

ME 363 Forming Project (100 points)

Due Date: 11/30/2023

Introduction

Metal forming software (AFDEX-2012) will be used in this project to design and simulate the metal forging process. AFDEX is a general purpose metal forming simulator, which can be applied not only to conventional bulk metal forming processes including forging, rolling, extrusion, and drawing, but also to new creative bulk metal forming processes. AFDEX is theoretically based on the rigid-thermoviscoplastic finite element method. AFDEX can solve the metal flow and heat transfer problems present in metal forming and die structural analysis.

Purpose

Learn to use the metal forming software to design and analyze the metal forming process under specific requirements.

Software

AFDEX-2012 (Adviser for Forging Design Expert) has been installed on the computers in ME 2028. From the desktop, go to Start → Programs → AFDEX-2012 and then click on AFDEX-2012. When the software is ready, proceed as described below.

Task 1: Tutorial

Follow the tutorial provided on the class website to familiarize yourself with the metal forming software AFDEX-2012. This tutorial will guide you through the steps to simulate a forming process with simple geometry. Once the simulation is finished, you can check the stress, strain, temperature, load, power, etc. with the post processing module of the software.

Task 2: Forming Process Design (3D)

Work piece: solid cylindrical billet

Design Requirements: The die is to press into the work piece by 50% of the work piece's initial height

Experimental Procedure:

1. Create *cylindrical* work piece geometry with a diameter of 50 mm, a height of 30 mm, and an angle of 45 deg (Figure 1). The angle specifies a slice of the work piece that we will use for simulation; a smaller angle results in a thinner slice and a faster simulation.
2. Create *pipe* upper and lower die geometry with an inner diameter of 20 mm, an outer diameter of 40 mm, a height of 30 mm, and an angle of 45 deg (Figure 1)
3. Select *ANSI 316 stainless steel (20 C)* from the material library for the work piece.
4. Define a manual press with *zero velocity* for the bottom die
5. Define a manual press with a *negative Y velocity* for the top die

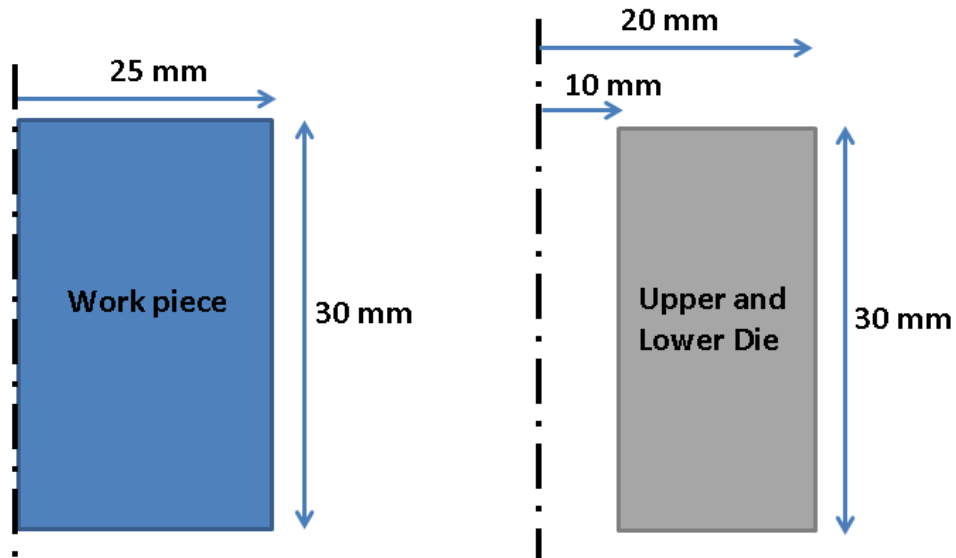


Figure 1: Work Piece and Die Geometry for 3D Simulation

Part A—Effect of Friction Coefficient:

