

# ME 363 Forming Project (100 points)

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**Due Date: Dec. 1, 2015**

## Introduction

Metal forming software (AFDEX-2012) will be used in this project to design and simulate the metal forming 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

### Work piece:

50 mm x 10 mm x 2mm sheet metal

### Objective:

- a) Understand the effect of hot and cold forming on the effective stress.
- b) Compare the effective stress in different materials undergoing the forming process.

### Design Requirements:

The final distance between the dies is to be equal to **1.8 mm**.

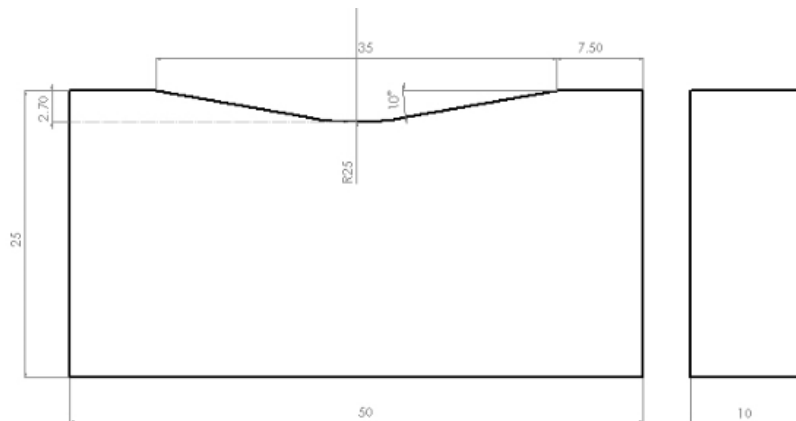
### Experimental Procedure:

#### Part A—Effect of hot or cold forming on effective stress and power

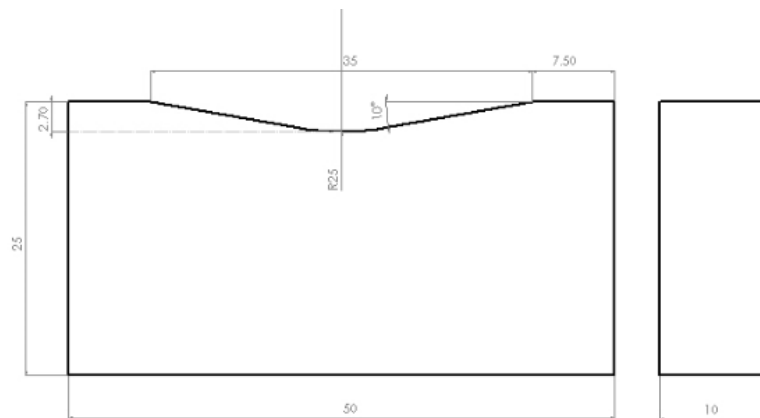
To study the effect of Hot or cold forming, run two simulations both using Aluminum with the following parameters. Choose the appropriate forming type (Hot or Cold).

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1. Create the upper and lower dies using any CAD software using the dimensions shown in Fig 1. and save it as a .stl file.
2. Import the .stl file for the upper and lower dies (Model > From file). Create the workpiece using AFEX (Model > Autoshape).
3. Select the workpiece material Aluminum 6061(T=20°C) for the cold forming case and Aluminum 6061(T=250-500°C) for the hot forming case from the library (Material>From Library).
4. Define a manual press with velocity  $V_y = -1$  mm/s for the upper die and zero velocity for the lower die (Press>Manual).
5. Set the friction type as coulomb and the friction coefficient as 0.05 (Friction>Manual)
6. Select the appropriate symmetry planes. Note: Workpiece should not expand in the z direction (refer to Fig.2)
7. Select the appropriate die stop criteria based on the design requirement.
8. Run the simulation (this will take up to half an hour) and measure the final maximum effective stress, final load and power vs time. Comment on the effect of temperature of workpiece on these values.



