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Material Modelling methodology for Automotive Plastic parts for dynamic simulation

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ABSTRACT

Key to any successful part developmentsis proper choice of material, process, and design meeting part performance requirements. Plastic (Polymer) contains much diverse materials and differs highly in physical behavior than that of metals. Considering dynamic analysis in crash event and more predominantly considering occupant safety, the occupant comes under contact of plastic parts. During accidental impact many modern grades of plastic used in commercial and industrial applications are required to sustain large strains before failure occurs.

The aim of the paper is to contribute to refining material models and test methods, thereby improving the numerical prediction of the response to impactloading. The correct description of plastics during simulation is very important for the injury criteria calculated with impactor model in case of contact between impactor and plastic interior parts. This was the motivation for the development of an appropriate material model. This paper gives an introduction for typical behaviorof plastics.Modeling the mechanical behavior of plastics for Crash simulation, which is a complex task due to the highly non-linear characteristics, also involve large strains and large displacements.

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I. INTRODUCTION

The Automotive interior is built with plastic and foam materials, because of its lightweight structure, ease of form structure with complex design, and cost effectiveness. However, these materials make it progressively difficult to fulfil the crash performance and strength standards required by the enhanced safety regulations. The deformation and failure of these materials largely affect the kinematics and injury risks of the occupant. Plastics are classified as crystalline or amorphous structures, according to the arrangement of cross-links that connect their molecular structure. Most vehicle interior parts consist of a combination of these two types of plastics, referred to as semicrystalline plastics. The objective of this study is to advance the numerical modelling scheme of vehicle interior polymer materials for their mechanical behaviours to simulate more realistic response.

II. BASICS OF PLASTIC BEHAVIOUR

The deformation behaviour of plastics can be explained by the molecular chain state. Yield appears after undergoing nonlinear elastic behaviour, in which the molecular chains become unbound by application of an external force.When material is subjected to high-strain deformation, it deforms permanently (plastic deformation) and eventually fails. In the Fig.1 the graph of stress-strain behaviour over the entire strain

range and the ultimate failure (rupture) for a typical polymeric material subjected to a tensile test. For sufficiently low stresses and strains, the polymeric material behaves as a linear elastic solid. The point where the behaviour starts to be non-linear is called the proportional limit. The local maximum in the stress-strain curve is called the yield point and indicates the onset of plastic (i.e. permanent) deformation. The corresponding stress and elongation are called yield strength and elongation at yield. Beyond the yield point the material stretches out considerably and a "neck" is formed; this region is called the plastic region. Further elongation leads to an abrupt increase in stress (strain hardening) and the ultimate rupture of the material. At the rupture point the corresponding stress and strain are called the ultimate strength and the elongation at break, respectively. The stress-strain behaviour of a polymeric material depends on various parameters such as molecular characteristics, microstructure, strain-rate and temperature. [1]

Constructing a material model for plastics, in terms of their structural analysis, is difficult due to their pressure dependency, dilation, softening, and anisotropic properties.A von-mises yield function and an isotropic hardening model have been used most often to represent the behaviour of plastic.The selection of plastic material is depends on the functionality of the component for the purpose that part will going to serve, accordingly the plastic.

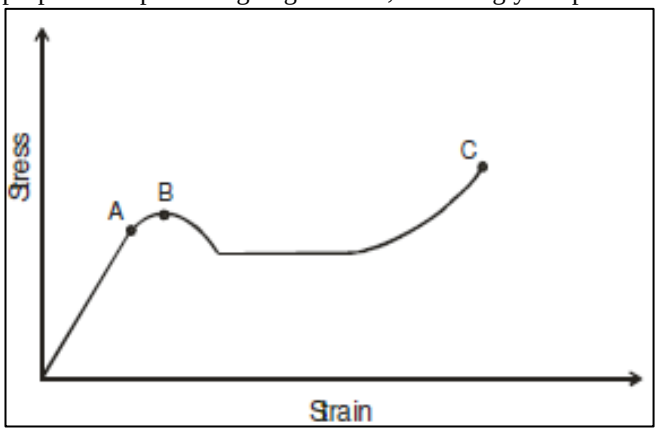


Fig.1 Typical stress-strain curveof polymeric material. A is the proportional point; B the yield point and C the rupture (break) point. [1]

