Y/AMT-485

Y-12

OAK RIDGE
Y-12
PLANT

LOCKHEED MARTIN

Project Accomplishment Summary
for
Project Number 92-Y12P-013-B2

HYDROFORMING DESIGN AND PROCESS ADVISOR

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October 10, 1996

Prepared by the
Oak Ridge Y-12 Plant
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

UCN-13672 (26 6-95)

DISCLAIMER

PROJECT ACCOMPLISHMENT SUMMARY

Title: Hydroforming Design and Process Advisor
DOE TTI Number: 92-Y12P-013-B2
CRADA Number: Y1292-0102
Partner: General Motors

BACKGROUND

The Y-12 Plant, located at Oak Ridge, Tennessee, has had many years experience in both tubular and sheet metal hydroforming. Because hydroforming is very difficult to model/simulate from strictly first principles, expert knowledge in design and process operations is an essential component in attaining the high precision and quality required for the production of nuclear weapons components. General Motors was interested in working together to develop a method for evaluating hydroforming part designs and determining "manufacturability" early in the design cycle. Any design flaws and manufacturing problems that could be determined early in the design stage saves time and money by avoiding reworks and modifications after the tooling has been produced.

Y-12 has developed tools and methods for capturing expert knowledge and putting this knowledge in a form that can be executed and accessed by others when key experts retire. The Y-12 Development Division has been involved in the development of "Design and Process Advisors" since 1978. These concepts have matured over the years, but all of the applications have the following things in common: 1) Capturing "process and expert" knowledge, 2) Linkage with graphics, CAD, and Product Definitions, 3) Integrating a variety of non-graphic data, and 4) Seamless integration (and encapsulation) of models, information, and data, into a "easy-to-use" Man-Machine Interface (MMI). The Y-12 Hydroforming Tool-die and Design Advisor (HTDA) project was completed and delivered to the Y-12 Plant. The HTDA effort was successful in combining expert knowledge, product definition (CAD models), and data in to easy to use software tool. The partnership between Y-12 and GM capitalized on the previous successes and experience of both organizations.

DESCRIPTION

The hydroforming process involves hydraulically forming components by conforming them to the inner contours of a die. These contours can be complex and can often cause the material being formed to be stressed to rupture. Considerable process knowledge and materials modeling expertise is required to design hydroform dies and hydroformed parts that are readily formed without being overly stressed.

For this CRADA, materials properties for steel tubes subjected to hydraulic stresses were collected; algorithms were developed which combined the materials properties data with process knowledge; and a user friendly graphical interface was utilized to make the system usable by a

design engineer. A prototype hydroforming advisor was completed and delivered to GM.

The technical objectives of the CRADA were met allowing for the development of an intelligent design systems, prediction of forming properties related to hydroforming, simulation and modeling of process execution, and design optimization. The design advisor allows a rapid and seamless approach to integration an otherwise enormous and onerous task of analysis and evaluation.

BENEFITS TO DOE

As a result of the work, many improvements have been made in the methods related to the development of design and process advisors. The Information Advisory System Testbed, a direct result of the GM CRADA project, has been used to start several new projects which has resulted in at least a 5:1 improvement in the cost and time required to produce the first working prototype. Similar knowledge-base design tool projects that traditionally have taken up to three years to complete have been reduced to just a few months because of the integration of software design tools in the IAS Testbed. The algorithms developed to predict loading and failure stresses in tubular hydroformed parts were combined with hydroforming process knowledge and a user friendly graphical interface to facilitate the design of complex hydroformed tubular components.

By completing the Y-12 Hydroforming Tool-die Design Advisor (an internal Y-12 plant project) and the GM CRADA project, there have been several benefits to the Y-12 design and productions activities. New hydroforming design parts can now be evaluated for "manufacturability" and a process script is generated that can be more effectively used by the new computer controlled hydroforming machines. Techniques have been developed that can work in conjunction with first-principle models to generate forming limits without the need to do extensive material testing. Compliance to best-manufacturing and quality standards are now easier to implement and insures that optimal design and process decisions are being make reducing cost, time, and waste.

ECONOMIC IMPACT

The tubular hydroforming technology can, and has had, a significant benefit to the General Motors by reducing the number of stamping operations required to produce the equivalent part using tubular hydroforming. Hydroforming can make complex tubular parts using just one set of dies. Traditional stamping usually requires several stamping operations, metal cutting, assembly, and welding; in contrast, the hydroforming process can produce the net shape part without any additional manufacturing steps. This reduction in the number of process steps is expected to cause an increase in overall product consistency and quality.

The complexity of the tubular hydroforming analysis is usually too cumbersome to be done routinely using the traditional Finite Element Method (FEM), or math-based modeling; however, the Tubular Hydroforming Advisor allows the part designer to simulate the entire process; namely, tube bending, die loading, and hydroforming while taking advantage of captured knowledge and numerical analysis. The complete simulation/analysis can be done in a fraction of the time usually required by using traditional FEM methods.

PROJECT STATUS
The technical work has been completed.

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Annual Sales: Approx. $150B

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Both of the above individuals would be willing to give feedback related to the project work and outcome.

PROJECT EXAMPLES

Since this is a software tool and example hydroforming parts are usually too large to be used for "show-and-tell" there are not tangible items; however, there are screen dumps (i.e., photographs of the computer screen) that can be shown to illustrated how the advisor works and there are photographs of actual production parts.

TECHNOLOGY COMMERCIALIZATION

General Motors has indicated that they are interested in customizing and commercializing a tubular advisor to be used within the mainstream design cycle. We have been working with General Motors to explore this possibility and to have the CRADA partners support this endeavor through a funds-in CRADA agreement.

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