Industry Day Theme # {Emerging Nano and Advanced Materials}

Development of Ultra-Fine Grained Sheet Materials Through Severe Plastic Deformation

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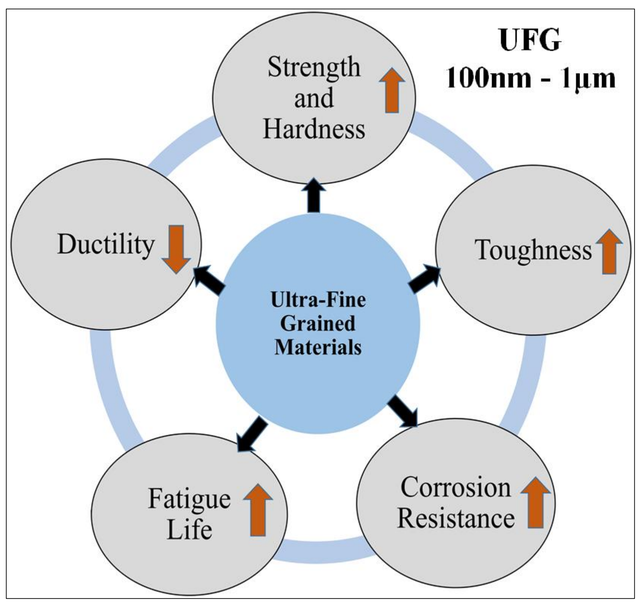
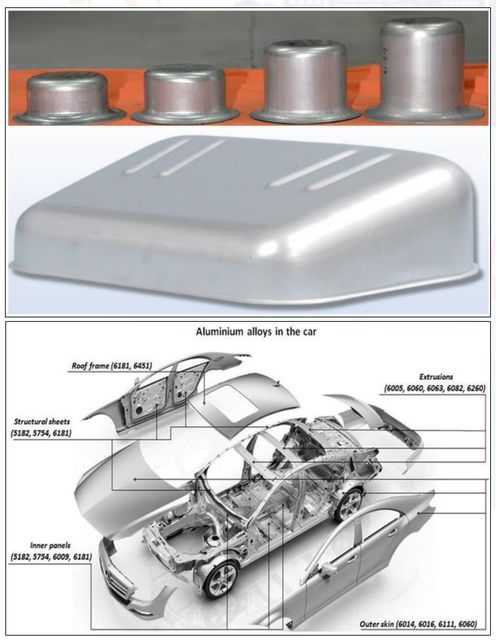
Abstract

The key requirement of the automobile and aerospace industries is the use of lightweight materials for greater efficiency and reduced emissions. Research activities are focused on using these materials with improved mechanical properties for lighter vehicle body and increased safety. In recent years, materials with nanograins have gained much attention to light-weighting. Cryorolling and constrained groove pressing (CGP) is the competent severe plastic deformation (SPD) route to produce ultra-fine grain (UFG) sheet metal. However, the ductility and formability of these materials is very low. The objective of the study is to produce UFG sheet materials of Al alloys with high strength and improved ductility for structural and stamping applications.

Introduction

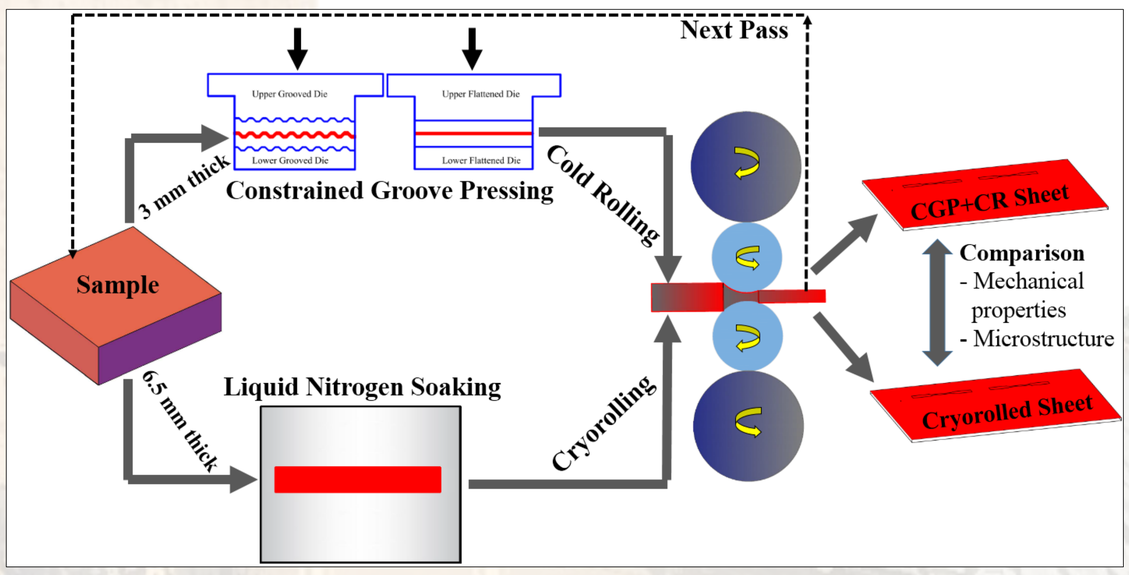
Properties and Applications of Ultra-Fine Grained Materials