III.STEPS INVOLVED IN MATERIAL MODEL

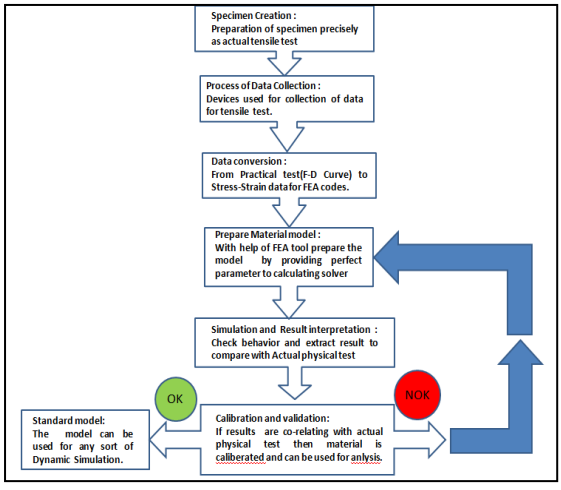


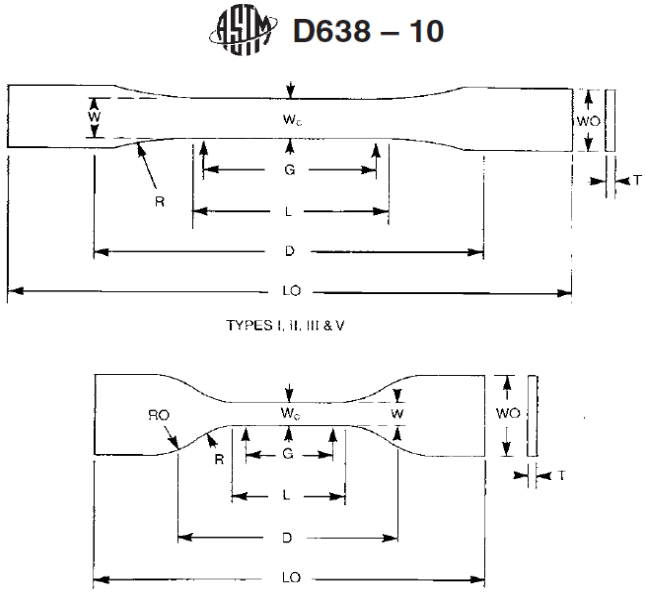
Fig.2 The Flow chart for creation for material model.

The material model creation is incorporated with few steps with is shown in Fig.2through which we can reach to our ultimate aim of preparation of well-defined material model. The model created must exhibit very close behaviour to that of actual specimen and must have close relationship of output F-Dcurve.High strain rate material modeling of polymers for use in crash has been stressed by a number of problems. These include poor quality and noisydata, material models inappropriate to polymer behavior and unclear material modelcalibration guidelines. The modeling of polymers is thus a difficult preparation witha highly variable success rate. In this paper we present amaterial modeling approach that can be applied for a wide variety of polymers.

There must be proper, neat and well-arrangedtensile data by eliminating unwanted noise for polymers at high strain rates. Considering limitation of crash material model we must follow present guidelines for the selectionof the right material model that best describes the various kinds of behavioursexhibited by different classes of polymers. The calibration dependson some ofrealistic choices in order to best fit the complex observedbehaviour to simplified material models available.Concurrence of our choice of material model and the calibration, we thenneed to validate the material model using computer simulation. The material modelling concepts presented here use the LS-DYNA softwareterminology; it is possible to translate these comments to other software codes thatuse analogous material models. [2]

IV. SPECIMEN CREATION

The geometries of the test samples, and the angle that the samples were cut from the plate withrespect to the extrusion direction, are shown in Fig. In reality there were two PP plates,one of thickness 5 mm and one of thickness 10 mm and the figure is a simplified model showingall the test specimens in the same plate.Uniaxial tension tests were carried out the two-four test samples with different thickness ASTM 638 type specimen shown inFig.3



