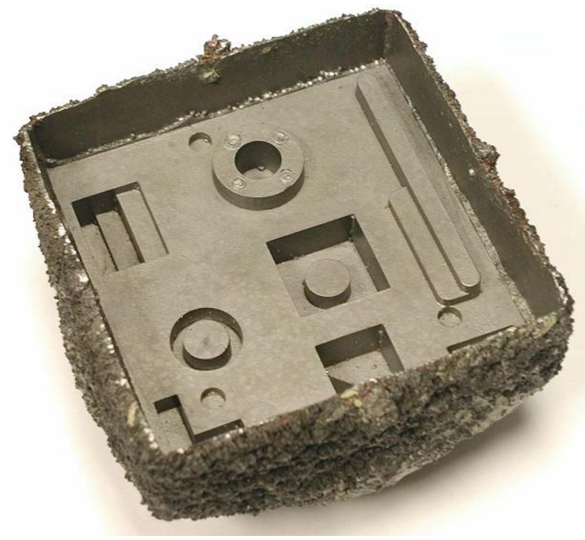


Figure 4 – CAD Model of the Die and RSP Tooling Die

2.0 Finite Element Analysis of the Original Design

The original design which is shown on the left side of Figure 4 by inspection is a thin walled die, and would not be appropriate for the forging application. Pressure was placed on the inside of the die in all areas and the die was contained on the bottom using fixed elements.

Error! Reference source not found.5 shows the results of the finite element analysis. The color fringes indicates where the stresses are applied through the use of colors. As indicated in the legend the brightest colors are the ones with higher stresses while the more neutral colors indicate a lesser stress. According to the results received, the maximum value was 13095 lbf/(in^2). This analysis served as a base line for the analyses that follow.

