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Development and Demonstration of Superplastic Roll Forming Technology for Automotive Components Final Report CRADA No. TC-1087-95-A

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Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Date: January 4, 1999 Revision: 1

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Kaiser Aluminum & Chemical Corporation (Kaiser).

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Lawrence Livermore National Laboratory
7000 East Avenue, L-795
Livermore, CA 94550

Kaiser Aluminum & Chemical Corporation
6177 Sunol Boulevard
Pleasanton, CA 94566

B. Project Scope

The Russian Federal Nuclear Center - All Russian Institute of Technical Physics (RFNC-VNIITF) and the Institute for Metals Superplasticity Problems (IMSP) have developed a superplastic roll forming technology that is unique worldwide and permits complex axisymmetric components, such as car wheels and turbine disks, to be formed in one metal forming operation. Current technology for making such components outside Russia requires either casting parts (with subsequent inferior mechanical properties) or forming several components followed by machining and welding operations. The RFNC-VNIITF approach offers the opportunity to manufacture a strong component in one continuous, economical operation. The resulting product could find acceptance in a high volume, highly competitive marketplace.

The overall objective of this project is to further evaluate and demonstrate the superplastic roll forming technology which has been developed by RFNC-VNIITF to the manufacturing of axisymmetric structural components, particularly wheels, either for passenger cars or cargo trucks. This project expands upon work done on a Thrust One project in which Russian-designed automotive wheels will be manufactured from three different aluminum alloys - 6010, 7475 and 6061. The Thrust One work will establish the feasibility of using this process for the manufacturing of automotive wheels and begin to establish the aluminum alloys and material microstructures that are required for successful forming using this technology. In the Thrust Two project described in this report additional information was gained on the materials and microstructures required for superplastic roll forming. Specifically an ultrahigh strength aluminum

alloy and an aluminum casting alloy were formed into wheels. In addition, a truck wheel was manufactured and a conceptual design for a wheel manufacturing facility was developed. Work on roll forming using an ultrahigh strength aluminum alloy and a casting alloy was done by IMSP, while work on roll forming of a truck wheel and the wheel manufacturing facility was done by RFNC-VNIITF. With this information Kaiser and Rockwell can establish the economic feasibility and appropriate market segments for this technology. The feasibility of high volume production can then also be assessed and a conceptual wheel manufacturing facility evaluated.

C. Technical

The work performed under this CRADA had four specific tasks:

1) Evaluate/demonstrate wheel manufacturing using an ultrahigh strength aluminum alloy (work performed by IMSP). The alloy for this task was aluminum alloy 7055, which has a minimum yield strength of 90 ksi and was obtained from Russian sources. The as-formed wheel was heat treated after forming to an overaged condition that should provide optimum stress corrosion resistance as required for good corrosion resistance in commercial wheels. Work on this task provided valuable information on the range of alloys and microstructures that can be successfully roll formed and would establish the feasibility of making a strong, ultra-lightweight wheel with significant performance advantages over existing wheels. Three wheels and two preforms were received from IMSP that were manufactured from the 7055 alloy. A report was also received describing the processing procedures used to manufacture these wheels. Comparisons will be made of the forming characteristics of this alloy relative to the Russian aluminum alloy AVT, the American alloys 7475 (coarse grain), 7475 (fine grain) and the 6061 alloy previously used in roll forming studies.

2) Evaluate/demonstrate wheel manufacturing using an aluminum casting alloy (work performed by IMSP). Current roll forming practice at RFNC/VNIITF requires forging a blank into a preform. This preform is then superplastically roll formed into the desired axisymmetric shape. In this task the forged preform was replaced with a cast preform. A typical aluminum casting alloy (Al295) was used and forged into the required shape and then subsequently superplastic roll formed into a wheel. Work on this task provided valuable information on the range of alloys and microstructures that can be successfully roll formed. It could also have a big impact on the economics of the process. Substitution of a cast preform for a forged preform would eliminate the forging step in the roll forming process. This change could dramatically lower the cost of making wheels using this technology. Three wheels were received from IMSP that were manufactured from the Al295 alloy. A report was also received describing the processing procedures used to manufacture these wheels. Comparisons will be made of the forming characteristics of this alloy

relative to the Russian aluminum alloy AVT, the American alloys 7475 (coarse grain), 7475 (fine grain) and the 6061 alloy previously used in roll forming studies.

3) Evaluate/demonstrate truck wheel manufacturing (work performed by RFNC-VNIITF). Work on previous tasks has focused on automotive wheels. Work on this task involved using the superplastic roll forming technology to manufacture a truck wheel of Russian design. The 6061 alloy was used. The work established the feasibly of forming larger sized components, specifically truck wheels, for which there is a large market. Three truck wheels and two preforms were received from RFNC-VNIITF that were manufactured using the superplastic roll forming process. A report was also prepared describing the processing procedures used to manufacture these wheels.