Dimensions (see drawings)	7 (0.28) or under		Over 7 to 14 (0.28 to 0.55), incl	4 (0.16) or under		Tolerances
	Type I	Type II	Type III	Type IV[B]	Type V[C,D]	
W—Width of narrow section[E,F]	13 (0.50)	6 (0.25)	19 (0.75)	6 (0.25)	3.18 (0.125)	±0.5 (±0.02)[B,C]
L—Length of narrow section	57 (2.25)	57 (2.25)	57 (2.25)	33 (1.30)	9.53 (0.375)	±0.5 (±0.02)[C]
WO—Width overall, min[G]	19 (0.75)	19 (0.75)	29 (1.13)	19 (0.75)	...	+6.4 (+0.25)
WO—Width overall, min[G]	...	...	...	...	9.53 (0.375)	+3.18 (+0.125)
LO—Length overall, min[H]	165 (6.5)	183 (7.2)	246 (9.7)	115 (4.5)	63.5 (2.5)	no max (no max)
G—Gage length[I]	50 (2.00)	50 (2.00)	50 (2.00)	...	7.62 (0.300)	±0.25 (±0.010)[C]
G—Gage length[J]	...	...	...	25 (1.00)	...	±0.13 (±0.005)
D—Distance between grips	115 (4.5)	135 (5.3)	115 (4.5)	65 (2.5)[J]	25.4 (1.0)	±5 (±0.2)
R—Radius of fillet	76 (3.00)	76 (3.00)	76 (3.00)	14 (0.56)	12.7 (0.5)	±1 (±0.04)[C]
RO—Outer radius (Type IV)	...	...	...	25 (1.00)	...	±1 (±0.04)

Fig.3 ASTM 638-10 Sample specimens [4]

The standard specimen used for the tensile test and predominant proposed are ASTM 638-10 or ISO 527,which are technically equivalent method of specimen development.

Tensile tests were carried out in a Zwick Z250 universaltest machine at 23 _C using constant cross-head speeds of10 and 100 mm/min. The length of the narrow portion ofthe specimen was 80 mm, resulting in nominal strain ratesof 0.0021 and 0.021 s_1, respectively. The load wasmeasured with a 2.5 kN load cell and the signal was loggedusing a 12 bit National Instruments DAQCard 6062E.A commercial Vic3D digital image correlation (DIC)system from Limess and Correlated Solutions wasused to measure the displacement field during loading.Two high resolution cameras (2452 _ 2052 pixels) withPentax 75 mmf/2.8 lenses were used. The cameras weremounted on a tripod and arranged so that two adjacentfaces of the specimen were visible to both cameras simultaneously,as illustrated in Fig. 1. This arrangement of thecameras allows measurement of out-of-plane displacementin addition to in-plane strains on the specimen surface.However, it results in a slightly lower spatial resolution inthe transverse directions than in the longitudinal directiondue to the acute angle between the optical axis and thesurfaces. Further, cross sections in the specimen will ingeneral not be aligned with rows of pixels in the capturedimages. Thus, points in a certain cross sectionhave to be identified based on their 3D coordinate in theobject coordinate system and not based on the pixel coordinatesin the image coordinate system. These points arerequired to calculate the current cross sectional area andthe true stress. [6]

V. LOAD AND STRAIN MEASUREMENTS

The load washer used in some work was a Kistler 9071A piezoelectric load washer. The response frequency of the load washerwas 30kHz. The response frequency together with the upper grip was estimated to be 20kHz. The load signal was amplified through a Kistler 5011 charge amplifier. The response frequency of the amplifier was 200kHz.To reduce the inertia effect, non-contact strain measurement devices are preferred for high rate testing. The strainwas measured using a Zimmer200XHelectro-optical extensometer. The unit traces the movements of two markersadhered on the gage section of the specimen via two lenses. The lens forms an image of the illuminated black and white targeton the photo cathode of the image converter that converts the optical image into an electron image to produce a voltage signal.The voltage output was converted to the extension with a linear relation established by calibration.

