Thermo-Mechanical Modeling of Taylor Impact Test of Polycarbonate

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1. INTRODUCTION & OBJECTIVE

Amorphous glassy polymers are widely used to fabricate many engineering components in various fields such as automobile, railway, defense, and aerospace. These components are largely subjected to loading at high strain rates. Taylor impact tests are used to characterize materials under high strain rates (~10^{-5} /s) and inhomogeneous deformation conditions. At such high loading rates heat generated due to plastic deformation and its effect on overall deformation behavior is significant in polymers. The present work focuses on the thermo-mechanical modeling of Taylor impact experiments on Polycarbonate using numerical simulations.

Towards this, Taylor impact experiments conducted by Sarva et al., 2007[1] on Polycarbonate (PC) are used. A constitutive model with elastic-viscoplastic behaviour, similar to the one suggested by [2], is employed for amorphous polymers. The modified version of the model as suggested by [3], captures the yield behavior at high loading rates. The same model is used for the simulation by including the temperature effect in to account.

Table1. Calibrated material parameters for strain rates 0.001-1700 S^{-1} for polycarbonate.

E	2100 MPa
ν	0.38
S_0	102 MPa
S_{ss}	80 MPa
h	1000 MPa
A_1	300
$\dot{\gamma}_{01}$	8.68×10^{20}
A_2	70
$\dot{\gamma}_{02}$	4.62×10^{6}
C_r	15 MPa
N	4.84
α	0.08

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

The thermo-mechanical material model is calibrated by fitting the numerical model to data obtained from uniaxial tension experiments [4] performed on PC at different strain rate and different temperature. Stress-strain curves obtained from fitting is shown in Fig. 1, which show good agreement at the temperatures 20^0 C, 80^0 C, and 120^0 C for the strain rates of 0.001 S^{-1} and 1700 S^{-1}. Calibrated material properties are listed in the Table 1. Further simulations on Taylor impact tests are under progress.

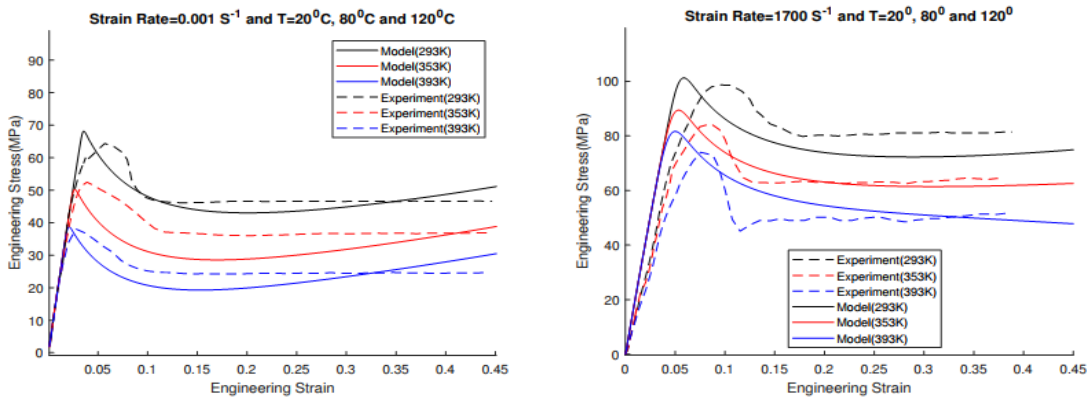

Fig.1 Stress-strain curves at temperatures 20^0 C, 80^0 C, and 120^0 C at strain rates 0.001 S^{-1} and 1700 S^{-1}

REFERENCES

[1] S. Sarva, A. D. Mulliken, and M. C. Boyce, "Mechanics of Taylor impact testing of polycarbonate," *Int. J. Solids Struct.*, vol. 44, no. 7, pp. 2381–2400, Apr. 2007, doi: 10.1016/j.ijsolstr.2006.07.012.

[2] M. C. Boyce, D. M. Parks, and A. S. Argon, "Large inelastic deformation of glassy polymers. part I: rate dependent constitutive model," *Mech. Mater.*, vol. 7, no. 1, pp. 15–33, Sep. 1988, doi: 10.1016/0167-6636(88)90003-8.

[3] A. Faye, "Effects of loading rate on void growth in amorphous glassy polymers," *Eur. J. Mech. - ASolids*, vol. 105, p. 105253, May 2024, doi: 10.1016/j.euromechsol.2024.105253.

[4] K. Cao, Y. Wang, and Y. Wang, "Experimental investigation and modeling of the tension behavior of polycarbonate with temperature effects from low to high strain rates," *Int. J. Solids Struct.*, vol. 51, no. 13, pp. 2539–2548, Jun. 2014, doi: 10.1016/j.ijsolstr.2014.03.026.