

Wall ironing with polymer coated sheet metal

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Wall Ironing with Polymer Coated Sheet Metal



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Hoogovens R&D

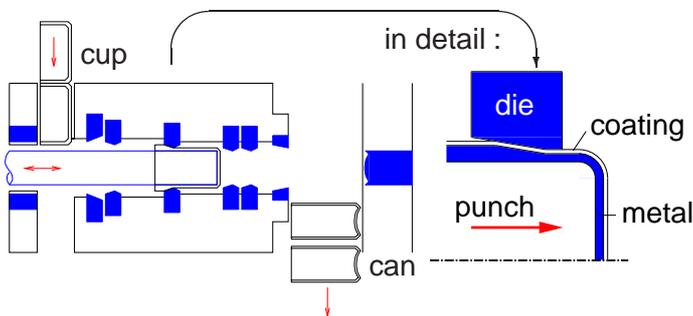
1. Introduction

Standard can making is a metal-forming process, consisting of three steps :

1. deep drawing → cup
2. wall ironing → thin-walled can
3. removal of lubricant/emulsion and lacquering of the cans



New approach before deformation, the sheet metal is coated with a polymer layer. This coating combines the functions of environmentally friendly lubricant, protection against corrosion, and emission-free lacquer.



Objective development of a validated model for the wall ironing process of coated metal sheet.

2. Constitutive modelling

A class of elasto-viscoplastic constitutive equations [1], is used to describe the mechanical behaviour of both metal and polymer coating under large deformations, high deformation rates, and high temperatures.

- ◇ metal : Bodner-Partom model
- ◇ coating : compressible Leonov model

3. Numerical method : OS-ALE

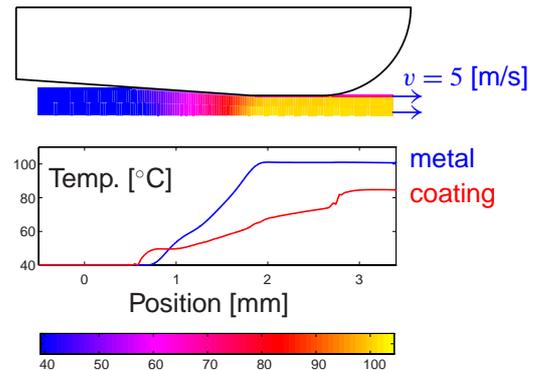
Arbitrary Lagrange Euler method based on operator splitting methodology (OS-ALE) includes the iterative scheme:

1. Updated Lagrange step
2. mesh reconditioning step
3. convective step of history variables to new mesh → Discontinuous Galerkin method

References

1. M.B. Rubin and A.L. Yarin. On the relationship between phenomenological models for elasto-viscoplastic metals and polymeric liquids. *Journal of Non-Newtonian Fluid Mechanics*, 50:79–88, 1993.
2. H.A. Bruck, S.R. McNeill, M.A. Sutton, and W.H. Peters III. Digital image correlation using Newton-Raphson method of partial differential correction. *Experimental Mechanics*, 29:261–267, 1989.

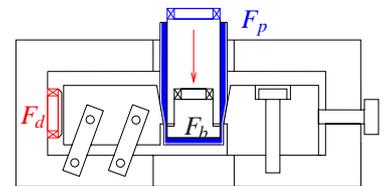
Thermo-mechanical coupled analysis :



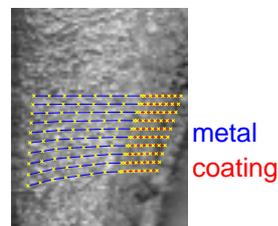
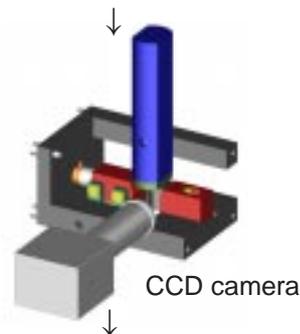
4. Experimental validation

Experimental set-up measures forces :

- (1) die force F_d
- (2) punch force F_p
- (3) bottom force F_b



Particle tracking is performed by using a digital image correlation technique [2].



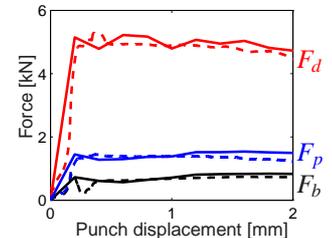
geometry: friction coefficients

$$\mu_p = \frac{F_p - F_b}{F_d}$$

$$\mu_d = \frac{F_p \cos(\alpha) - F_d \sin(\alpha)}{F_d \cos(\alpha) + F_p \sin(\alpha)}$$

OS-ALE simulation

dashed : experiment
solid : simulation



5. Conclusion

Good agreement between numerical and experimental results has been obtained under conditions similar to industrial ones (i.e. large strains, high strain rates, and high pressures)