The strain was calculatedbased on the relative displacement between the two markers.The nominal strain rate was estimated as the crosshead speed V divided by the gage length of the specimen l:$\varepsilon = V/l$. Theactual strain rate experienced by the specimen in the gage section varies depending on the material. Thecalculated strain rates based on the strain measurement from the optical extensometer for specimens testedat a nominal strain rate 40/s. There is a starting region during which strain rate increases rapidly with strain. Until thespecimens reach strains of approximately 10%, the curves level off and remain nearly constant until failure. The tested specimens showed relatively uniform deformation throughout thegage length. The tested specimens, on the other hand, exhibited localized deformation. Forbrittle materials such as PA/glass, the specimen may fail before reaching the targeted strain rate.Thisexample demonstrates another complexity in dynamic material testing. The strain rate varies in the elastic deformationregion. A relatively constant strain rate may be obtained only in the plastic deformation region at strain levels greater than 0.1. In addition, the actual strain rate achieved in a specimen depends on the material. To get the targeted strain rateaccurately, one has to rely on trial and error and test a few extra specimens.[7]Tensile data are required for all four elastic-plastic materials models considered here. The data obtained from tensile test measurements of bulk adhesive are nominal (or engineering) values, where stresses and strains have been calculated using the initial specimen dimensionsTensile testsfor the determination of Young's modulus (E') and Poisson's ratio (ν) are carried out on standard specimensunder constant deformation rate in a tensile test machine at relatively low strain rates e.g. 10 mm/min. For best accuracy, contacting extensometers should be used for the measurement of axial and transverse strain, εT and εt. Two extensometers mounted on opposite faces of the specimen should preferably be used for the axial strain measurement to eliminate small non-uniformity in the strain through the thickness of the specimen caused by bending. The transverse strain measurement should be made close to the axial gauge section and, if possible, between the contact points of the extensometers. The contact pressure used to attach the extensometers to the specimen should be large enough to prevent slippage but insufficient to indent the specimen surface. Strain gauges are not recommended as they locally stiffen the specimen.

Values for Young's modulus and Poisson's ratio are calculated from the regression slopes in the linear region of the σT-εT and εt-εT curves. Use of regression slopes is preferable to single point values owing to the potential scatter in the data points (particularly the εt-εT data) that is mainly due to uncertainties in the small extensions measured. Whilst elastic values can be determined over any strain range where the data appear linear, the slight curvature due to visco-elastic effects will tend to reduce the value of E as the strain range widens.The measurement of tensile hardening curves involves use of the same tests out to larger strains. Contacting extensometers, unless they have been modified, typically have an upper strain limit of around 0.05. They may also initiate premature failure in the specimen at a point of contact. For these tests, the use of a video extensometer is therefore preferable for the measurement of axial strain. The video extensometer gauge

markings are visible on the tensile test specimen. These instruments are generally unsatisfactory for the measurement of small displacements and so a contacting device is best used to measure the lateral strain for the determination of true stresses and the plastic component of Poisson's ratio.[8].Here are typical tensile data for a rubber-toughened epoxy. The data are shown in tabular and graphical form. In tensile the data collected in form of force and displacement is converted to true Stress and Effective Plastic Strain.

Nominal Strain	Nominal Stress (MPa)
0.0004	1.44
0.0015	4.80
0.0035	10.34
0.0053	15.73
0.0070	20.71
0.0086	24.28
0.0103	28.02
0.0120	31.59
0.0135	34.93
0.0153	37.89
0.0172	40.46
0.0189	43.13
0.0211	45.03
0.0230	46.81
0.0251	48.57
0.0274	49.68
0.0298	50.65
0.0322	51.46
0.0348	52.25
0.0373	52.90
0.0399	53.36
0.0423	53.63
0.0452	54.07
0.0476	54.46
0.0504	54.80
0.0533	54.98
0.0560	55.33
0.0588	55.84
0.0615	55.97
0.0643	56.19
0.0670	56.32
0.0699	56.44
0.0728	56.79
0.0758	56.86
0.0786	57.09
0.0812	57.17
0.0842	57.26

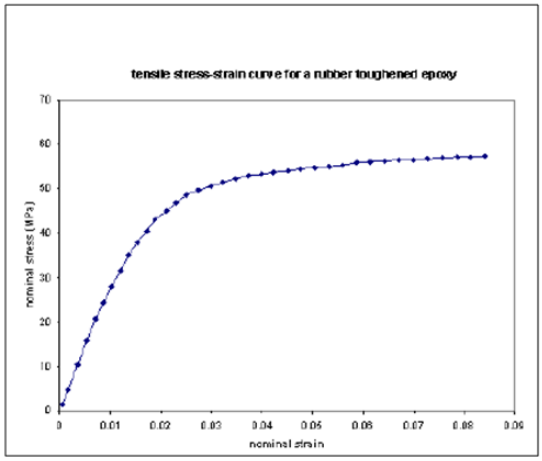


Fig.4 The typical Stress-Strain curve [8]

VI. TENSILE DATA CALCULATION

Below Tab.1 shows the calculation to obtain the True stress-True Strain values. With help of these equations we can arrive to the input for material model to incorporate its material non-linearity.