4) Conceptual design of a wheel production line (work performed by RFNC-VNIITF). In this task, the equipment and procedures that would be used for high volume, commercial production of car wheels was studied. The results of this study were documented in a report. This work will help establish the material and processing costs for making wheels using the superplastic roll forming technology. With this information the economic feasibility and appropriate market segments for technology can be established. The report could also form part of a business plan that would be used to establish a Russian-based industry for manufacturing wheels using the superplastic roll forming process. The objective of this production line is to produce automobile wheels at the highest production rate possible. The production line should be capable of high volume production - producing over 1 million wheels year. In this conceptual study consideration was given to thermo-mechanical processing of the as-received material, preform manufacturing, preform heating and movement before isothermal roll forming, isothermal roll forming, part removal and final machining and finishing operations required to manufacture a finished wheel. The study specified in detail the equipment used and the specific operations performed in each step in the process

D. Partner Contribution

Kaiser Aluminum evaluated the wheels and prepared three reports on their findings. The three reports were as follows.

a. Metallographic analysis of the wheel. The results included the microstructures produced during forming, surface finish of the wheel and the hardness profiles of the wheel.

b. Evaluation of the superplastic forming characteristics of the wheel. The results included elevated temperature deformation and fracture behavior of the alloys.

c. Non-destructive evaluation of the wheel. The results included dimensional characterization of the wheel, lateral runout, radial runout, residual hoop stress, weight and material utilization factor.

Lawrence Livermore National Laboratory also evaluated the mechanical properties of the as-formed wheels and the processing characteristics of the starting material, forged preform and final wheel. The results were documented in reference (a) below.

E. Documents/Reference List

1. Documents:

a. C.K. Syn, D.R. Lesuer, T.G. Nieh, H.S. Yang, K.R. Brown, R.O. Kaibyshev and E.N. Petrov, "Roll Forming Technology for Manufacturing Axisymmetric Automotive Components", Aluminum Alloys II, (TMS, Warrendale, 173, 1998), edited by S.K. Das.

b. Report by IMSP on Task 1, Material Support Agreement B330335. Report describes the results of superplastic roll forming the 7055 alloy, 1998.

c. Report by IMSP on Task 2, Material Support Agreement B330335. Report describes the results of superplastic roll forming the 295 casting alloy, 1998.

d. Report by RFNC-VNIITF on Task 2, Material Support Agreement B324082. "Manufacturing 7JX15 Wheels from 6061 Alloy by Roll Forming", 1998.

e. Report by RFNC-VNIITF on Task 3, Material Support Agreement B324082. "Automatic Line of Manufacturing of Automobile Truck Wheels (11.75 X 22.5") from Aluminum Alloy 6061 with Productivity 1,000,000 Wheels per Year", 1998.

2. Subject Inventions:

Regents' Subject Inventions: none

Kaiser's Subject Inventions:

F. Acknowledgment

Participant's signature of the final report indicates the following:

1) The Participant has reviewed the final report and concurs with the statements made therein.
2) The Participant agrees that any modifications or changes from the initial proposal were discussed and agreed to during the term of the project.
3) The Participant certifies that:
   a) all reports either completed or in process are listed;
   b) all subject inventions attributable to the project have been disclosed or are included on a list attached to this report; and
   c) appropriate measures have been taken to protect intellectual property attributable to this project.
4) The Participant certifies that if tangible personal property was exchanged during the agreement, all has either been returned to the initial custodian or transferred permanently.

5) The Participant certifies that proprietary information has been returned or destroyed by LLNL.

H. S. Yang 2/16/99
Dr. Henry S. Yang Date
Kaiser Aluminum & Chemical Corporation

Donald Lesuer 2/24/99
Dr. Donald R. Lesuer Date
Lawrence Livermore National Laboratory

Attachment I - Subject Inventions

Industrial Partnerships and Commercialization
Mail Station L-795
Ext. 2-6416
Fax 3-8988

Final Report
Attachment I

February 23, 1999

MEMORANDUM

To: Donald R. Lesuer, L-342

From: Veronica Lanier, L-795 VBL

Subject: Kaiser CRADA Nos. TC-1087-95A

Enclosed for your signature please find the Final Report executed by Kaiser. However, Kaiser did not complete section E.2, "Kaiser's Subject Inventions." If you are aware of any Kaiser Subject Inventions for this project, please let me know.

Please sign the Final Report where indicated and return the original to me.

Thank you for your assistance in this regard.

VCA/CRADA/FINAL/TC-1087-95 022399 Memo

Veronica

Kaiser had no "subject inventions"

Don Lesuer

University of California
LAWRENCE LIVERMORE
NATIONAL LABORATORY