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PROGRAM AND ABSTRACTS

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Influence of friction on strain distribution in Nakazima formability tests

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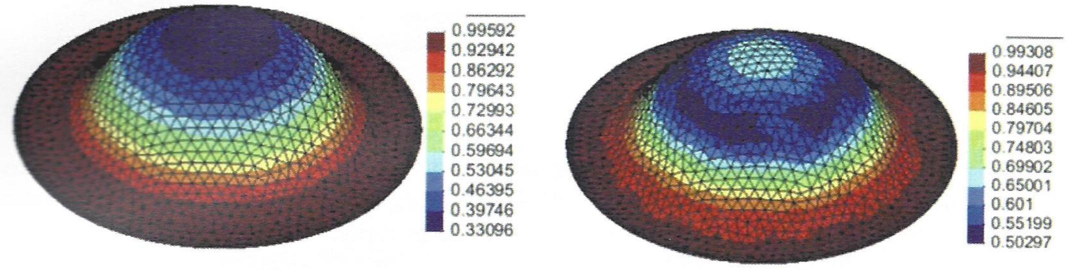
This paper presents numerical investigations of the influence of friction in the contact between a sheet and a punch on sheet deformation in Nakazima type formability tests. The Nakazima test [1] is one of the most commonly used tests to study experimentally formability of metal sheets. It consists in stretching of a sheet specimen by means of a hemispherical punch until occurrence of fracture. A fractured circular specimen after testing is shown in Figure 1. Failure points for different strain paths obtained by taking different specimen geometries define a forming limit curve for the tested material.

Figure 1: Fractured circular specimen after testing.

Friction, affecting strain paths in a tested specimen, is usually undesired phenomenon in formability tests, therefore different measures are taken to reduce friction. In the Nakazima tests, either oil, grease or polymer foils should be used as lubricant systems [1]. Tribological conditions should be adjusted so that fracture occurs within a distance less than 15% of the punch diameter away from the apex of the dome. Zero friction would allow us to obtain fracture at the center of specimen with nearly strain path at fracture point. The failure location is very sensitive to friction. Even small increase of friction displaces the location of fracture [2].

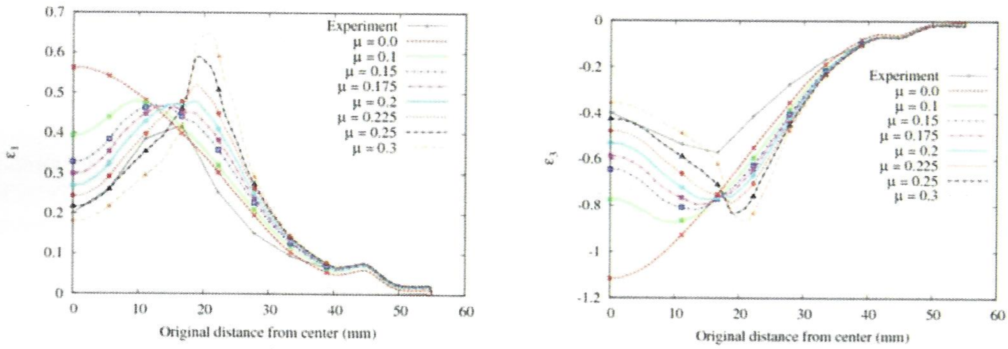
The aim of this study has been to develop a numerical model allowing us to identify frictional conditions in a selected case of the Nakazima test and study numerically effect of change of friction on strain distribution and failure location in a sheet specimen. Numerical simulations have been performed assuming the data corresponding to own laboratory tests carried out for the steel grade DC04 1 mm thick.

Numerical analyses have been performed using the authors' own computer explicit dynamic finite element developed within a framework of the project Numpress [3]. Sheet was discretized with a linear shell triangular elements BST [4]. The material has been considered assuming the Hill'48 model. The tools have been modelled as rigid bodies whose surfaces has been discretized with triangular facets. Frictional contact between the tool and sheet has been treated using the Coulomb model of friction. Deformation process has been analysed under prescribed motion of the punch. The effect of friction on the location of fracture is demonstrated in Figure 2. In the frictionless case, maximum thinning, indicating a possible fracture, is obtained at the center of the blank, while in the case with non-zero friction the area of diffused necking is displaced from the centre by a certain distance. Strain distribution along the sheet radius for different values of the friction coefficient is shown in Figure 3.



a) b)

Figure 2: Simulated distribution of sheet thickness in the stamped circular specimen: a) without friction, b) with friction (Coulomb coefficient 0.3)



a) b)

Figure 3: Strain distribution along the radius: a) major principal strain, b) thickness strain.

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