Tab.1Tensile Data Calculation [8]

True stress, σ_T	True Stress	$\sigma_T = \frac{\sigma'_T}{(1-\nu'\varepsilon'_T)^2}$
True strain, ε_T	True Strain	$\varepsilon_T = \ln(1+\varepsilon'_T)$
True transverse stress, ε_t	True Transverse Strain	$\varepsilon_t = \ln(1+\varepsilon'_t)$
Nominal Poisson's ratio, ν'	Nominal Poisson's Ratio	$\nu' = -\frac{\varepsilon'_t}{\varepsilon'_T}$
Young's Modulus, E'	Young's Modulus	$E = \frac{\sigma_T}{\varepsilon'_T}$
True Elastic modulus, E	True Poisson's Ratio	$\nu = -\frac{\varepsilon_t}{\varepsilon_T}$
True Poisson's ratio, ν	True Plastic Strain	$\varepsilon^p_T = \varepsilon_T - \ln\left(1+\frac{\sigma_T}{E}\right)$
True plastic strain, ε^p_T	True Transverse Plastic Strain	$\varepsilon^p_t = \varepsilon_t - \ln\left(1-\nu'\frac{\sigma_T}{E}\right)$
True transverse plastic strain, ε^p_t	True Plastic Poisson's Ratio	$\nu^p = -\frac{\varepsilon^p_t}{\varepsilon^p_T}$
True plastic Poisson's ratio, ν^p		

Force is converted to true stress, since true stress is ratio of load to cross-sectional area during its time frame of tensile test event when there is continuous elongation of specimen. The cross-sectionsgoes on decreasing till the necking of specimen occurs and ultimate results in breaking. Strain values are extracted from displacement from tensile test which varies with respect to initial length to change in length.

VII. NUMERICAL MODEL PREPARATION

Constructing a material model for plastics, in termsof their structural analysis, is difficult due to theirpressure dependency, dilatation, softening, and anisotropic properties.

i. Test data has to be available asengineering stress vs. engineering strain(Excel / ASCII).

ii. Visual inspection of the data is necessary first. The goal is to obtain a single sufficiently smooth i.e. non oscillatory curve for each strain rate:
   a) Eliminate strong oscillating curves
   b) Scattering at the same strain rate?
   c) If yes: take the averageof selectedcurves at the same strain rate i.e. eliminate outer layers
   d) If no: take the average of all tests at thesame strain rate

iii. Determine average Young's modulus, True Strain $\varepsilon = \ln(1+\varepsilon_0)$,True Stress $\sigma = \sigma_0(1+\varepsilon_0)$

iv. Compute yield curve for each strain rate.

v. Derive the smoothed curve (that is obtained in step 2) numerically by central difference scheme

$$\frac{d\sigma}{d\varepsilon} = \frac{\sigma_{n+1} - \sigma_{n-1}}{\varepsilon_{n+1} - \varepsilon_{n-1}}$$

vi. Identify the onset of the material instability (necking), i.e. find

$$\sigma - \frac{d\sigma}{d\varepsilon} = 0 \Longrightarrow \varepsilon^*$$

Where e* is the strain where necking occursIf there is an intersection,compute for each strain e > e*:

$$\sigma = \sigma * e^{(\varepsilon - \varepsilon^*)}$$

else, compute the hardening curve:

$$\sigma_y = \sigma, \qquad \varepsilon^p = \varepsilon - \frac{\sigma}{E}$$

In describing the rate-dependent behavior of a polymer, additional complicationsoccur. Up to the vicinity of yield, certain polymers exhibit significantrate-dependency of modulus while others do not .This is in distinct contrast tometal behavior where the expected behavioral trend istoward no dependency of modulus with strain rate, as exemplified by the LSDYNAMAT-24 type material model. A consequence of this finding is thatpolymers exhibiting rate dependency of modulus cannot be described by a MAT24type model. The use of a MAT24 type model for such materials will result insignificant error in stiffness predictions. These and other limitations must beconsidered carefully in selection of a material model for describing ratedependency of polymers.The combination of the effect of stress as well as strain-rate on the rate dependentstress-strain relationship of polymers, as explained above creates a complexsituation that is only crudely approximated with currently available materialmodels. By proper selection, is possible to conduct meaningfulsimulation by selecting existing material models that most closely match thebehaviour shown by the material data.With respect to the rate-dependency of the plasticity behaviour, a remarkableconsistency is observed for a large variety of polymers. A predominant trend existstoward agreement with the Eyring equation, which is characterized as a linearlyincreasing relationship between yield stress s. log strain rates.Obvious exception is the case of polymers exhibiting brittle failure where the resultis noisier. In contrast, the Cowper-Symonds model which is used extensivelyfor metals and is implemented in MAT24 fails to

capture the correct trend leadingto modeling inaccuracy in modeling rate dependency of polymers[2]

