Electrohydraulic Forming of Near Net Shape Automotive Panels

The Development of Advancing Automotive Panel Manufacturing for Increased Energy and Material Savings

The U.S. automotive industry manufactures approximately 17 million vehicles annually that each contain 900 pounds of stamped steel sheet metal parts. The current technology predominately used in automotive panel manufacturing is conventional stamping, which includes drawing, piercing, trimming, and flanging operations. These approaches use two-sided tooling and rely on metal-to-metal contact between the tools/dies and the workpiece to achieve metal forming. This approach is becoming substantially more difficult to apply, given the increasing strength and hardness of the metals that are being formed.

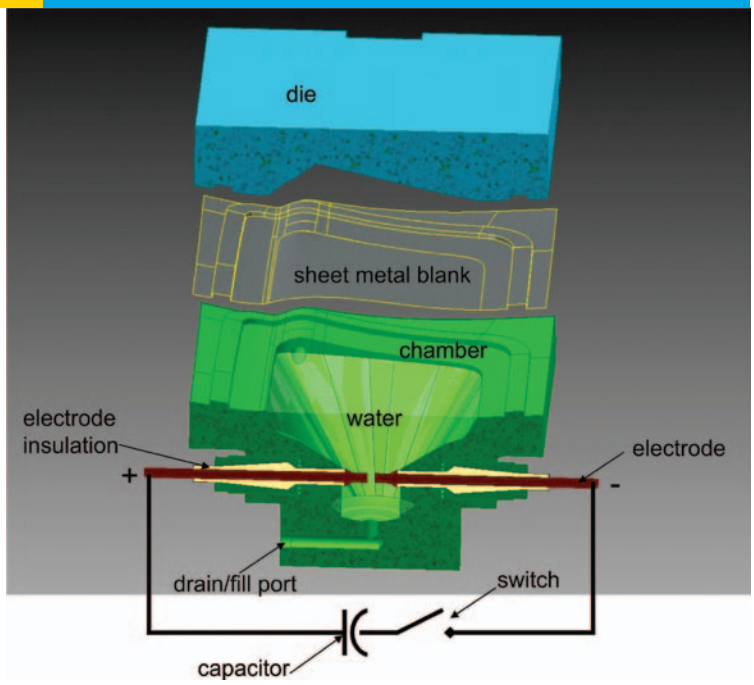
As a result of these operational shortcomings, these processes are extremely energy-intensive and often involve multiple steps and equipment. Also, conventional forming processes use significant amounts of material because they cannot produce the very thin automotive panels required to significantly decrease the thickness of materials that comprise automotive structures.

Electrohydraulic forming (EHF) is a high-rate forming process based upon the high-voltage discharge of capacitors between two electrodes positioned in a fluid-filled chamber. This promising process is extremely fast; uses lower-cost, single-sided tooling; and potentially derives significantly increased formability from many sheet metal materials because it involves elevated strain rates.

This project will advance the EHF process and reduce the energy use and carbon emissions from panel manufacturing, increasing the competitiveness of the U.S. automotive industry.

Benefits for Our Industry and Our Nation

The application of EHF by automotive manufacturers and their suppliers will significantly reduce the amount of tooling, manufacturing equipment, and required material input, compared with conventional stamping technology. Successful use of EHF would also provide substantial improvement in formability for both advanced high strength steels (AHSS) and aluminum alloys, improvement in trimmed surface quality, elimination of springback of the stamped part, and a substantial reduction of cost of the tooling fabrication and alignment.



Schematic of the electrohydraulic forming process. The electrohydraulic effect is created via a shock wave generated by the discharge of high-voltage capacitors through a pair of electrodes in a liquid-filled chamber.

Image courtesy of Ford Motor Company.

Applications in Our Nation's Industry

Electrohydraulic forming is a highly viable manufacturing technology because it can be used to form all types of sheet materials. This multimaterial capability will allow vehicle manufacturers and their suppliers to make the necessary investments to bring EHF into commercial applications because they will not have to limit their capabilities to a single family of materials, such as steel or aluminum.

Project Description

The goal of this project is to develop the EHF process as a near net shape automotive panel manufacturing technology that simultaneously reduces the energy embedded in vehicles and the energy consumed while producing automotive structures.

The technical objectives of this project include developing the following:

- A predictive numerical design tool for EHF processes,
- An electrode discharge chamber equipment design suitable for automotive panel manufacturing,
- A laboratory prototyping system that will be utilized for process development, and
- One full-scale automotive prototype using the developed EHF process.

Barriers

- The stamping of aluminum alloys and advanced high-strength steels using conventional methods increases springback—defined as the elastic relaxation of a stamped blank that occurs after release from the stamping die. Solving this problem often requires expensive iterative solutions.
- Electrohydraulic forming has had very limited industrial use—mostly in experimental facilities or in very low volume production. The main reasons for this have been the lack of advanced equipment capable of delivering the high-voltage discharge in a timely manner, the erosion of electrodes, die material requirements, need for process models, dealing with water as a transmitting medium (and attendant scaling issues), and the lack of economic drivers when energy prices are low.

Pathways

The principal elements of EHF have been demonstrated at the laboratory scale, and equipment capable of commercial-scale operations appears technically feasible. However, several tasks need to be completed to move EHF into commercialization. These tasks include the development of robust and durable electrodes and automated process and equipment controls, which must meet automotive durability and maintenance requirements; demonstration of key elements of process equipment automation; and demonstration of process-cycle operating times compatible with medium- to high-volume stamping and forming.

Milestones

This project started in August 2008.

- Predictive modeling of electrohydraulic forming process
- Electrode system and discharge chamber design and development (Near completion)
- Demonstration of EHF process and equipment on a production-scale part

Commercialization

Ford Motor Company, through the Ford Research & Advanced Engineering organization, will lead the commercialization efforts for the technology. In terms of EHF intellectual property, Ford believes the technology must be licensed outside the company to obtain the desired cost and energy benefits. This will result in an aggressive approach to engage the automotive supply base, which will lead to broader application of EHF over a shorter period of time. Ford Motor Company also plans to bring the technology in-house for pre-launch if successful.

Project Partners

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