LA-CRADA- 98-2

Title: ULTRA-NARROW GAP LASER WELDING OF BeAl ALLOYS

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FINAL REPORT
REF: 95-LANL-303-DPI

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Based on LANL Form 1756

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Ultra-Narrow Gap Laser Welding of BeAl Alloys

Final Report

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A. Parties

The project is a relationship between Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, New Mexico 87545 and

OptiCAD Corporation
P.O. Box 10123
Santa Fe, New Mexico 87504-6123

B. Project Scope

The original scope of the project was to develop a method to enhance the laser welding of BeAl alloys by the use of weld joint designs based on the principals of non-imaging optics. The projected three year program focused on the development of geometric optical models which predict the trapping of laser energy within the weld joint and experimental validation of these models. The first year was fully funded, meeting all expectations and deliverables for the demonstration of the method for aluminum only. The second year funding levels did not allow any work to be done at Los Alamos. OptiCAD continued with model development with a change in scope to model the laser welding requirements of ongoing weapons related programs which could provide data for model validation. The project ended at the end of FY97 without funding a third year and never reaching the goal of welding beryllium, as a result.

C. Technical

Despite the poor funding situation, original quality process research was accomplished and reported as described in the three technical reports of Appendix A. Solid technical contribution, directly applicable to weapons programs is evidenced by the inclusion of an optically designed laser weld joint being specified on a LANL drawing of an aluminum subassembly.

D. Partner Contributions

The industrial partner completed constructing laser ray tracing models for more than a dozen cases involving straight, curved, tubular section and braze joints. A change was made to the OptiCAD software package to accommodate our request to include the effects of angle dependent laser energy absorption and is now included within their standard software package. This library of laser welding modules contributed to the sale of the product to Oak Ridge National Laboratory and collaborations with our UK counterparts at Aldermaston. Puget Sound Naval Shipyard is currently interested in this software package. Had the project continued to its proper completion, with the laboratory supplying its share of the cost shared R&D for three years, a complete commercially viable software tool would have resulted. No subject inventions were created during the time of this contract.

E. Documents/Reference List

No CRADA protected documents were generated. A library of laser simulation modules was constructed and is given in Appendix B.

F. Acknowledgment

Industrial Partner's signature on 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 modification or changes from the initial proposal were discussed and agreed to during the terms of the project;
- 3) The participant certifies that all reports either completed or in progress are listed and all subject inventions and associated intellectual property protection measures attributable to the project have been disclosed or are included on the list attached to this report;
- 4) The Participant certifies that proprietary information has been returned or destroyed by Los Alamos National Laboratory.

Edward Sklar 10.10.97 John O. Milewski 9-30-97
[Edward Sklar] [Date] [John Milewski] [Date]

FINAL ABSTRACT

Ultra-Narrow Gap Laser Welding of BeAl Alloys

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Three dimensional optical ray tracing models were constructed for various laser welding and brazing joint designs. These models allow various scenarios of laser optics, joint design, and optical material properties to be included in a model which predicts the location of energy absorption within the weld joint. Experimental validation was performed using aluminum and stainless steel to verify the location of melting and qualitatively compare the enthalpy of melting with the energy concentration predicted by the model. Up to a five fold increase in melting was observed in actual weld cross sections.

PROJECT ACCOMPLISHMENTS SUMMARY

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BACKGROUND

Laser welding of aluminum and beryllium is difficult due to the high reflectivity of these materials to laser energy and the significant energy loss incurred when using conventional weld joint designs. To understand the application of the principals of non-imaging optics to the concentration of laser energy into specially designed weld joints requires optical ray tracing models which extend the design of the laser system to include the weld joint. Significant benefits in welding highly reflective materials and optimizing production welding processes can be realized by the use of these simplified models, which run on desk top PCs. LANL expertise in laser welding and experimentation complemented OptiCAD's expertise in optical system design software to produce simple well understood process models directly applicable to a wide range of materials processing applications using lasers.