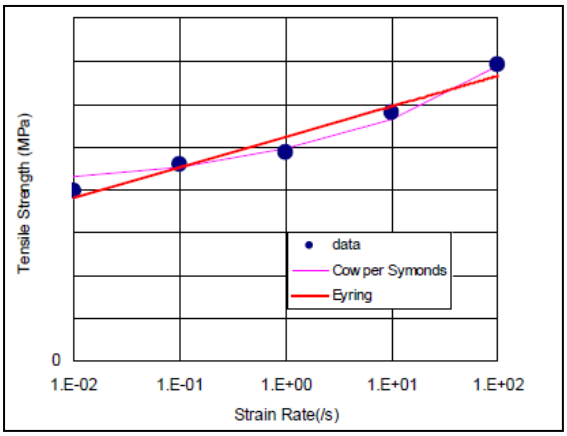


Fig.5TheEyringvs. Cowper Symonds equations for rate dependency of yield stress. [2]

Its simplestand most commonly used nuance couples Cowper-Symonds model with anelastic-plastic curve as follows. The elastic region is modelled as rate independentup to an arbitrarily or otherwise determined yield point, beyond which the stressstraincurve at the lowest strain rate of interest is decomposed into an elasticplasticmodel. This produces a curve of stress v. plastic strain (ES v. EPS).Sincepolymers are non-linear elastic followed by elastic-plastic, an arbitrary choice isusually made somewhere along the increasing part of the stress-strain curvedenoting the onset of plastic strain limitation of linear elasticity.Applying the Cowper-Symonds equation, it is now possibleto scale this curve to other strain rates. The equation has the advantage of smoothextrapolation without limits. However, since the equation is incapable of trulydescribing the rate dependency of the yield phenomenon (Figure 3), it cannotaccurately scale the plasticity curve to high strain rates. A possible solution is touse the LCSR option, which permits the submission of a table of scale factors foreach strain rate. LCSR is an interesting option which allows fidelity to the testdata. However, it must be used with caution. High strain rate data isexperimentally difficult to obtain so that there is often scatter in the data. Thisscatter must be smoothed in some way so that the resultant model contains nospurious behaviour. Since we know that the Eyring Equation appears to accuratelydescribe the rate dependency of most ductile polymers, the LCSR table can bederived from a best fit of the yield stress v. log strain rate data. This approachcarries two advantages: first, the elimination of noise and second, the ability toextrapolate the model to 'higher that tested' strain rates, since LCSR based MAT24terminates rate dependency computation when the highest strain rate in the table isexceeded.

Cowper Symonds

$$\sigma_y\left(\dot{\varepsilon},\varepsilon_p\right)=\sigma_y\left(0,\varepsilon_p\right)\left[1+\left(\frac{\dot{\varepsilon}}{C}\right)^{\frac{1}{p}}\right]$$

Parameters C, p can be used directly in the MAT_24 card

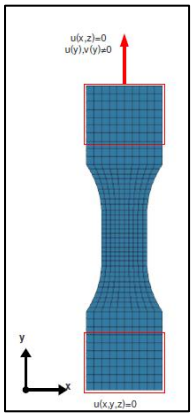
Fig.6Cowper-Symonds equation for extrapolating higher strain rate. [11]

