

OPTIMIZATION OF PROCESS PARAMETERS IN DEEP DRAWING OF MONEL 400 CONICAL CUPS

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ABSTRACT

Objective of this current work was to optimize the process parameters in the deep drawing of MONEL-400 conical cup. The design procedure for finite element analysis was carried out as per Taguchi's techniques using DEFORM software code. Stresses induced in the cups are within the limit of ultimate strength of MONEL-400. The sheet thickness and step depth had influenced the reduction of sheet thickness during the cup formation.

The present project work was carried out in two phases. Initial phase is numerical simulation of physical process with finite element analysis and the final phase analysis of results for understanding its formability. The finite element analysis was carried out using DEFORM software.

Experiments of the current work were designed using the Taguchi technique and ANOVA method was employed to estimate influence of process parameters punch velocity, coefficient of friction, sheet thickness, number of steps on stresses and strains developed in the sheet and to find significant process parameters affecting the formability. Thickness variation along the wall and flanges of cups and forming limit diagram were presented for all the cups.

The process parameters which majorly influence formability of conical cups were coefficient of friction and the step depth of forming process. The majority of the thickness reduction takes place in the middle part of wall of the cup but not in the flange or bottom part of wall of the cup. Stresses induced are lower than ultimate tensile strength of the material.

The following are the conclusions that are drawn from the current work:

- It was observed from present work that the process parameters, which had greater influence on the formability of deep drawing of conical cups of Monel 400, were the coefficient of friction and the blank thickness.
- The damage of the cups was lower in trial 7 when the thickness was high and

coefficient of friction was low.

- Damage of the cup decreased with increase in thickness.
- Surface expansion ratio was higher for trial 2, when coefficient of friction was high.
- Higher the coefficient of friction higher the surface expansion ratio.
- Height of the cup was closer to the desired height in trial 5, when displacement per step was low.
- Displacement per step was the major parameter that influenced the height of the cup.