DESCRIPTION

The purpose of the project was to develop and validate models used to enhance the laser welding of highly reflective materials. OptiCAD constructed the models, LANL ran the models in case studies and validated the results through experimentation. The results of this effort demonstrated a five fold increase in laser melting of aluminum using these specially designed weld joints, allowing the joining of aluminum using a laser previously unable to do so. Four technical papers were published in refereed physics journals, presented to international conferences, and submitted to the conferences proceedings. OptiCAD was able to enhance its software product and sell a copy of its software to Oak Ridge National Laboratory. The early demise of the project funding made the program fall short of its full potential both to OptiCAD, Los Alamos and potential benefit to industry.

BENEFITS TO DOE

Direct and immediate benefits to core weapons programs such as the Pit Rebuild program allowed the application of laser welding to the construction of aluminum components and resulted in an improved method to laser braze plutonium. The application of laser joining to the core weapons programs has significant benefit in improved safety, reduced waste and operator exposure, reduced facility requirements as well as a host of other technical benefits.

ECONOMIC IMPACT

Many interactions with the partnership for new generation vehicles helped expose this technology to the automotive industry. Aluminum vehicle construction could benefit greatly from this technology, as evidenced by US Auto company interest at the conferences where this was presented. USCAR representatives visited Los Alamos on a number of occasions to review this technology. Direct benefit to the metals products industry would occur in the high speed welding of pipe and tube. This application would benefit from laser assisted arc welding using these specially designed weld joints.

Local economic impact to northern New Mexico entailed the support of a small high tech business in Santa Fe.

PROJECT STATUS

The project was terminated before completion due to the close out of the Cost Shared R&D subcontracts which could support small businesses not able to support the full cost share of a common CRADA.

LANL POINT OF CONTACT

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Material Science and Technology: Metallurgy, Welding Section
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Los Alamos, NM 87545

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milewski@lanl.gov

COMPANY INFORMATION

OptiCAD Corporation
Edward Sklar: President
number of employees: 3
505-988-7883
FAX 505-265-7054
Edward Sklar is willing to discuss the project.

PROJECT EXAMPLES

N/A

APPENDIX B

LISTING OF MODEL CASES CONSTRUCTED

Braze

Concentric_Tubes

Equal_Sides_AngDep_Reflection

Equal_Sides_Simple_Reflection

Parallel_Sides_AngDep_Reflection

Parallel_Sides_Simple_Reflection

Rolls_Case_2

Rolls_Case-1

Shim_In_Seam

Tube

Unequal_Sides_AngDep_Reflection

Unequal_Sides_Simple_Reflection

Wire_In_Seam_Case_1

Wire_In_Seam_Case_2

CLOSEOUT CHECKLIST

95-LANL-303-DPI

OptiCad

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Please Circle the response to each item and return the checklist to the Civilian and Industrial Technology Program Office.

- YES ☒ NO Did you loan any equipment to Los Alamos National Laboratory?
- YES ☒ NO If you loaned equipment to Los Alamos, has it been returned to you?
- YES ☒ NO Did Los Alamos National Laboratory loan any equipment to you?
- YES ☒ NO If Los Alamos loaned equipment to you, has it been returned to Los Alamos?
- ☒ YES ☒ NO Have you received a copy of the Final Report and Final Abstract for review?
- ☒ YES ☒ NO If you have received these items, have you reviewed them and returned them to Los Alamos?
- YES ☒ NO Did any Subject Inventions arise in the course of the work performed under this CRADA?
- ☒ YES ☒ NO Have all known Subject Inventions and patents, including partners and joint, been disclosed to Los Alamos? If Yes, please list the Subject Inventions.

Please list any patents applied for or received as a result of this CRADA.

NA

- YES ☒ NO Was any material subject to copyright (e.g., software) developed under this CRADA? If Yes, please list.
- YES ☒ NO Is your company interested in an exclusive license for intellectual property generated under this CRADA?
- YES ☒ NO Please list any CRADA deliverables that are not complete. Indicate the anticipated completion date or recovery plan. *NA*

Edward Sklar ☒ *Ehr Sklar*
(Industrial Contact Name Printed and Signed)

President, OptiCAD Corporation
Title Date