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Numerical simulation method of roller hemming on variable curvature aluminium alloy sheet with adhesive

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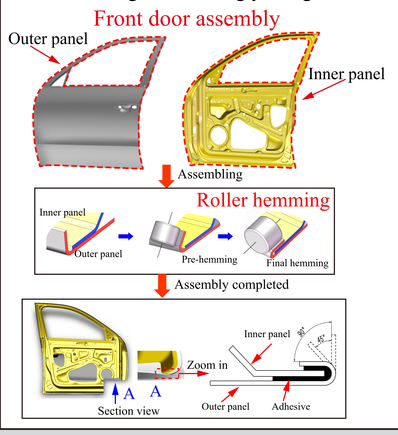
Introduction

Roller hemming is increasingly being used in the manufacture of autobody closure panels.



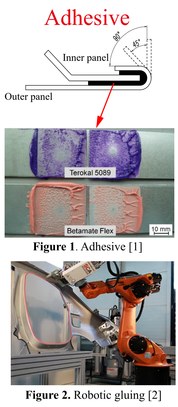


Figure 1. Adhesive [1]

Figure 2. Robotic gluing [2]

Figure 3. Industrial robot [3]

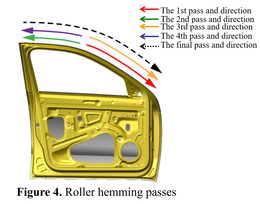


Figure 4. Roller hemming passes

Research objectives

- For the sheets with variable curvature, the posture of roller will be calculated in the roller hemming process.
- For the heterogeneous coupling between the adhesive and the sheet, a fluid-solid coupling simulation model will be established.

Methods

The method of discrete variable curvature curve

The motion of the roller is superimposed by the following motion patterns: (1) The roller moves horizontally along the X axis. (2) The roller moves horizontally along the Y axis. (3) The roller rotates around the Z axis. (4) The roller rotates around its axis.

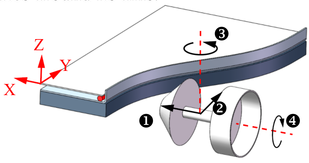
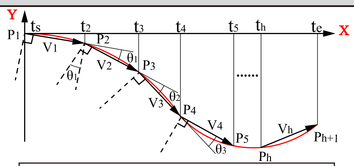


Figure 5. The motion of the roller



Prepare the trajectory curve *C* of the roller

↓

Divide the trajectory curve *C* into h equal parts

↓

Calculate the coordinate value of each point *Pi*

↓

Solve the vector *Vi* between adjacent points in turn

↓

Calculate the angles *θi* of adjacent vectors in turn

↓

Set the load conditions of the finite element simulation according to the vector *Vi* and the angle *θi*

Numerical simulation

Take the variable curvature aluminium alloy sheet as the research object, and carry out the roller hemming simulation.

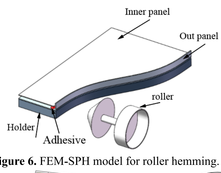


Figure 6. FEM-SPH model for roller hemming.

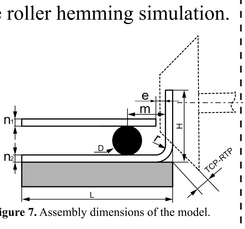


Figure 7. Assembly dimensions of the model.

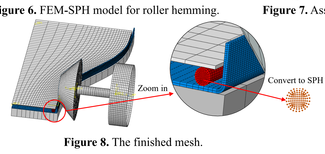


Figure 8. The finished mesh.

Based on the curve discretization method above, the motion posture of the roller at each time step is calculated.

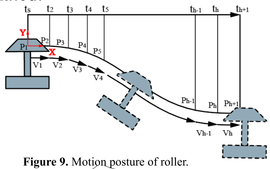


Figure 9. Motion posture of roller.

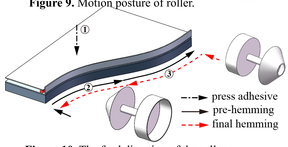
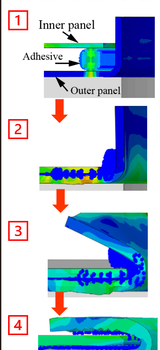


Figure 10. The feed direction of the roller.

Results

The flow behavior of adhesive during the roller hemming process



The adhesive is transformed into SPH particles.

The part of adhesive flows between the inner and the outer panel, and the other part fills the corner of the outer panel.

In pre-hemming, the adhesive gradually flows to the upper side of the inner panel.

In final hemming, the adhesive fills the gap between the two panels.

The motion posture of the roller

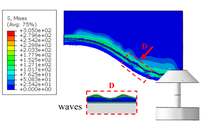


Figure 11. The motion posture of the roller at the end of the pre-hemming.

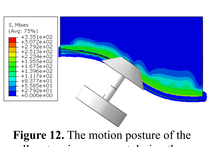


Figure 12. The motion posture of the roller at a given moment during the final hemming.

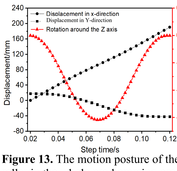


Figure 13. The motion posture of the roller in the whole pre-hemming process.

The motion posture of the roller is consistent with the actual motion of the roller, which proves that the method of discrete variable curvature curves can effectively solve the hemming forming problem of aluminum alloy sheet with plane curved edge .

Conclusions

- The method of discrete variable curvature curve is proposed. The roller hemming along the curve of variable curvature is realized.
- The roller forming analysis model of aluminum alloy sheet with variable curvature was established. The interaction between adhesive and panel was simulated effectively by FEM-SPH coupling method.
- The established numerical model lays the foundation for forming quality analysis.

Acknowledgement

Thanks for the support of The National Natural Science Foundation of China (NO.51975416).

References

[1] Han Jin-e. The simulation analysis and experimental study of roller hemming process on aluminum alloy hood[D]. Hefei University of Technology, 2017

[2] Zhao Yixi, Zhang Yansong, Lai Xinmin. Effect of Epoxy Adhesive on Nugget Formation in Resistance Welding of SAE1004/DP600/DP780 Steel Sheets[J]. Materials, 2018,11(10): 1828.

[3] https://www.dupont.com/brands/betamate.html