Dissecting defects

Part I: Examining process variables to find stamped part quality flaws

Editor's Note: This article is Part I of a three-part series discussing quality defects commonly seen in stamped parts and process variables that affect formed part quality. Part II, which will appear in November, discusses new technologies used to test incoming sheet material properties and methods used to control the quality of incoming sheet material. Part III, which will appear in the December issue, explains how commercially available systems are used in stamping process control.

Types of Quality Defects

Two main types of defects typically occur in stamped automotive body components (see **Figure 1**):

1. Surface defects, such as cracks and necking
2. Form defects, such as fall-in, wrinkling, and marking lines

These quality defects can be classified further as static or dynamic.

Static defects, such as surface imprints, are not process-related but instead are caused by contaminated die or tool faces. These defects are corrected simply by cleaning the die or tool surface before stamping.

Dynamic defects are process-related and are caused by the forming process. For example, cracking and necking commonly occur when formability of the deformed sheet material is limited. Side-wall and flange wrinkles are caused by high tangential compressive stresses in the sheet. Marking lines occur when sheet material undergoes high tensile stresses as it flows over sharp tool corners. Fall-in is commonly observed where areas of high strain rate are surrounded by large areas of low strain rate.

Dynamic defects can be corrected by controlling process variables (forming forces, forming speeds, and friction forces) and incoming sheet coil properties.

Factors Affecting Formed Part Quality

In industrial mass production of autobody panels, single-acting presses with either single or multi-point control (MPC) die cushion systems are predominantly used for deep drawing (see **Figure 2**). Drawing is followed by secondary operations such as trimming, restriking, and flanging. The quality of the formed autobody panel is significantly influenced by the drawing operation.

Variables influencing formed part quality that can be adjusted in the press shop during production can be defined as control variables. The two main types of control variables are process variables and incoming sheet material.

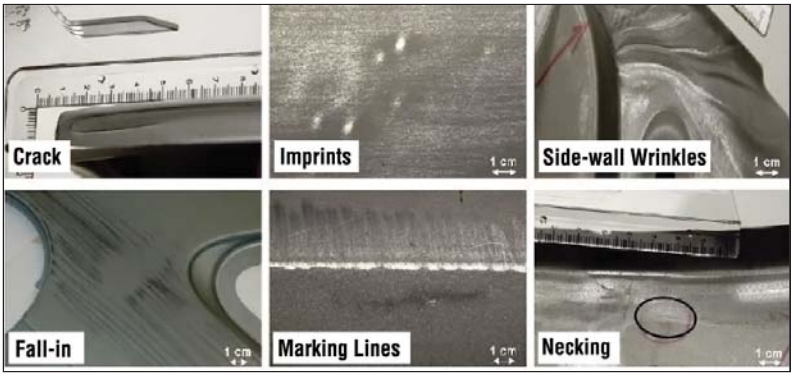

Figure 1

Many quality defects can occur in stamping.

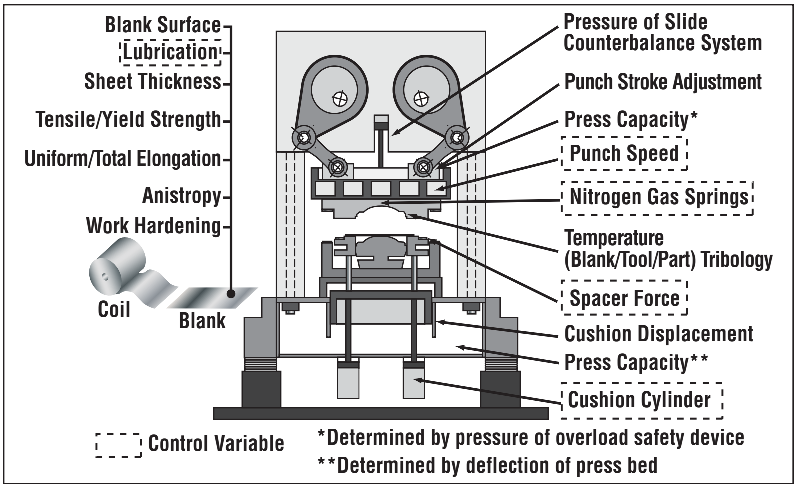

Figure 2

This schematic shows the factors that affect form quality with a single-acting mechanical press using an MPC die cushion system for BHF application. Control variables are those that influence formed part quality and can be adjusted during the production cycle.

Process Variables. Within the realm of stamping, process variables are:

1. Press variables — In a MPC blank holder system, several individually programmable cushion pins are placed around the blank perimeter, and an appropriate blank holder force (BHF) is selected at each pin location. When the BHF in select cushion pins is locally controlled, material flow in localized regions also can be controlled.

Flexible BHF control systems can accommodate variations in incoming sheet material properties and thicknesses. The punch or forming speed also is a control variable because it influences the increase in tool temperature during the forming operation.

2. Tool variables — Nitrogen gas springs are placed inside tools to allow local application of BHF in well-defined areas of the blank, thus allowing for better control of sheet material flow during the forming process. Spacers mounted on blank holders also can be used to control the sheet material flow locally. Spotting or tool grinding during production can be eliminated through the use of spacers.

3. Lubrication — Material flow during the forming and drawing operations depends on the lubricant, which affects frictional forces at the blank-tool interface. Incoming blanks may either be precoated or sprayed with lubricant during the forming process. Lubricant performance also is influenced by the tool temperature.

Modern press technology allows for automatic process control of press variables (BHF control) and lubrication. On older presses, tools can be adjusted only manually, so automatic process control of tool variables is not possible. For automated control of tool variables, automatically adjustable height spacers and nitrogen gas spring systems with automatic pressure control are needed.

Incoming Sheet Material. In studies conducted at Technical University of Munich, in cooperation with AUDI AG-Ingolstadt Germany, tensile tests were conducted for incoming sheet material. The yield strength, tensile strength, uniform elongation, and total elongation were measured.

Incoming sheet material can vary substantially. The n-value of the incoming transformation-induced plasticity (TRIP) steels used for forming B-pillars varied from 0.18 to 0.22, about ±10 percent of the nominal n-value of 0.2. Thickness of TRIP steel blanks measured over a production cycle varied in thickness from 1.935 mm to 1.980 mm.

Variations in blank thickness and material properties of incoming sheet coil can result in undesirable scrap rates in production. These variations may be within the coil or across suppliers, heats, or batches. Variations are especially high with newer and higher-strength steels, such as dual-phase and TRIP grades. Therefore, incoming coils must be tested to see if they match customer specifications. Conventionally, this is done by a tensile test, which gives the yield strength, ultimate tensile strength, and total elongation. ST

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All figures from H. Hoffman et. al, "Automatic Process Control in Press Shops," in proceedings of the 12th International Conference—Sheet Metal 2007, Key Engineering Materials, Vol. 344 (2007), pp. 881-888.