Grain refinement, strain hardening, and dislocation strengthening – improve strength and toughness

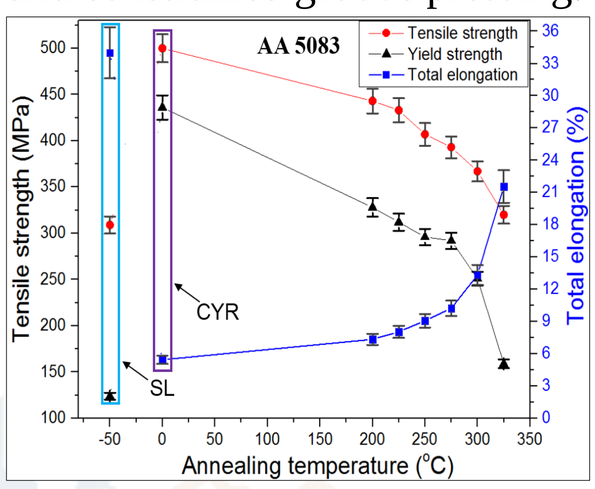
Materials and Methods

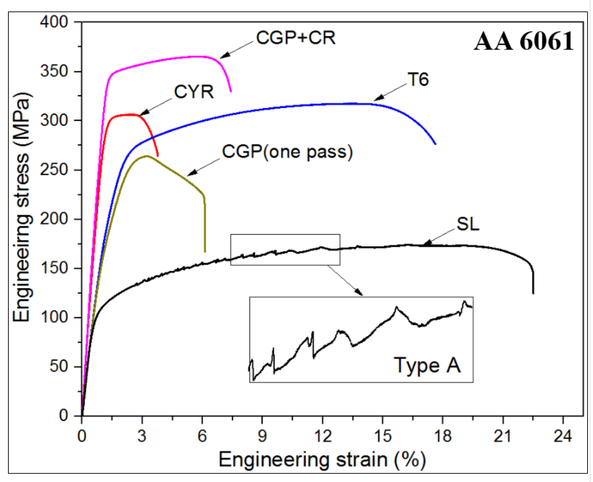


Cryorolling and Constrained Groove Pressing

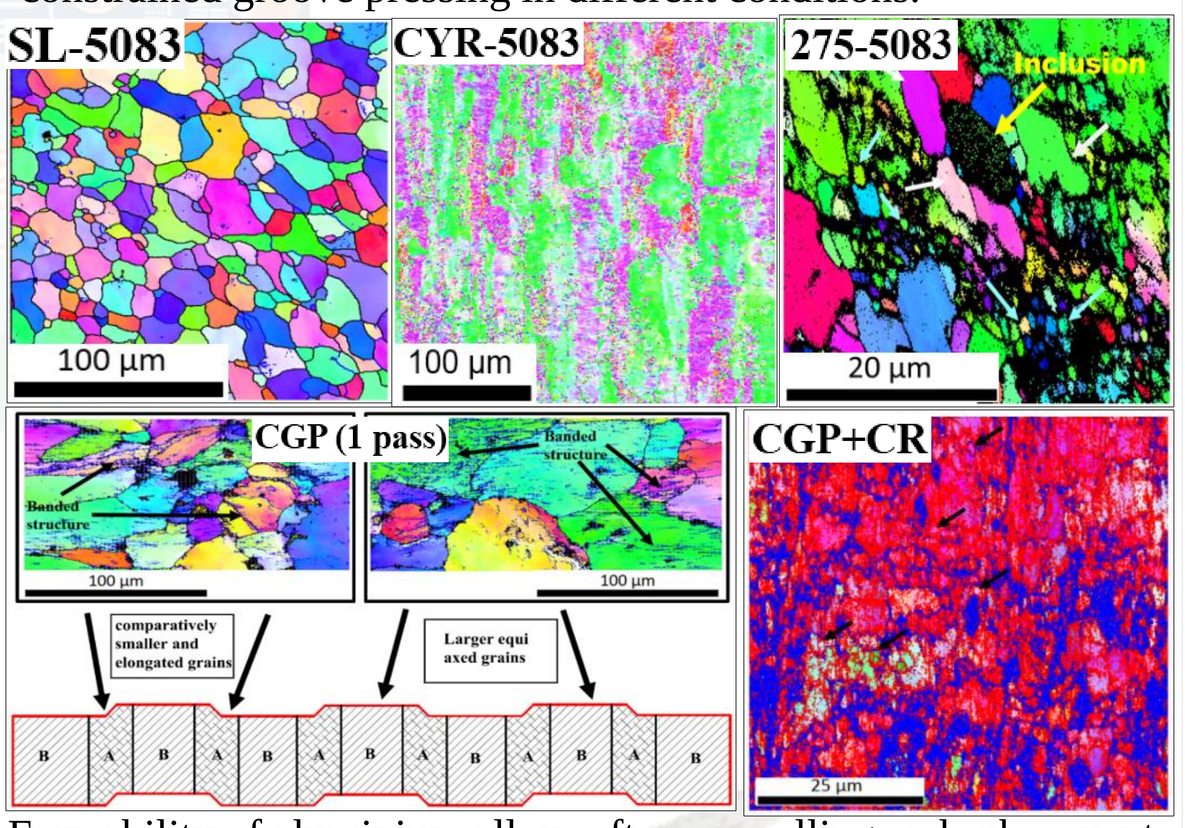
Results

Mechanical properties of aluminium alloys after cryorolling and constrained groove pressing.

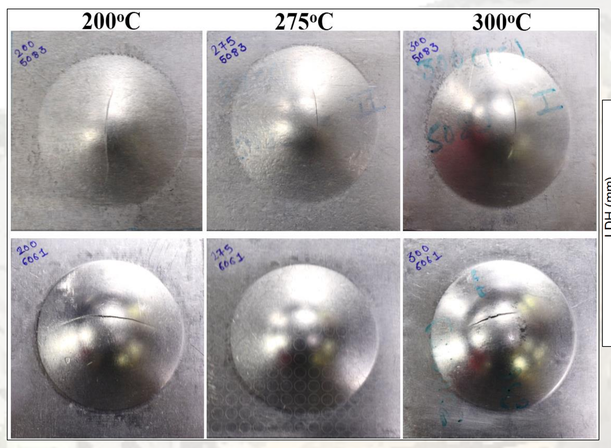


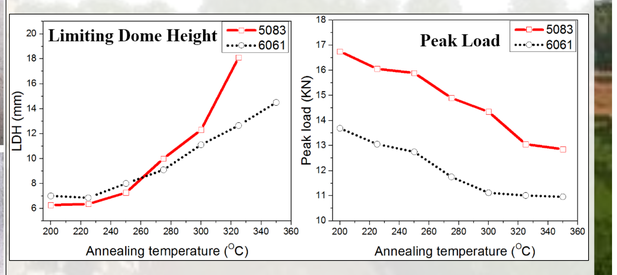


Microstructure of aluminium alloys after cryorolling and constrained groove pressing in different conditions.



Formability of aluminium alloys after cryorolling and subsequent annealing at different temperatures.





Conclusions

Cryorolling and constrained groove pressing are suitable techniques to develop ultra-fine grained sheet materials. CGP followed by cold rolling is an alternate route for cryorolling to produce the high strength sheets of Al alloys with UFG structure. Cryorolling followed by short annealing resulted in optimal combination of strength and formability.

Industrial Significance

Cryorolling and CGP have potential for large-scale production of lightweight sheet materials to manufacture automotive components.

Technology Readiness Level

Lab scale facilities for cryorolling and CGP have been established.

References

T.G. Langdon, Twenty-five years of ultra fine-grained materials: Achieving exceptional properties through grain refinement, Acta Mater. 61 (2013) 7035–7059.

R.Z. Valiev, R.K. Islamgaliev, I.V. Alexandrov, Bulk nanostructured materials from severe plastic deformation, Prog. Mater. Sci. 45 (2000) 103–189.

A. Dhal, S.K. Panigrahi, M.S. Shunmugam, Insight into the microstructural evolution during cryo-severe plastic deformation and post-deformation annealing of aluminum and its alloys, J. Alloys Compd. 726 (2017) 1205-1219.

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