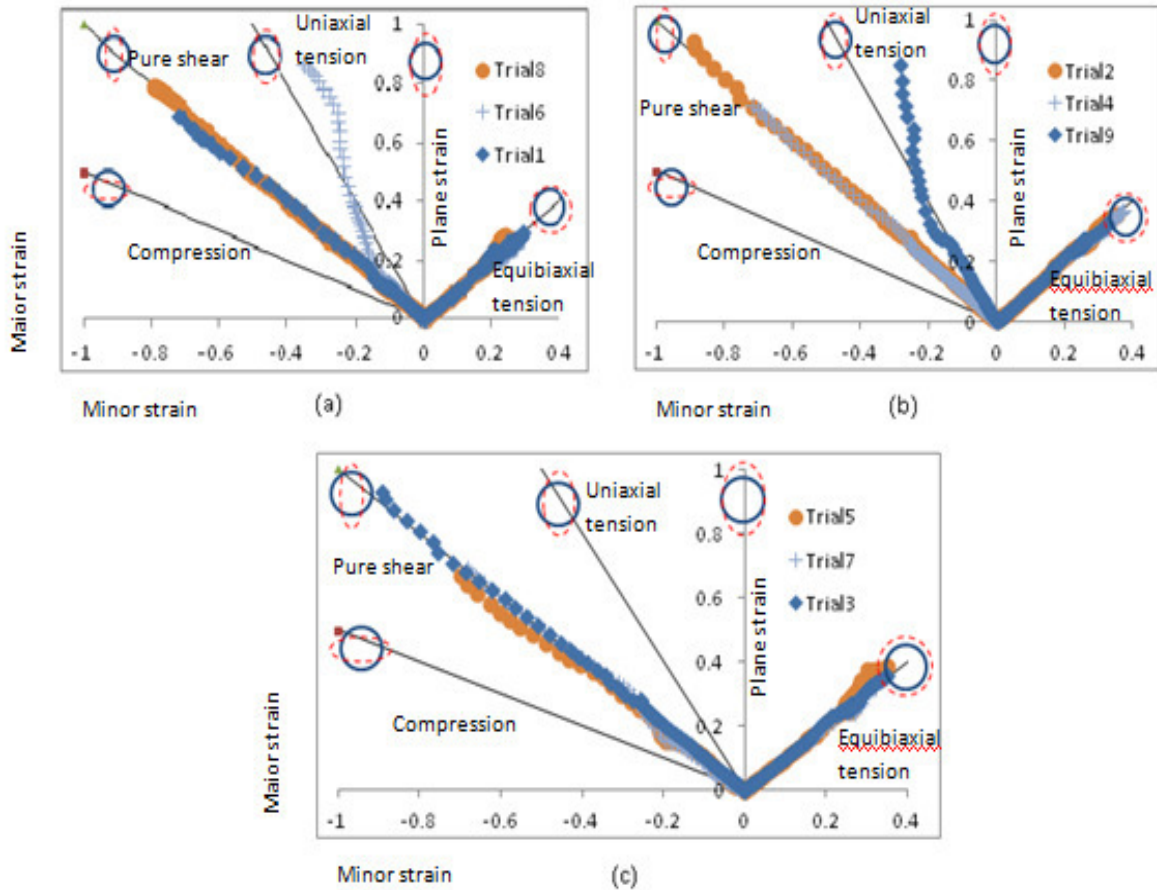


Figure: forming limit diagrams with damages for different blank thickness

REFERENCES

1. A.C. Reddy, Finite element analysis of reverse superplastic blow forming of Ti-Al-4V alloy for optimized control of thickness variation using ABAQUS, Journal of Manufacturing Engineering, vol.1, no.1, pp.6-9, 2006.
2. J.J.V. Jeyasingh, G. Kothandaraman, P.P.Sinha, B. Nageswara Rao, A.C.Reddy, Spherical dome formation by transformation of superplasticity of titanium alloys and titanium matrix composites, Materials Science and Engineering: A, vol.478, no.1&2, pp.397-401, 2008.
3. J.V.Jeysingh, B. Nageswara Rao, A. C. Reddy, Investigation on failures of hydroforming deep drawing processes, Materials Science Research Journal, vol.2, no.3 & 4, pp.145-167, 2008.

4. J.J.V.Jeysingh, B. Nageswara Rao, A. C. Reddy, Development of a ductile fracture criterion in cold forming, *Materials Science Research Journal*, vol.2, no.3&4, pp.191-206, 2008.
5. J.V.Jeysingh, B. Nageswara Rao, A. C. Reddy, Gas pressure forming of spherical domes from Pb-Sn eutectic alloy superplastic sheet material, *Materials Science Research Journal*, vol.2, no.3&4, pp.241-258, 2008.
6. A. C. Reddy, Influence of strain rate and temperature on superplastic behavior of sinter forged Al6061/SiC metal matrix composites, *International Journal of Engineering Research & Technology*, vol.4, no.2, pp.189-198, 2011.
7. A. C. Reddy, T. Kishen Kumar Reddy, M. Vidya Sagar, Experimental characterization of warm deep drawing process for EDD steel, *International Journal of Multidisciplinary Research & Advances in Engineering*, vol.4, no.3, pp.53-62, 2012.
8. A. C. Reddy, Simulation analysis of four-pass shape roll forming of I-sections, *International Journal of Mechanical and Production Engineering Research and Development*, vol.5, no.1, pp.35-44, 2015.
9. KothapalliChandini, A. C. Reddy, Parametric Importance of Warm Deep Drawing Process for 1070A Aluminium Alloy: Validation through FEA, *International Journal of Scientific & Engineering Research*, vol.6, no.4, pp.399-407, 2015.
10. Balla Yamuna, A. C. Reddy, Parametric Merit of Warm Deep Drawing Process for 1080A Aluminium Alloy: Validation through FEA, *International Journal of Scientific & Engineering Research*, vol.6, no.4, pp.416-424, 2015.
11. Thirunagari Srinivas, A. C. Reddy, Parametric Optimization of Warm Deep Drawing Process of 1100 Aluminum Alloy: Validation through FEA, *International Journal of Scientific & Engineering Research*, vol.6, no.4, pp.425-433, 2015.
12. A. C. Reddy, Homogenization and Parametric Consequence of Warm Deep Drawing Process for 1050A Aluminum Alloy: Validation through FEA, *International Journal of Science and Research*, vol.4, no.4, pp.2034-2042, 2015.
13. A. C. Reddy, Parametric Optimization of Warm Deep Drawing Process of 2014T6 Aluminum Alloy Using FEA, *International Journal of Scientific & Engineering Research*, vol.6, no.5, pp.1016-1024, 2015.
14. A. C. Reddy, Finite Element Analysis of Warm Deep Drawing Process for 2017T4 Aluminum Alloy: Parametric Significance Using Taguchi Technique, *International Journal of Advanced Research*, vol.3, no.5, pp.1247-1255, 2015.
15. A. C. Reddy, Parametric Significance of Warm Drawing Process for 2024T4 Aluminum Alloy through FEA, *International Journal of Science and Research*, vol.4, no.5, pp.2345-2351, 2015.
16. Balla Yamuna, A. C. Reddy, Finite Element Analysis of Warm Deep Drawing Process for Conical Cup of AA1080 Aluminum Alloy, *International Journal of Advanced Research*, vol.3, no.6, pp.1309-1317, 2015.
17. KothapalliChandini, A. C. Reddy, Finite Element Analysis of Warm Deep Drawing Process for Pyramidal Cup of AA1070 Aluminum Alloy, *International Journal of Advanced Research*, vol.3, no.6, pp.1325-1334, 2015.
18. Thirunagari Srinivas, A. C. Reddy, Finite Element Analysis of Warm Deep Drawing Process for Rectangular Cup of AA1100 Aluminum Alloy, *International Journal of Advanced Research*, vol.3, no.6, pp.1383-1391, 2015.
19. A. C. Reddy, Formability of Warm Deep Drawing Process for AA1050-H18 Pyramidal Cups, *International Journal of Science and Research*, vol.4, no.7, pp.2111-2119, 2015.
20. A. C. Reddy, Formability of Warm Deep Drawing Process for AA1050-H18 Rectangular Cups, *International Journal of Mechanical and Production Engineering Research and Development*, vol.5, no.4, pp.85-97, 2015.

