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FALET-HL-CEMUC–Forming of aluminum alloys at elevated temperature

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The aim of the training period of Dr H. Laurent in "Centro de Engenharia Mecânica da Universidade de Coimbra (CEMUC)" was to study the effect of the temperature on the sensibility of forming and springback at warm forming conditions of aluminium alloys. For this, numerical, experimental and theoretical studies have been performed. This work have lead to publish common works in several journals and international conferences [1, 2, 3, 4, 5, 6].

Stamping is the most efficient and massive manufacturing technology on which many industries rely for forming parts from sheet metals. In our days there is a strong market need to manufacture sheet metal-based products with higher geometrical complexity and improved dimensional accuracy at a lower cost. These requirements can only be met by the simultaneous development of the lean manufacturing, concepts and new technology. In this context, the thermally-based forming is an approach very attractive for manufacturers. Indeed, the warm forming technique has been attempted to improve deep drawability and to reduce the cost for production of metal alloys. Another advantage of the warm deep-drawing process is the reduction of the springback after forming.

This study given new testing methods, new materials characterisation which become increasingly important as the industry is striving for more innovative forming methods to accommodate the market needs. The springback of a sheet metal alloy during the warm deep-drawing process has been evaluated, comparing several phenomenological models for the prediction of springback as a function of either the temperature. An experimental springback ring test (named Demeri's test) has been performed to measure the material deformation and the displacement during cup forming, ring trimming and springback after ring splitting. Several numerical models with commercial

and in-house codes have be used to show the influence of constitutive models in the prediction of springback in warm conditions.

The analysis of residual stresses at the end of the forming stage and the study the ring's springback, shows that the evolution of tangential stresses are different as a function of the element type and plastic yield criteria. Element types but also yield criteria are then critical in determining the distribution of the stress in the cup. The reason lies in difficulty to predict the complex strain path during forming deformation which induces residual stresses. Different residual stress distributions produce different opening results.

For the future, it seems very important to investigate the friction behaviour for sheet forming processes at elevated temperature. Deep drawing processes are impossible if the sheet metal is not lubricated, otherwise die wear and galling will occur, and good flow of the formed material will not take place, resulting in poor quality products. There are serious ecological and economic concerns resulting from the use of these lubricants. The removal or, at least, a severe reduction of the amount of lubricant used during the stamping operation of a metal sheet is then of paramount importance to the reduction of the respective environmental impact in the different stages of a product life cycle. However, the simple reduction of lubricant at the temperatures of the warm forming process, where classical lubricants loose efficiency, can commit the success of the forming process. Nowadays new coatings are widely employed in the die surfaces increasing their wear resistance in order to increase the life time of the tools. The new challenge is now the application of coatings in the die surface not only to increase its resistance but also to allow a reduction or even to eliminate the oil based deep drawing lubricants, even at warm forming temperatures, performing the processes only with the corrosion protection of the coils, conducing to a real use of sustainable materials and manufacturing technologies. This new endeavour will necessarily lead to new technological process conditions that must be studied and optimised in order to guarantee that the formed part would have the envisaged geometry and properties.

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