The Development of Intelligent Servo-Controlled Forming Technology

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Introduction

To optimize product performance, increase reliability, and reduce cost, designers are using new materials with unique properties. While these high-performance alloys are lighter, stronger, and easier to recycle, many are difficult to form. In addition, U.S. manufacturers who rely on forming processes need new testing standards, improved prediction capabilities, increased first-time quality, greater process agility, more adaptable automation, new net-shape processing methods, and more sustainable operations to stay globally competitive.

EWI's Focus on Forming Technologies

The EWI Forming Center was established in collaboration with The Ohio State University (OSU) to serve as a nexus of applied research and thought leadership on materials forming technology. By focusing on sheet-metal forming and forging processes, this unique center has supported manufacturers in the automotive, aerospace, heavy manufacturing, and consumer products industries, conducted multiple joint-industry projects, and executed more than 30 confidential client-funded projects. Since the Center's launch in 2012, EWI and OSU have jointly hosted six annual workshops to address major technical issues and introduce practical solutions for the Center's industry partners.

In September 2016, the Center received a capital funding grant of $1.5M from the State of Ohio to invest in state-of-the-art equipment related to materials forming. In addition to increasing EWI's ability to provide clients with complete manufacturing solutions, this added equipment capability will be used to train Ohio State University students and industry professionals to help develop and maintain a strong workforce for U.S. manufacturing.

To ensure alignment with the needs of the Center's industry partners, the Forming Center Consortium (FCC) will be launched in the spring of 2017. The FCC will address new technical challenges in materials forming and develop innovative practical solutions. By joining the FCC, industry partners will have the unique opportunity to take part in pre-competitive development of new forming technologies. Research topics currently being discussed include real-time monitoring of material properties, evaluation of lubricants to improve stamping quality and subsequent joining processes, warm forming and joining of magnesium alloys, and hot forming of titanium, nickel, and aluminum alloys.

Intelligent Servo-controlled Forming Technology

An upcoming FCC project will focus on developing an intelligent servo-controlled forming process and integrating it into an industry-scale manufacturing system within five years. A conceptual design of this process was publically introduced at the 2016 International Automotive Body Congress (Figure 1)[1].

This new servo-controlled forming process will integrate nondestructive evaluation (NDE) sensor measurements of incoming material properties, real-time data acquisition, visual monitoring of product quality and geometry during production, and computer-aided engineering (CAE) predictions of the final product's mechanical properties. Based on these real-time data, a control algorithm will be created to optimize the servo-drive press ram speed and motion, as well as the cushion force. Control algorithm outputs

[1]Kim, H., "Intelligent Servo-Controlled Forming Process for Lightweight Structures", 2016 International Automotive Body Congress (IABC), September 28-29, 2016.

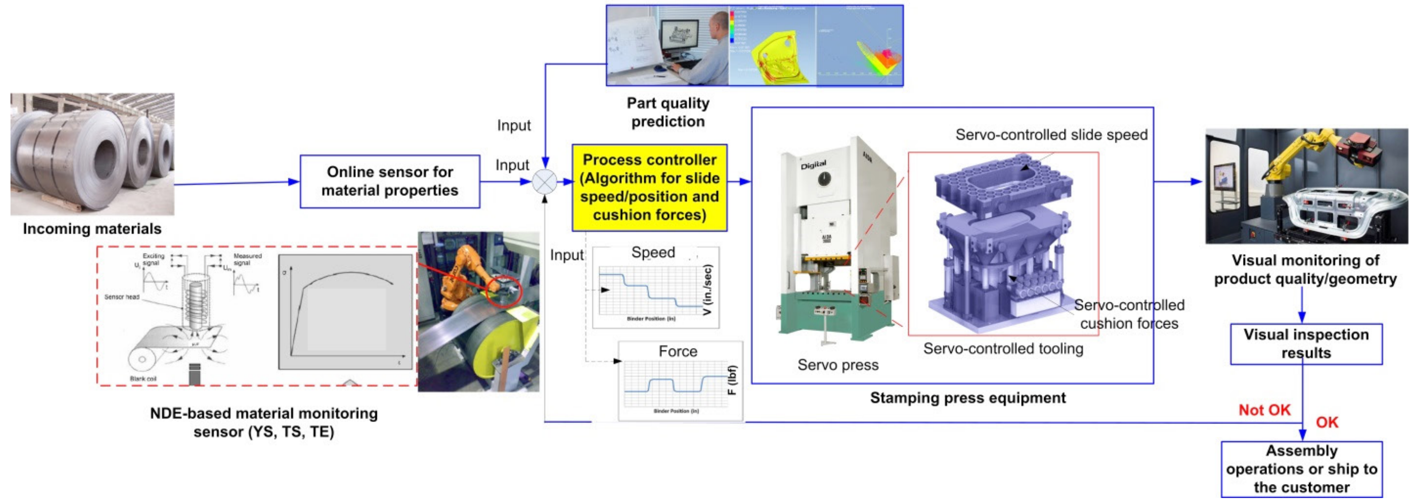

Figure 1: Conceptual design of the intelligent servo-controlled forming process (Source: EWI Forming Center)

will then be directly linked to the press control panel through interface software.

While academia and industry have conducted numerous studies on how to best use servo-drive presses with new, difficult-to-form lightweight materials, most are based on trial and error by changing process parameters such as slide speed, motion, and contact pressure. This approach neglects the fact that modifying these parameters can also affect other variables such as material plasticity, die friction, and tooling characteristics. In contrast, the proposed project will first establish the relationship models between process parameters, the affected variables, and resulting part quality. These models will be integrated into the control algorithm, which will then be integrated into the servo-drive press, the coil feeder, the NDE system, and the 3D part-scanning tool. A similar algorithm can be used off-line with conventional mechanical and hydraulic presses. The primary goal of this complete approach is to provide critical process information to optimize force and speed control of the stamping press and cushion system.

EWI has applied for federal and state government cost-match funding to leverage industry-partner contributions to this program, with final award announcements expected by the middle of 2017.

Conclusion

Variations in the material properties and quality of emerging high-strength steel, titanium, and aluminum alloys result in additional forming challenges that significantly increase the cost of product design and production. To enable the use of these materials in lightweight structures, the U.S. forming industry needs a process capable of adapting to such variations by controlling forming process conditions via real-time monitoring of incoming material properties, assessment of product quality and geometry during production, and predictions of final part quality.

The proposed technology is expected to yield the following benefits:

- Real-time monitoring of variations in incoming material properties and stamping quality

- Real-time parameter adjustments to adapt to variations in incoming material
- Faster processing time for complex parts and hard-to-form materials
- Improved understanding of the formability of new materials
- Precise control of press slide speed/position and cushion force
- Energy savings and scrap rate reduction
- Customized workforce training on company-specific equipment using acquired control algorithms

To learn more, contact the EWI Forming Center Technical Director Hyunok Kim (hkim@ewi.org or 614.688.5239) or visit ewi.org/ewi-forming-center.

Hyunok Kim *brings a diverse background of academic, industry, engineering, research, and teaching experience to his role as Technical Director of the EWI Forming Center. He possesses a comprehensive knowledge of forming technology. His areas of expertise include cold/warm/hot sheet and bulk forming technologies, forming equipment, tribology, simulations, and formability testing/analysis. He has led numerous government- and industry-sponsored research programs of hot and warm forming of automotive and aerospace structures, manufacturing fuel cell components, and shear fracture/edge cracking in stamping advanced high strength steel(AHSS), springback control, and crash modeling of AHSS automotive structure parts.*