21. A. C. Reddy, Formability of superplastic deep drawing process with moving blank holder for AA1050-H18 conical cups, *International Journal of Research in Engineering and Technology*, vol.4, no.8, pp.124-132, 2015.
22. A. C. Reddy, Formability of High Temperature and High Strain Rate Superplastic Deep Drawing Process for AA2219 Cylindrical Cups, *International Journal of Advanced Research*, vol.3, no.10, pp.1016-1024, 2015.
23. C. R. Alavala, High temperature and high strain rate superplastic deep drawing process for AA2618 alloy cylindrical cups, *International Journal of Scientific Engineering and Applied Science*, vol.2, no.2, pp.35-41, 2016.
24. C. R. Alavala, Practicability of High Temperature and High Strain Rate Superplastic Deep Drawing Process for AA3003 Alloy Cylindrical Cups, *International Journal of Engineering Inventions*, vol.5, no.3, pp.16-23, 2016.
25. C. R. Alavala, High temperature and high strain rate superplastic deep drawing process for AA5049 alloy cylindrical cups, *International Journal of Engineering Sciences & Research Technology*, vol.5, no.2, pp.261-268, 2016.
26. V. Srija, A. C. Reddy, Single Point Incremental Forming of AA1050-H18 Alloy Frustum of Cone Cups, *International Journal of Science and Research*, vol.5, no.6, pp.1138-1143, 2016.
27. T. Santhosh Kumar, A. C. Reddy, Finite Element Analysis of Formability of Pyramid-al Cups Fabricated from AA1100-H18 Alloy, *International Journal of Science and Research*, vol.5, no.6, pp.1172-1177, 2016.
28. A. Raviteja, A. C. Reddy, Finite Element Analysis of Single Point Incremental Deep Drawing Process for Truncated Pyramidal Cups from AA 1070 Alloy, *International Journal of Innovative Science, Engineering & Technology*, vol.3, no.6, pp.263-268, 2016.
29. V. Srija, A. C. Reddy, Numerical Simulation of Truncated Pyramidal Cups of AA1050-H18 Alloy Fabricated by Single Point Incremental Forming, *International Journal of Engineering Sciences & Research Technology*, vol.5, no.6, pp.741-749, 2016.
30. T. Santhosh Kumar, A. C. Reddy, Single Point Incremental Forming and Significance of Its Process Parameters on Formability of Conical Cups Fabricated from AA1100-H18 Alloy, *International Journal of Engineering Inventions*, vol.5, no.6, pp.10-18, 2016.
31. A. Raviteja, A. C. Reddy, Implication of Process Parameters of Single Point Incremental Forming for Conical Frustum Cups from AA1070 Using FEA, *International Journal of Research in Engineering and Technology*, vol.5, no.6, pp.124-129, 2016.
32. T. Santhosh Kumar, V. Srija, A. Ravi Teja, A. C. Reddy, Influence of Process Parameters of Single Point incremental Deep Drawing Process for Truncated Pyramidal Cups from 304 Stainless Steel using FEA, *International Journal of Scientific & Engineering Research*, vol.7, no.6, pp.100-105, 2016.
33. G. Devendar, A. A. C. Reddy, Study on Deep Drawing Process Parameters - A Review, *International Journal of Scientific & Engineering Research*, vol.7, no.6, pp.149-155, 2016.
34. C. R. Alavala, FEM Analysis of Single Point Incremental Forming Process and Validation with Grid-Based Experimental Deformation Analysis, *International Journal of Mechanical Engineering*, vol.5, no.5, pp.1-6, 2016.
35. C. R. Alavala, Validation of Single Point Incremental Forming Process for Deep Drawn Pyramidal Cups using Experimental Grid-Based Deformation, *International Journal of Engineering Sciences & Research Technology*, vol. 5, no.8, pp.481-488, 2016.
36. G. Devendar, A. C. Reddy, Formability Limit Diagrams of Cold Deep Drawing Process for Nickel 201 Cylindrical Cups, *International Journal of Science and Research*, vol.5, no.8, pp.1591-1598, 2016.

