Project plan, Degree Project in Master of Science in Engineering

Course code: MT2525

PARTICIPATING STUDENTS

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Personal identification number:

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Registered on programme: MTAMT Registered on semester

ASSIGNED EXAMINER/SUPERVISOR/PEER REVIEWER (acronyms)

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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

Modelling of an orthotropic plastic material for Abaqus based on experimental evidence.

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 different orientations (i.e. machine (MD) and transverse/ cross direction (CD)). Loading unloading and reloading curves (See Fig. 1) in terms of force and displacement form tensile testing machine can provide useful information about material model. These results together with Digital Image Correlation (DIC), a virtual extension measuring technique response can further enhance the understanding of the material behaviour [1]. It is possible to choose plasticity framework and model the material as orthotropic plastic and define the initial and subsequent yield surface. It requires a lot of testing in different loading case in different direction that includes but not limited to uniaxial tensile test and uniaxial compression tests in three orthotropic direction, biaxial test and shear tests. A useful review on experiments in support of constitutive modelling in terms of orthotropic plasticity simulations can be found here [2]. For the thin LDPE under study, it will be difficult to perform some of the tests. Mixed plasticity is recommended if the material experiences unloading and reverse loading at any material point in a simulation and hence Bauschinger effect should be considered. Cyclic tests can be useful for this purpose.

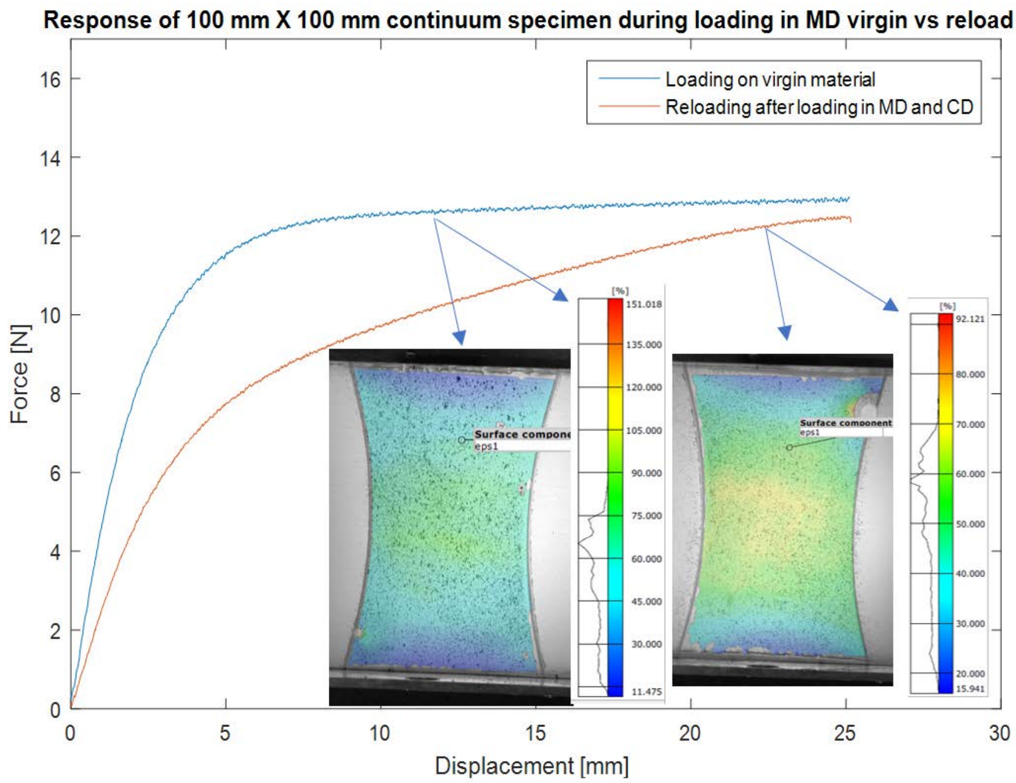

Figure 1: Loading and reloading response of LDPE

However, a very different modelling framework using spring damper for example Arruda-Boyce material model for viscoplastic polymers like LDPE are being popular since plasticity models emerging originally from study of metal needs much modification to be accurately used for polymers [3]. A useful study on adopting plasticity on paper board simulation modelling can be a useful to understand the state of art [4].

2. Objectives

The study will aim to complete the following tasks,

Complete set of tests on LDPE film to characterize initial and subsequent yield loci

Depending on the tests possible of those shown in Fig. 2 the initial yield surface will be constructed. Cyclic loading and reloading (loading in one direction (MD), then load in orthogonal direction (CD) and finally load again in MD direction in a tensile test) of the specimen will be used to find few points during the evolution of yield surface. A stiffness degradation phenomenon observed during reloading compared to virgin material (see Fig. 1) will be quantified for using as internal variable for the simulation in MD and CD.

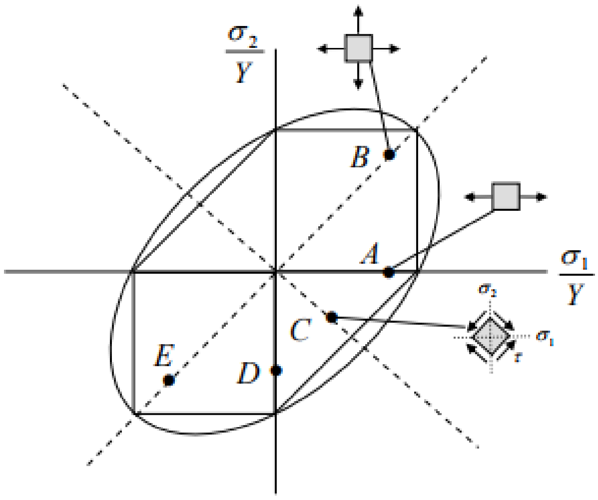

Figure 2: Tests to construct yield surface in 2D principal stress space (Point D is at compression) [5]

Development of orthotropic mixed plastic material subroutine in ABAQUS

Write a UMAT material subroutine for the above material model that can be used for ABAQUS simulations.

Optimization as required

It can be necessary to optimize the material parameters that in simulations can mimic the experimental responses in terms of force-displacement and strain field in a tensile (fracture mode I), tearing (fracture mode III) and a full cycle of loading.

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

- Material parameters for initial yield surface, subsequent yield surface until damage and stiffness degradation from tests mentioned above.
- A working UMAT for ABAQUS that reflects the expected material behaviour satisfactorily.
- Implementation of the developed material model for tensile, tear and cyclic (one cycle) loading.

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, ABAQUS, GOM correlate, FORTRAN, suitable imaging devices and attachments.

Limitation includes using GOM correlate non-professional version with few limitations in measurement, difficulty with compression and bi-axial tests using thin LDPE films with tensile test rig at BTH.

References

[1] 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.

[2] Kuwabara, T. (2007). Advances in experiments on metal sheets and tubes in support of constitutive modeling and forming simulations. International Journal of Plasticity, 23(3), 385-419.

[3] Tømmernes, V. (2014). Implementation of the Arruda-Boyce Material Model for Polymers in Abaqus (Master's thesis, Institutt for konstruksjonsteknikk).

[4] Harrysson, A., & Ristinmaa, M. (2008). Large strain elasto-plastic model of paper and corrugated board. International journal of solids and structures, 45(11), 3334-3352.

[5]http://homepages.engineering.auckland.ac.nz/~pkel015/SolidMechanicsBooks/Part_II/08_Plasticity/08_Plasticity_03_YieldCriteria.pdf