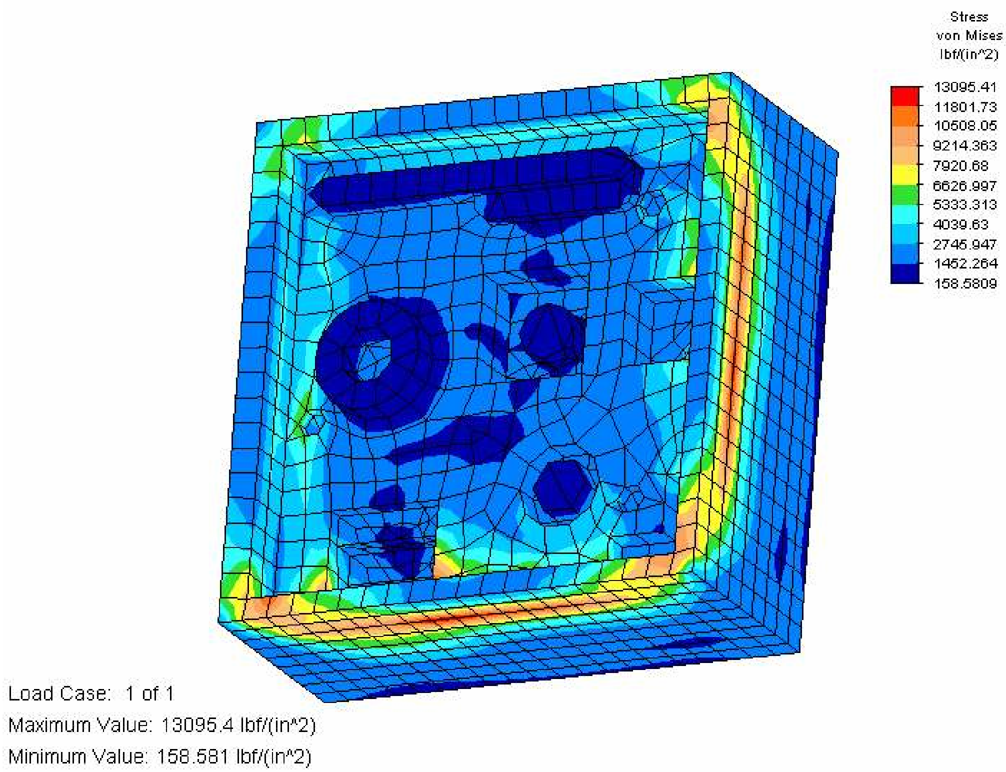


Figure 5 – von Mises Stress Results - Original Die Design

3.0 Larger Wall

In the next iteration of the original design, it was decided to increase the wall size. This change was done because is visible in the original design that there was a lot of stresses occurring in the thinner walls. The new design was then tested with von Mises. This value turned out to be a lot smaller. As Figure 1 shows below the maximum value of the von Mises stress is that of 5047 lbf/(in^2). However this is a bad picture of the modeled die because the sides are not seen to visually indicate if the stresses have been reduced due to implementing a larger wall.

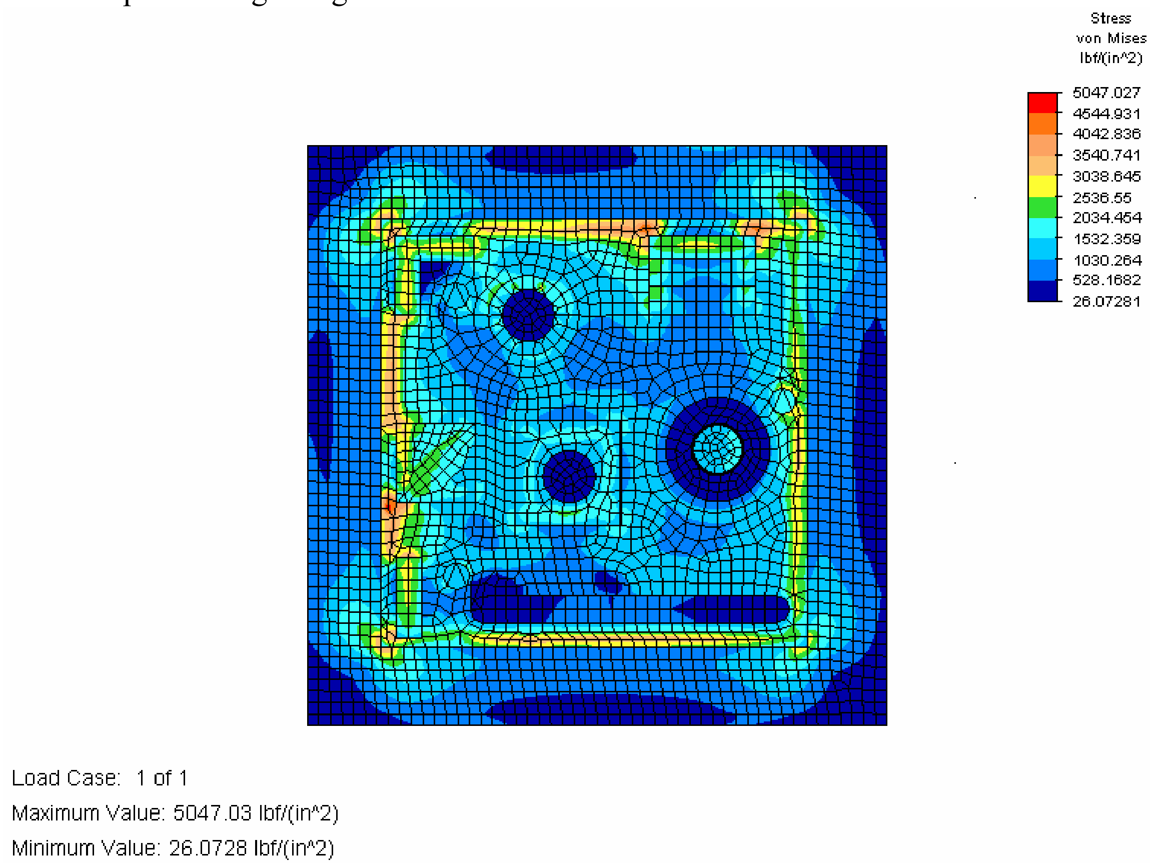


Figure 1 Larger wall model

4.0 Shrink Ring

The next attempt in creating a die with very little stresses placed on it was a shrink ring. This design changed the die from the square that is to a circle type that is seen in Figure 2. The reasoning behind this change is that when Figure 1 is examined closely, the picture of the die really is a good picture. In this figure it shows the primary stress circle the die. Using the imaginary circle to our advantage, the die was able to be redesigned as shown. It is tested and again the stresses changed to our advantage. The maximum value that is seen is 3972 lbf/(in^2).