1. Set the *friction type* to Coulomb, and the *friction coefficient* to 0.3 for the top and bottom dies
2. Set the *stop criteria* according to the **design requirements**
3. Select the *planes of symmetry* as the two sides of the “pie slice” of our workpiece
4. Run the simulation. This will take several minutes.
5. Measure and record the maximum height of the center “bubble”, and the maximum diameter of the formed part (Figure 2)
6. Record the final load in the Y-direction
7. Repeat steps 1-6 with a friction coefficient of 0.05
8. Record the maximum height and final load for each friction coefficient and comment on the effect of friction coefficient on the final work piece shape

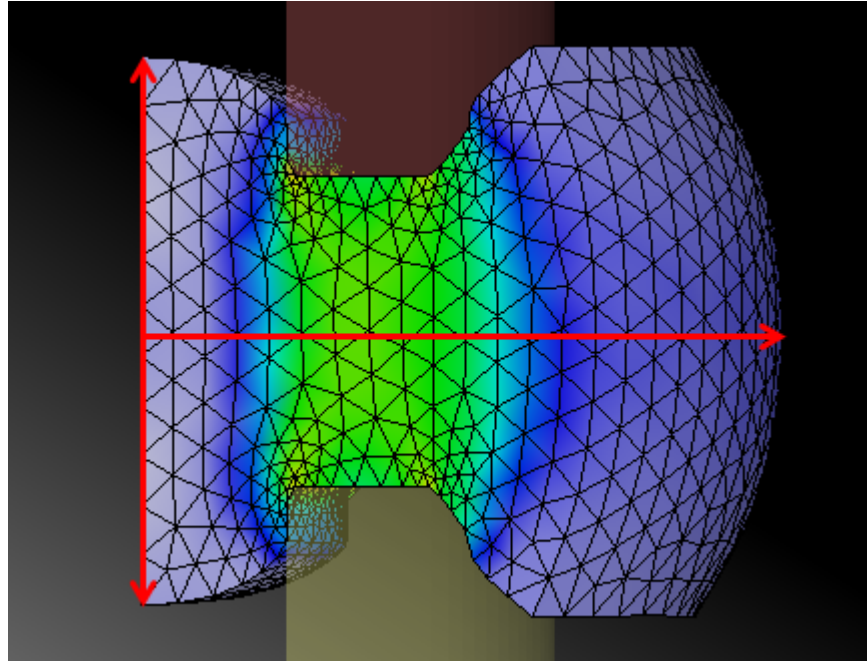


Figure 2: Formed Height Measurement

Part B—Effect of Hot and Cold Forging

1. Set the process *forming type* to hot (Figure 3) by right-clicking on the top of project tree and selecting *Properties*
2. Change the material to *AISI_316SS* ($T = 600\text{--}1200\text{ C}$)
3. Set the Coulomb *friction coefficient* to 0.05
4. Run the simulation and record the final load in the Y-direction
5. Compare these final load values with the final load from Part A