Using MAT24 with LCSR as described above, we can successfullyovercome the limitation of the Cowper-Symonds model in the simulation ofpolymer rate-dependency.A serious limitation of MAT24 arises from the fact that the actual failure strainstypically decrease with increasing strain rate. This variation is not accommodatedby the model, which assumes that failure strain is constant and independent ofstrain rate, as would be typical for metals. Failure in MAT_24 occurs when theaccumulated plastic strain in an element reaches the failure stress value specifiedin the FAIL term. At each time step, after the trial stress is computed, if the trialstress is found to be outside the yield surface (Von-Mises), LS-DYNA scales thestress back to the yield surface and then obtains the accumulated plastic strain byusing the material model to calculate the corresponding effective plastic strain(EPS) at the strain rate seen by the element. If this accumulated plastic strainequals FAIL, the element is removed. FAIL is usually chosen by the analyst as thelargest failure strain in the material data. This is the conservative approach. If thedata shows a variation in failure strains with strain rates, a check must be made bythe analyst to review the strain-rate experienced by the part, to pick a value ofFAIL at that corresponding strain rate. This is described later. It is clear that withpolymers with ductile-brittle transitions or where the failure strain is highly ratedependent that this limitation can have a significant impact on the simulation.The LCSS option of MAT24 is very useful when the shape of the plasticity curvechanges with strain rate. This phenomenon is often observed in polymers. In thiscase, by submitting a plasticity curve for each strain-rate, we are able toindependently describe the stress-strain behaviour as a function of strain rateallowing us the ultimate in flexibility offered by the model. It may still be a usefulexercise to smooth the rate-dependency using the approach outlined earlier. LCSShowever does not offer relief in the modelling of ductile-brittle transitions,because of the limitation of FAIL. Proper implementation of LCSS requires thatwe extrapolate all the plasticity curves to the largest failure strain (FAIL) that weintend to use in the model. Consequently information regarding the change infailure strain with strain rate is lost.When handling post-yield behavior, a number ofcomplications arise. Most post yield behavior is accompanied by necking,localized non-uniform deformation, which leads to a condition where the cross-sectionalarea of the deformation zone is unknown. Consequently, the stress is alsoan unknown and can only be crudely estimated by making some assumptionsabout the cross-sectional area. The most common procedure is to assume that thetrue stress calculation applies in this region as well. A consequence of thisassumption is that the slope of the stress-strain curve is seen to gradually increasewith increasing strain. In the case of olefine materials such as polypropylene andpolyethylene whose necking phenomenon is more closely equated withunravelling or unzipping of the dendrite structure, it is more likely that the stressremains constant during necking. In any case, to model these regions usingMAT24, it is only essential to eliminate negative slopes in the model [2].

VIII. CALIBERATION AND VALIDATION MODEL PREPARATION

The Tensile test data used for deriving material data is simulated through finite element analysis using as input data

the material card elaborated according to procedure mentioned before. Re-obtaining from the finite element analysis same values of curve Force Vs Displacement as the one measured experimentally is validation criteria treated as "Reverse problem". Any deviation from desired are used to correct the input data. Material model in FE preprocessor follow mesh building parameters highlight in below Fig.7



- Element size (average): Shell, 0.5x 0.5 mm in the central area, thickness 3.2
- Element type: element 2 Belytschko-Tsay. ELFORM=2 in *SECTION_SHELL
- Integration Points: 5.
- Hourglass Control: Flanagan-Belytschko Integration, IHQ=2 in *CONTROL_HOURGLASS
- Plasticity: radial return. MITER=3 in *CONTROL_SHELL
- Variable thickness: ISTUPD =1 in *CONTROL_SHELL

Fig.7FEA Setup and LS-Dyna cards to integrate the MAT-24 model[11]

The MAT-24 material model has simplistic structure to define material nonlinearity.LS-DYNA internally checks the slope of the curve. When this slope falls below the modulus E specified in the material card, the material is assumed to have yielded. The treatment of plasticity then follows MAT24, as described earlier. The LCSR scaling of the stress-strain curve allows this model to be scaled to high strain rates in a manner similar to MAT24. The LCSR table of yield stress v. strain rate is a better choice for modeling rate-dependency that the Cowper-Symonds equation for the same reasons described earlier. Below is the structure of material card MAT-24.

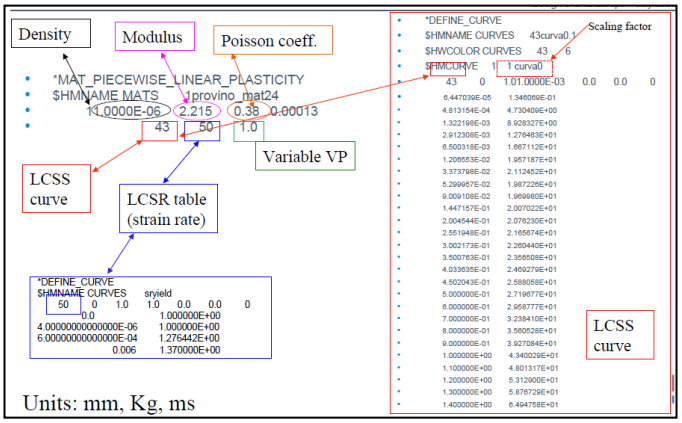


Fig.8MAT-24 model structure [11]

The inverse modelling strategy used to identify the behaviour of material regarding their stress-strain nature, strain-rate parameter, yielding behaviour of material to predict experimental tensile response for this purpose we perform numerical analysis of tensile specimen. Comparison betweenexperimental test response and numerical simulation of material model is reflected in F-D curve.