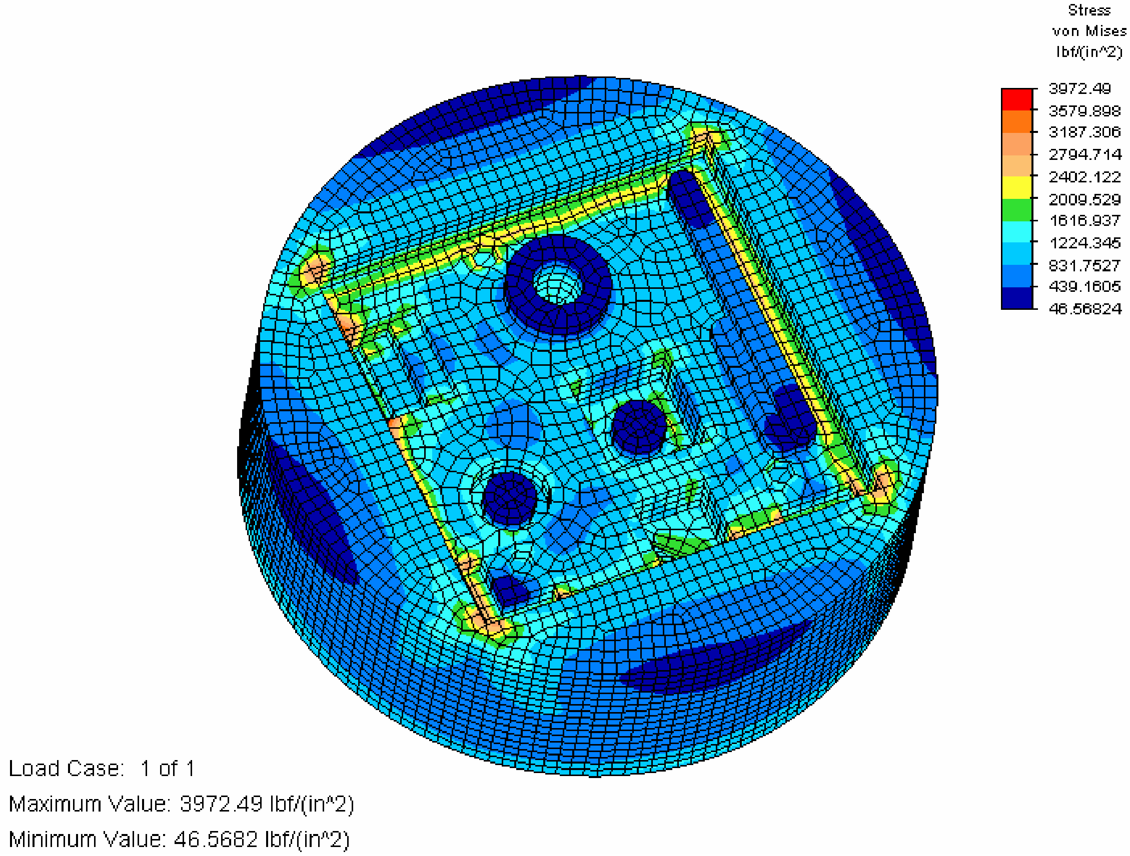


Figure 2 Shrink ring model

5.0 Conclusions and Recommendations

Engineers use a wide range of tools and techniques to ensure that the designs they create are safe. However, accidents sometimes happen and when they do, companies need to know if a product failed because the design was inadequate or if some other cause, such as user error, was to blame. It is my best recommendation that a shrink model will insure the longest life and less chance of failure. If a company were to use the original design then failure is inevitable.

6.0 References

ALGOR. Algor.com. 2004. <http://www.algor.com/>.