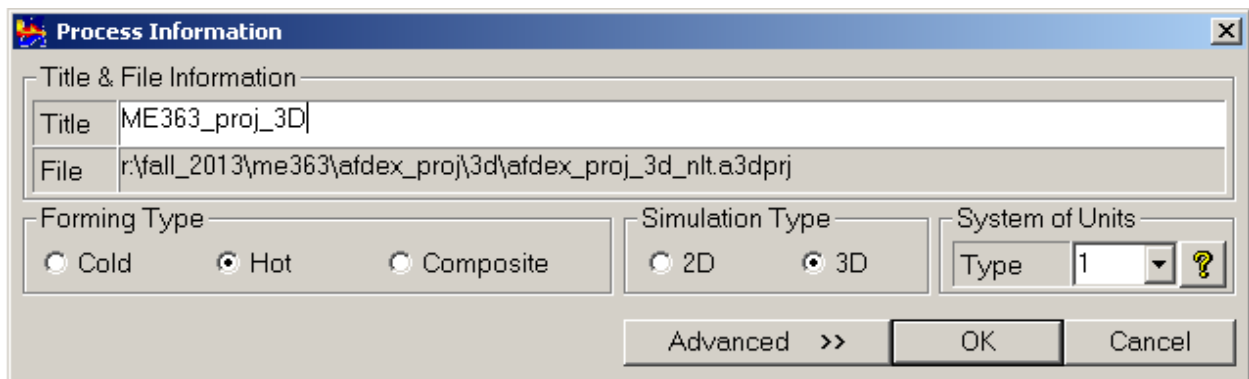
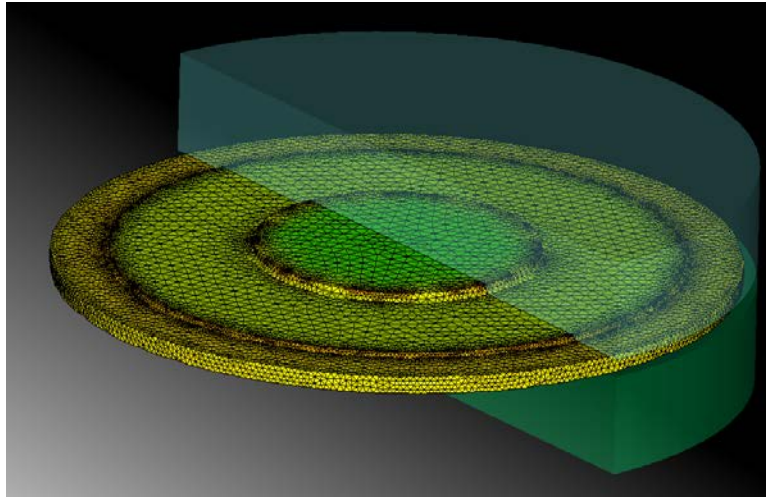


Figure 3: Process Information Window

Task 3: Blind flange forging



Summary: For this task, you will be simulating the process of forging a blind flange. You will simulate the workpiece temperature, power level, and effective stress during the forging process.

Work piece: Solid cylindrical billet radius of 14 mm and height of 3mm.

Design Requirements: The die should translate 1.5 mm in the y-direction.

Part design: A blind flange is a round plate which has no center hole, and because of this feature it is used for sealing the end of a pipe. Blind flanges are commonly used in petrochemical and pipe engineering. Blind flanges allow for easy access to the interior of the line. The bolt holes as shown in Figure 4 will be drilled after the forging process. The dimensions of the blind flange is shown in Figure 5.



Figure 4: Image of a blind flange

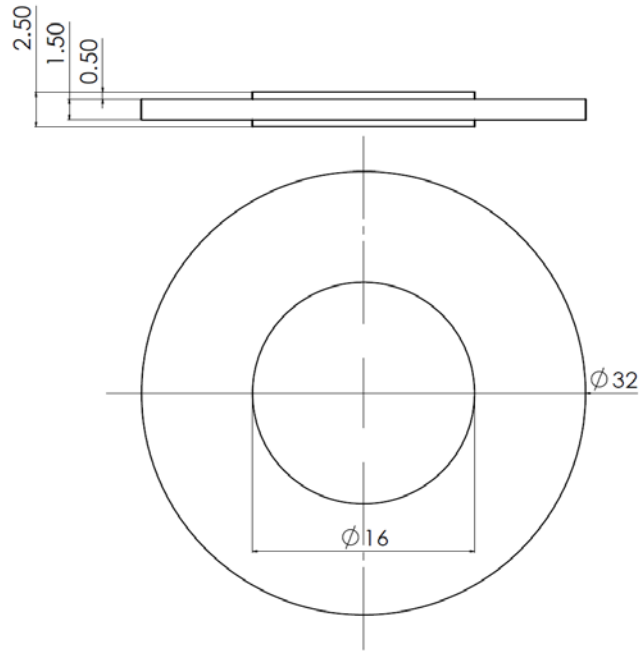


Figure 5: Dimensions of the blind flange

Experimental Procedure:

1. In the work space window click model-> From File -> C:\Program Files (x86)\AFDEX_2012\3D_Exmample\Ex01
Choose Lowerdie-flange, Upperdie-flange, and Billet-flange.
These Stl files contain the geometries of the upper die, lower die, and workpiece. The geometries were set to an angle of 45° (symmetry boundary conditions) to reduce computation time.

