

Preface

Stamping is a long-established, widely used industrial process for economical high-volume production. It is used extensively in the automotive industry, as well as for production of white goods and many other products. In this book we present an approach, based on process control, to improve stamped part quality at reduced cost by eliminating tearing, wrinkling and springback. The concept is straightforward: measure punch forces and then adjust the blank holder (i.e., binder) forces (i.e., how tightly we hold the blank material in place) at various locations around its periphery and at various times during the stamping process to properly control the draw-in of blank material into the die. Of course, how to do this is the challenge! This book describes in detail how this simple goal can be achieved through real-time control technology.

A reconfigurable set of hydraulic actuators (e.g., 12–24) is placed under the die to enable the control of the blank holder forces at various locations around the die periphery. These blank holder forces at each actuator are varied during the short duration (e.g., <1 sec) of the press stroke. The careful design of a controller, termed the *machine controller*, is needed to ensure that the desired blank holder forces are achieved at each hydraulic actuator and at each instant in time during the press stroke. Furthermore, we also measure the punch force during stamping, and design another controller, termed the *process controller*, to ensure that the desired punch force values are achieved during stamping despite the presence of disturbances (e.g., lubrication or material thickness variations). Maintaining the desired punch force leads to consistent draw-in of blank material and improves stamped part quality by eliminating wrinkling, tearing and springback.

In this book we describe the methods for designing these controllers, and present experimental validation results from die try-out tests. The proposed system has also been evaluated in pilot tests in production and has also been shown to improve the formability of hard-to-form materials, such as lightweight alloys.

This book is the result of a multi-year research collaboration among the authors. We would like to thank the State of Michigan's Twenty-first Century Fund for their financial support of this research project, and also thank our industrial collaborators Troy Design And Manufacturing (TDM) Company, Ogihara America Corporation and OPAL-RT Technologies.

The real-time computer control equipment used was provided by OPAL-RT. The die try-out tests, and the experimental results presented in the book, were

based on extensive studies carried out by Dr. Yongseob Lim and Dr. Ravi Venugopal at TDM in Warren, Michigan with considerable assistance from TDM management, engineers and operators. The stamping process control system described in this book was also evaluated by Dr. Lim and Dr. Venugopal in pilot production tests at Ogiwara's plant in Howell, Michigan. The research work provided the basis for the doctoral dissertation of Dr. Yongseob Lim, under the supervision of Professor A. Galip Ulsoy, at the University of Michigan, Ann Arbor. The company Intellicass, Inc. (see <http://www.intellicass.com/>) was established by Dr. Venugopal and utilizes the research described in this book.

We hope that this book will provide a foundation for the widespread use of process control systems in stamping, and thereby provide the significant benefits to both producers and consumers that we have described in [Chap. 9](#).

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