37. C. R. Alavala, Development of High Temperature and High Strain Rate Super Plastic Deep Drawing Process for 5656 Al Alloy Cylindrical Cups, International Journal of Mechanical and Production Engineering, vol.4, no.10, pp.187-193, 2016.
38. B. Navya Sri, A. C. Reddy, Formability Of Elliptical SS304 Cups in Single Point Incremental Forming Process by Finite Element Method, International Journal of Research in Engineering & Technology, vol.4, no.11, pp.9-16, 2016.
39. K. Sai Santosh Kumar, A. C. Reddy, Die Less Single Point Incremental Forming Process of AA6082 Sheet Metal to Draw Parabolic Cups using ABAQUS, International Journal of Advanced Technology in Engineering and Science, vol.4, no.11, pp.127-134, 2016.
40. T. Manohar Reddy, A. C. Reddy, Numerical Investigations on The Single Point Incremental Forming of 60-40 Brass to Fabricate Hyperbolic Cups, International Journal of Advance Research in Science and Engineering, vol.5, no.11, pp.161-170, 2016.
41. G. Soujanya, A. C. Reddy, Analysis of Single Point Incremental Forming Process to Fabricate Phosphorous Bronze Hemispherical Cups, International Journal of Innovative Science, Engineering & Technology, vol.3, no.11, pp.139-144, 2016.
42. A. C. Reddy, Numerical and Experimental Investigation of Single Point Incremental Forming Process for Phosphorus Bronze Hemispherical Cups, International Journal of Scientific & Engineering Research, vol.8, no.1, pp.957-963, 2017.
43. A. C. Reddy, Evaluation of Single Point Incremental Forming Process for Parabolic AA6082 Cups, International Journal of Scientific & Engineering Research, vol.8, no.1, 964-970, 2017.
44. A. C. Reddy, Experimental and Numerical Studies on Formability of Stainless Steel 304 in Incremental Sheet Metal Forming of Elliptical Cups, International Journal of Scientific & Engineering Research, vol.8, no.1, pp.971-976, 2017.
45. A. C. Reddy, Pilot Studies on Single Point Incremental Forming Process for Hyperbolic Brass Cups, International Journal of Scientific & Engineering Research, vol.8, no.1, pp.977-982, 2017.
46. A. C. Reddy, Effect of Recrystallization Temperature on Formability of Hot Deep Drawn Cylindrical Cups from 6082 Al Alloy, Indian Journal of Engineering, vol.14, no.36, pp.157-166, 2017.
47. A. C. Reddy, Formability Analysis of 6063 Al Alloy for Deep Drawn Cylindrical Cups with Constant and Progressive Blank Holding Force, SSRG International Journal of Mechanical Engineering, vol.4, no.5, pp.26-32, 2017.
48. Shashank Chagalamarri, G. Devendar, A. C. Reddy, Assessment of Strain and Stress – Based Formability Diagrams of Inconel 600 Hemispherical Cups Drawn by Single Point Incremental Forming Process using ABAQUS, International Journal of Advanced Technology in Engineering and Science, vol.5, no.5, pp.710-719, 2017.
49. B. Sumanth Kumar, G. Devendar, A. C. Reddy, Formability Analysis of Parabolic Cups Drawn from Ni201 using Single Point Incremental Forming Process, International Journal of Engineering Sciences & Research Technology, vol.6, no.5, pp.619-628, 2017.
50. A. C. Reddy, Formability of 5083 Al Alloy Hemi-Spherical Shells Using Hot Deep Drawing Process, International Journal of Mechanics and Solids, vol.9, no.3, pp.257-266, 2017.
51. A. C. Reddy, Evaluation of Formability Limit Diagrams of Arsenic Brass (70/30) Using Finite Element Analysis, International Journal of Mechanical Engineering and Information Technology, vol.5, no.6, pp.1651-1656, 2017.
52. A. C. Reddy, Impact of High Temperature and Beta-Phase on Formability of Cylindrical Cups from Cu-28%Zn and Cu-37%Zn Alloys, International Journal of Material Sciences and Technology, vol.7, no.1, pp.17-26, 2017.