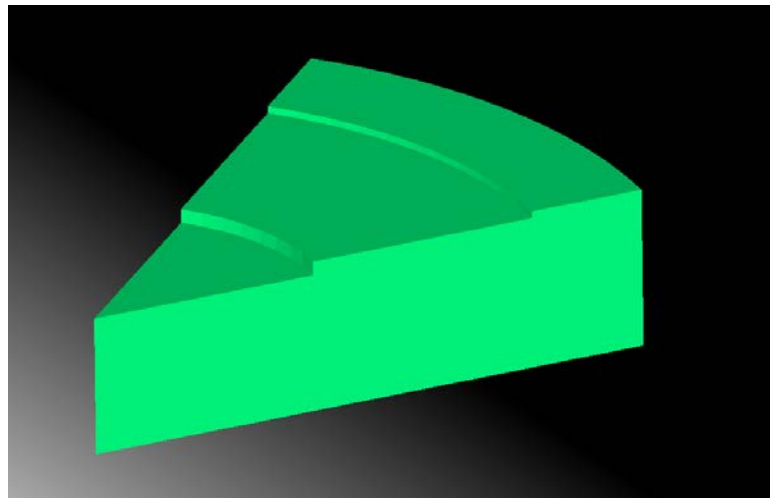


Figure 6: Lower die geometry

2. Move the MODL01_lowerdie-flange.stl, MODL01_upperdie-flange.stl, and MODL01_billet-flange.stl from the workspace window into the Lower Die, Upper Die, and Workpiece, respectively.
3. Select *ANSI 304 stainless steel (20 °C)* from the material library for the work piece
4. Define a manual press with a *-1 mm/s Y velocity* for the top die
5. Set the *friction coefficient* to 0.05
6. Set the process *forming type* to cold (Figure 3)
7. Define the appropriate symmetry planes
8. Set the stop criterion. The simulation should stop when the distance between the nodes as shown in Figure 7 is 1 mm.

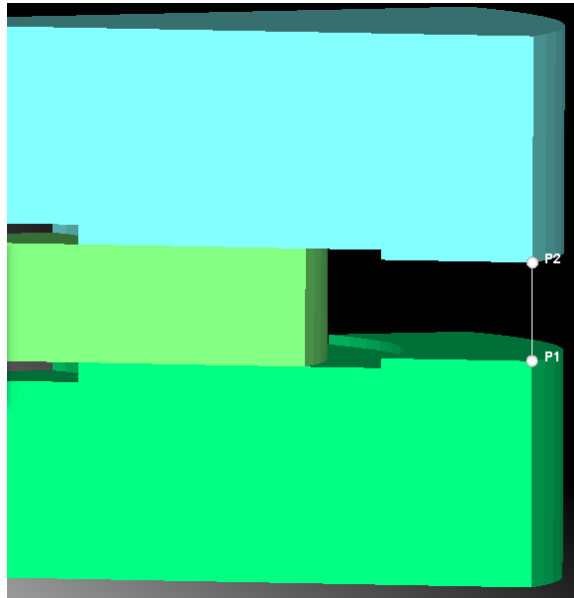


Figure 7. Nodes used for the stop criterion

9. Repeat steps 1-9 using AA_6061 (20 °C) as the workpiece material

Items to be included in report:

1. Problem set-up for each case and a summary table showing the parameters used for simulation.
2. Simulation results:
 - a. Task 2 Part A: show the effect of friction coefficient on the final shape of the part and on the load vs. stroke curve
 - b. Task 2 Part B: show the effect of cold and hot forging on the final shape of the part and on the load vs. stroke curve for a friction coefficient of 0.05
 - c. Task 3: compare the workpiece temperature, effective stress, and power vs. stroke curve between AISI_304SS and AA_6061
3. Analysis of the results is required for all three parts
4. Conclusion: A brief summary of the project and important conclusions drawn from the project

Comments on the project:

Please evaluate the project and provide your comments on a separate sheet of paper. This part will be counted toward your grade; your comments will be used to improve the design of the project for future classes.