(a)



(b)

Figure 1: Die Geometry for 3D Simulation a) Upper die b) Lower die

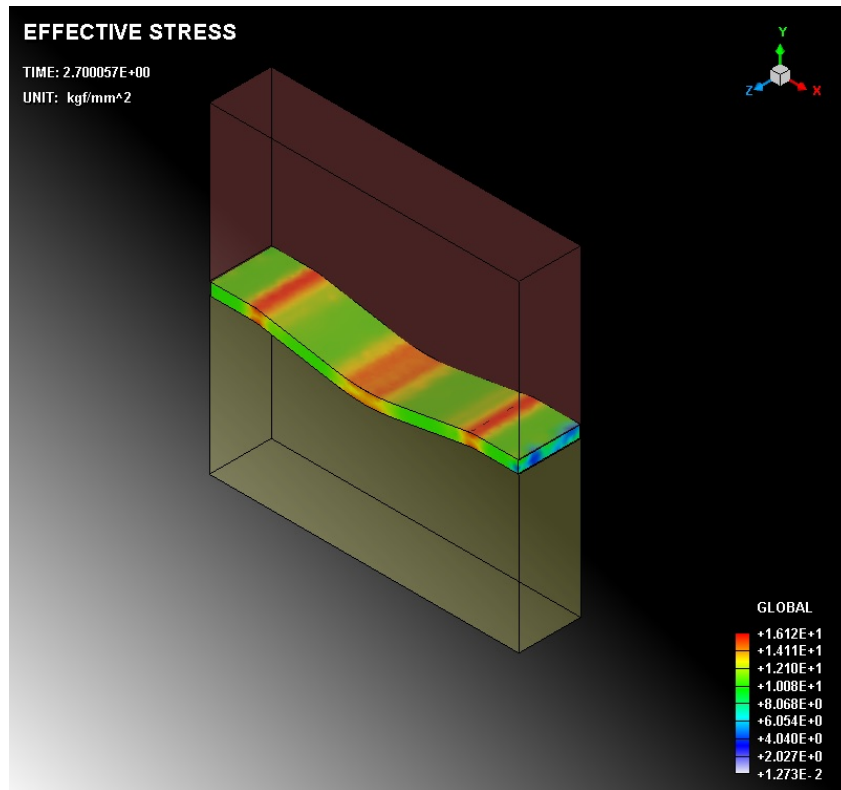


Figure 2: Effective stress of workpiece after forming

### Part B—Effect of material type on effective stress and power

To study the effect material type, run two simulations using Aluminum and stainless steel with the following parameters. Use cold forming in both cases.

1. Use the same dies and workpiece geometry as in part A.
2. Select the workpiece material Aluminum 6061( $T=20^{\circ}\text{C}$ ) for the first case and Stainless steel 304 ( $T=20^{\circ}\text{C}$ ) for the second case (Material>From Library). .
3. Define a manual press with velocity  $V_y=-1$  mm/s for the upper die and zero velocity for the lower die (Press>Manual).
4. Set the friction type as coulomb and the friction coefficient as 0.05 (Friction>Manual)
5. Select the appropriate symmetry planes. Note: Workpiece should not expand in the z direction (refer to Fig.2)
6. Run the simulation and measure the maximum effective stress at the final time step, the final load and power vs time. Comment on the effect of material type of workpiece on these values.

### Task 3: Forming process optimization

#### Objective:

Minimize the production time by varying the die velocity.

#### Design Requirements:

1. The final distance between the dies is to be equal to **1.8 mm**.
2. Maximum power should not exceed 175W.
3. Maximum temperature should not exceed 39 °C
4. Maximum effective stress should not exceed 185 MPa
5. Maximum speed on the first stroke and second stroke should not exceed 5 mm/s and 3 mm/s, respectively.

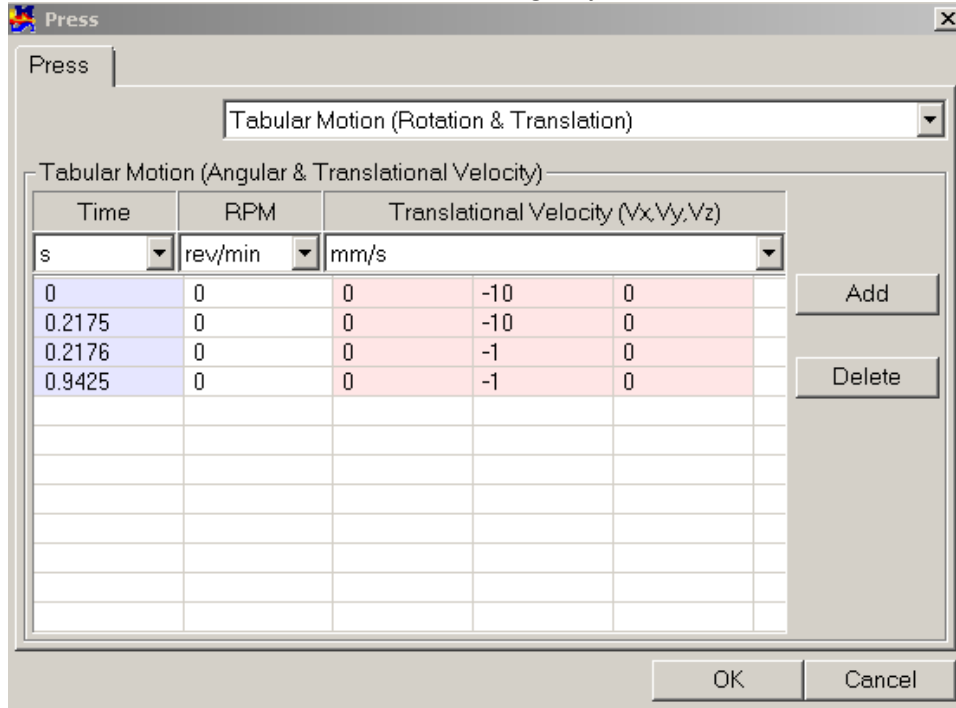
#### Experimental Procedure:

