T011: Load Prediction Troubleshooting

Introduction

This document will show you how to troubleshoot load discrepancies between reality and DEFORM.

Problem Description

Load is a function of the material flow stress, forming shape, press velocity profile and friction. Aligning each of these factors with reality will produce an accurate load.

Background Information

The material flow stress is a major factor in predicting load. Flow stress is essentially the materials resistance to deformation. The flow stress is a function of temperature, strain and strain rate. Increasing the material temperature typically decreases the flow stress. Increasing strain and strain rate typically increases the flow stress of a material.

To get accurate results it's important to make sure the material file has data defined for the temperature, strain and strain rate ranges experienced in the forming process.

Solution

Material:

The material flow stress is driven by temperature, strain and strain rate.

- Temperature - affected by previous heating, forming, transfer and dwell operations
- Strain - affected by the previous forming and annealing operations
- Strain Rate - affected by the velocity profile of the forming tool(s).

Hot forming tips (temperature and strain rate are most important):

- It is important to simulate all transfer and dwell operations to accheve the appropriate temperature and temperature gradient.
- An annealing process can be approximated by initializing the strain to zero and the temperature to the final furnace temperature.

- The strain rate is dependent upon the velocity profile of the press. It is important that the press model in DEFORM matches reality.

Cold forming tips (strain most important):

- Flow stress of cold forming data can vary quite a bit, depending on how it is processed. To achieve accurate results, the flow stress data should be derived from the actual material being used.

1. The most accurate option is to test a material sample with a tension or compression test.
2. Another good option is to use the YS and UTS from the material supplier to extrapolate a flow stress curve.
3. If neither of these options are available it may be appropriate to use www.matweb.com to find the YS and UTS of a material with the same chemistry and similar processing.
4. Cold forming data from the DEFORM library can be used if no other data sources are available. The exact processing history for many of the room temperature material data sets in DEFORM is often not known. Thus, the processing for the material in DEFORM may be very different from the processing for your own material.

- It is important to simulate all prior forming operations so that the accumulated strain distribution is correct.

Forming Shape:

It may seem obvious, but it is important that the shape of the dies and workpiece match what is on the shop floor. When making die revisions it is common to accidentally use an old tool design when the real process is using the latest revision of the tool. Also, the final forged shape in DEFORM should match the forged product shape. You can compare the die fill (particularly at corners), flash thickness and overall shape.

If you use a symmetric model in DEFORM you will need to scale the load to match reality. If your model is quarter symmetry you will need to multiply the load by four to see the load that it takes to form an entire 360 degree part. The Load-Stroke graphing tool in the postprocessor contains a scaling feature that can be used to account for symmetry.

Friction:

Friction plays a smaller role in affecting the load compared to the other variables. However, to predict the load accurately it's still important to match the friction of the process. DEFORM's default values are a good starting point.

Cold forming (carbide dies)	0.08
Cold forming (steel dies)	0.12
Warm forming	0.25
Hot forging (lubricated)	0.3
Hot forging (dry)	0.7
Aluminum	0.4

The values above are for the shear friction model. These values are appropriate when the pressure between the workpiece and tool is high compared to the flow stress of the workpiece (as it is in most forming or forging operations). When the pressure is lower (as in the sliding of a billet against an extrusion die case) the coulomb friction model becomes more accurate. DEFORM also offers a hybrid friction model that switches between coulomb and shear models as a function of pressure.

Related Information

When using tetrahedral elements is it recommended to turn on 'Element + Node Output' for strain and stress. You can do this in The Simulation Controls menu. Simulation Controls > Advanced > Output Control