53. M. Jaswanth Krishna, A. C. Reddy, Evaluation of Process Parameters of Conical Cups in Incremental Deep Drawing Process, International Journal of Science and Research, vol.7, no.6, pp.-1350, 2018.
54. P. Kamesh, A. C. Reddy, Micromechanical Plastic Behavior of AA5454 Alloy used for Fabrication of Pyramidal Cups, International Journal of Science and Research, vol.7, no.6, pp.1225-1230, 2018.
55. TeniyaChoppala, A. C. Reddy, Elastoplastic Behavior of AA2124 Alloy used to make Hemispherical Cups, International Journal of Science and Research, vol.7, no.6, pp.1295-1300, 2018.
56. T. Madhavi, A. C. Reddy, Manufacturing simulation and optimization of turbine blade die used in forging process, National Conference on Advances in Mechanical Engineering, Hyderabad, 13-14th May 2005, pp.127-131.
57. J. J. V. Jeyasingh, K. Dhananjayan, G. Kothandaraman, P. P. Sinha, B. Nageswara Rao, A. C. Reddy, Studies on the gas pressure formed Pb-Sn Eutectic alloy spherical domes, National Aerospace Manufacturing Seminar, Thiruvanthapuram, 22-23rd September 2005, pp.294-302.
58. J. J. V. Jeyasingh, K. Dhananjayan, G. Kothandaraman, P. P. Sinha, B. Nageswara Rao, A. C. Reddy, Spherical dome formation by transformation superplasticity of Titanium matrix composites, National Aerospace Manufacturing Seminar, Thiruvanthapuram, 22-23rd September 2005, pp.303-308.
59. M. Vidya Sagar, A. C. Reddy, Finite volume analysis of two-stage forging process for aluminium 7075 alloy, International Conference on Advanced Materials and Manufacturing Technologies, JNTUH Hyderabad, 18-20 December 2014, pp.228-238.
60. C.R. Alavala, Finite Element Methods: Basic Concepts and Applications, PHI Learning Pvt. Ltd., New Delhi, 2008.
61. C.R. Alavala, CAD/CAM: Concepts and Applications, PHI Learning Pvt. Ltd., New Delhi, 2008.