1. Use the same dies and workpiece geometry as in part A. Set the forming type as cold forming.
2. Select the workpiece material Aluminum 6061(T=20°C) forming from the library (Material>From Library).
3. Define a manual press with the first velocity to cover 2.175 mm (3/4th of the stroke) and second velocity to cover 0.725 mm (1/4th of the stroke) for the upper die.
4. Set the friction type as coulomb and the friction coefficient as 0.05 (Friction>Manual)
5. Select the appropriate symmetry planes. Note: Workpiece should not expand in the z direction (refer to Fig.2)
6. Select the appropriate die stop criteria based on the design requirement.
7. Run the simulation (this will take several minutes) to check whether you meet the design requirements.
8. Iterate through steps 1-7 to find optimum velocity

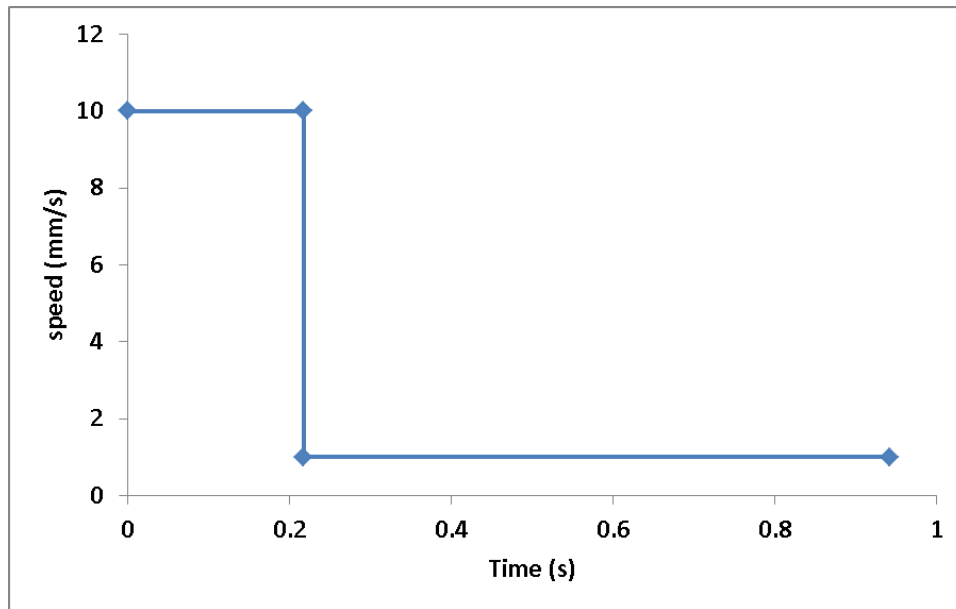
Hint: The die velocity can be varied in steps within the process as shown below in Fig 3.

1. Set the initial velocity at time zero.
2. Set the same initial velocity at end time of the first stroke.
3. Set the second velocity 0.0001 seconds after the end of the first stroke. (The program will ramp up the die velocity within this time)
4. Set the second velocity at end time of the second stroke.

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(a)



(b)

Figure 3: Variable die speed set up a) setup menu b) speed profile

**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) Show the effect of hot and cold forming on the final maximum effective stress, final load and power vs time
  - b) Show the effect of different materials on the final maximum effective stress, final load and power vs time

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- c) Show your final design and optimization process
- 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.