Project plan, Degree Project in Master of Science in Engineering

Course code: MT2525

PARTICIPATING STUDENTS

Name of student 1:

Personal identification number:

Name of student 2 (if any):

Personal identification number:

Registered on programme: MTAMT Registered on semester

ASSIGNED EXAMINER/SUPERVISOR/PEER REVIEWER (acronyms)

Examiner: Ansel Berghuvud (ABE)

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INDUSTRY/ORGANIZATION (F/O)

Industry/Organization hosting the degree project: Institute of mechanical engineering, BTH.

Co-advisor from Industry/Organization:

Contact information for external advisor:

PROVIDE PRELIMINARY/WORKING TITLE FOR THE DEGREE PROJECT

Development of a Nakajima test rig and its potential variants setup for polymer film failure testing driven by FEM simulation.

1. Introduction

Packages are the means of preservation, distribution and convenience of use for food, medicine and other consumer products. Package durability and opening is being compromised in many cases because of cutting cost in the design and production of opening techniques. The introduction of a new package-opening technique, material or geometry forces new design measurements that require a large number of prototype developments and physical testing. In order to achieve more rapid and accurate design, the finite element method (FEM) simulations are widely used in packaging industries to compliment and reduce the amount of physical testing. The most widely used packaging materials in liquid food packaging industries are low-density polyethylene (LDPE) as thin film, aluminum (Al) as thin foil, paper board, polypropylene (PP) and high-density polyethylene (HDPE). These materials are already widely studied for monotonic uniaxial loading. In practice, during the life time and opening of the packages the material experiences multiaxial loading sometimes beyond initial yielding, reverse loading and reloading. During opening the material experience failure. Particularly, low-density polyethylene (LDPE) layer of the package is very thin, measured between 14-30 micron is orthotropic and highly ductile. To characterise the material properties and to use them for FEM simulation it is necessary to test this material in multiaxial loading that can possibly impose different mixed straining of the

material. For similar purpose, Nakajima testing is a widely used method for steel sheet that provides forming limit curve in multi axial loading [1]. This forming limit curve information can provide with failure limit of the material at different loading condition with the help of Digital Image Correlation (DIC), a virtual extension measuring technique [2].
However, this test method was not found to be used for highly ductile polymers like LDPE. It would be interesting to explore this possibility and any other variant of this method that can be appropriate for characterization of LDPE failure constitutive properties.

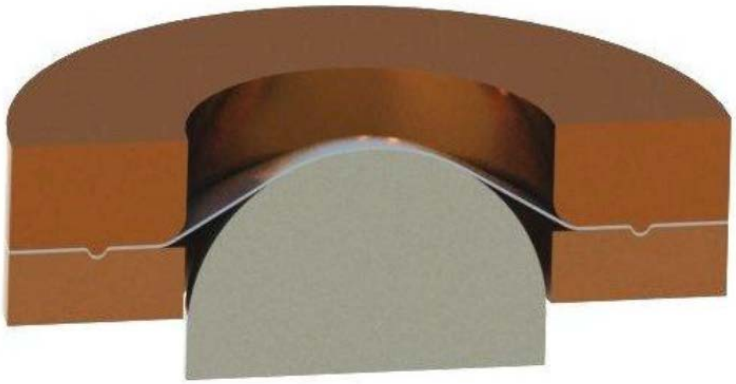

Figure 1: Nakajima test rig as used for steel sheet testing [2]

2. Objectives

The study will aim to complete the following tasks,

Use of FEM simulation to optimize initial geometry and predict the outcome

Forecast suitable dimension from the literature and use finite element simulation on available LDPE material model (elasto-plastic including damage) to define initial model. See figure 3.

Test rig setups:

This includes, study on geometry suitable for LDPE polymer, choose the material for punch, build the Nakajima setup using 3D printers and carpentry workshop, application of stochastic pattern patterns for Digital Image Correlation (DIC) studies with single camera and find suitable algorithm to convert spherical punch image into flat plan image for analysing with GOM.

Variant of Nakajima suitable for LDPE:

Possibility of using other test method that are variants of Nakajima will be explored. Few initial recommendations are,

- Use ring or roller shaped hollow punch instead of hemi-sphere/sphere for multiaxial loading of LDPE.
- Shear torsion testing.

Optimization as required

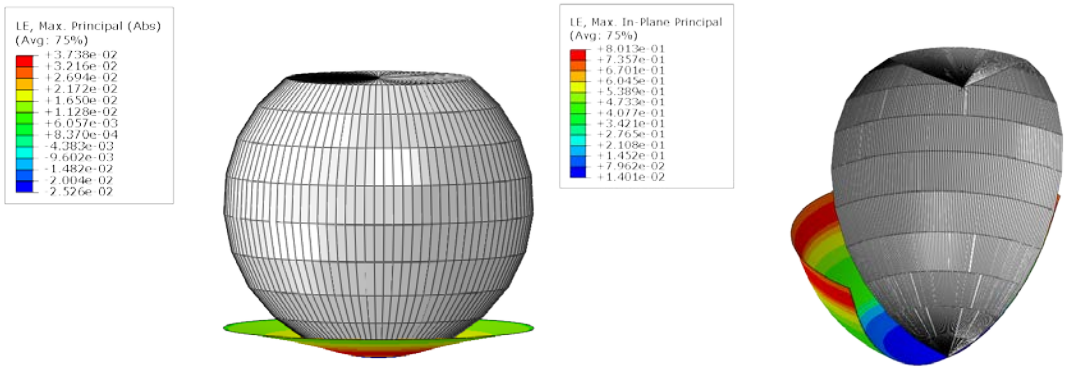

Figure 2: Response from initial model as predicted from simulation

3. Thesis question and/or technical problem

Write the objective questions in What/how format

4. Method

Tell as much possible how the objectives will be achieved

5. Expected outcomes

- A working Nakajima test rig for LDPE.
- At least one variant of the method as an extension.
- Measurement of fracture strain at different straining by accounting for the possible imaging error caused by the curvature of the punch sphere/ semi-sphere. This will be used as material constitutive in a separate project emphasizing on material modelling.

6. Time and activity plan

Starting and finishing of different part of work described in the method and the writing, defines process.

Month/Time **Tasks to be completed**

In the above format.

7. Assets and limitations

Tensile testing machine, Carpentry workshop, 3D printers, ABAQUS, GOM correlate, suitable imaging devices and attachments.

Limitation includes using GOM correlate non-professional version with few limitations in measurement, surface finish from 3D printers at BTH.

References

[1] Nakazima, K., Kikuma, T., & Hasuka, K. (1968). Study on the formability of steel sheets. YAWATA TECH REP, SEPT. 1968,--264--, 8517-8530.

[2] Hora, P., Berisha, B., Gorji, M., & Manopulo, N. (2012). A generalized approach for the prediction of necking and rupture phenomena in the sheet metal forming. IDDRG2012, Mumbai, India, 79-93.