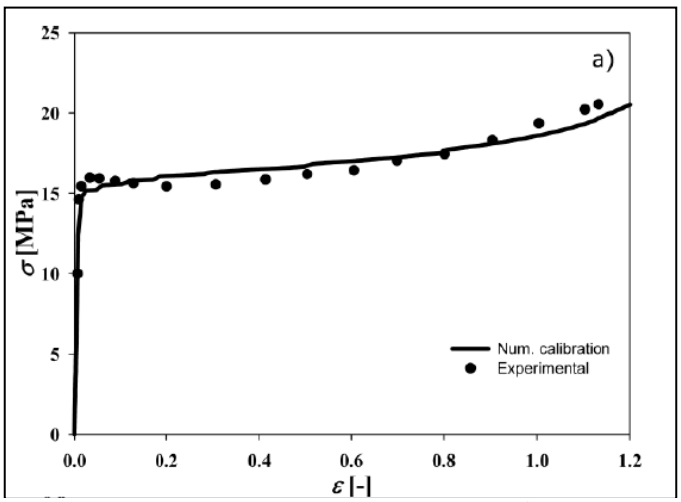


Fig.9 Tensile True Stress-True strain response comparison of experimental data and numerical experimentation[6]

Finally, the inverse modeling approach is based on a local strategy where the correct data transferbetween experiments and finite element loadingconditions is guaranteed. Accordingly, local strainrate values, measured from DIC, are directlyapplied as the loading condition to the finiteelement used to represent the material point.A material model was calibrated based on the experimental data from the tension tests. It was observed that the material experienced hardening in the tension tests, aswell as strain rate dependency. The tension tests were numerically simulated inorder to validate the parameters in the material model.The calibrated material model was able to capture the main characteristics of the materialpolypropylene.

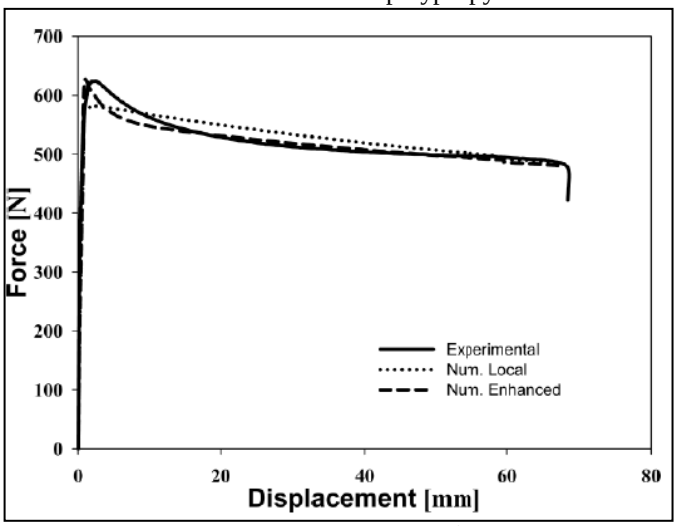


Fig.10 Force-Displacement response comparison of experimental data and numerical experimentation[6]

However, the model had limitations, as it was not able to correctly predict thebehavior of the material at high strain rates. The numerical simulation experiences hardening although theexperimental curve flattens out. The hardening in the simulation curve is likely to be caused bythe difference between the calibrated material model and the experimental test.The force-displacement curves from the experimental data and the numericalsimulation are seen.

IX. CONCLUSION.

A number of material models exist that could be used for the modeling ofpolymeric behavior. Recently lot of work is going on in calibration of material model to capture the behavior of plastic by different methodology and process. The quality ofsimulation result depends strongly on quality of experimental work and optimization of input parameters.

Simple validations allow the analyst to evaluate the reliability of the material calibration.Such a validated material model can form a basis for material model tuning basedon more complex experiments. The Tensile test data used for deriving material data is simulated through finite element analysis using material modelas elaborated.Since the input parameters are calibrated from tensile tests itself, material model can be considerably accurate.

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