# Multipoint-control die cushion systems for stamping complex parts

## Part III: Predicting blank holder force

*Editor's Note: This article is Part III of a three-part series on multipoint-control (MPC) die cushion systems. Part I, which appeared in the September issue, discussed novel press and design concepts using MPC systems. Part II, which appeared in the October issue, covered MPC systems applied to the forming of stainless steel double sinks. Part III discusses prediction of blank holder force.*

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Modern presses that are equipped with multipoint-control (MPC) die cushion systems allow the blank holder force (BHF) to vary during the press stroke. This capability is currently underused because BHF prediction in each cushion pin is time-consuming and expensive.

With constant BHF, conventional steel sheets can be formed with few tryouts. However, with the increasing use of lightweight materials and high-strength steels with low formability, there is a need for precise, localized control of metal flow using MPC systems. For increasingly complex parts, MPC can expand the process window.

Four possible ways to apply BHF during forming with an MPC unit are:

1. BHF same in all cushion pins and constant during the press stroke
2. BHF variable in location over blank holder surface and constant during the press stroke
3. BHF same in all cushion pins but changing during the press stroke
4. BHF variable in location over blank holder surface but changing during press stroke

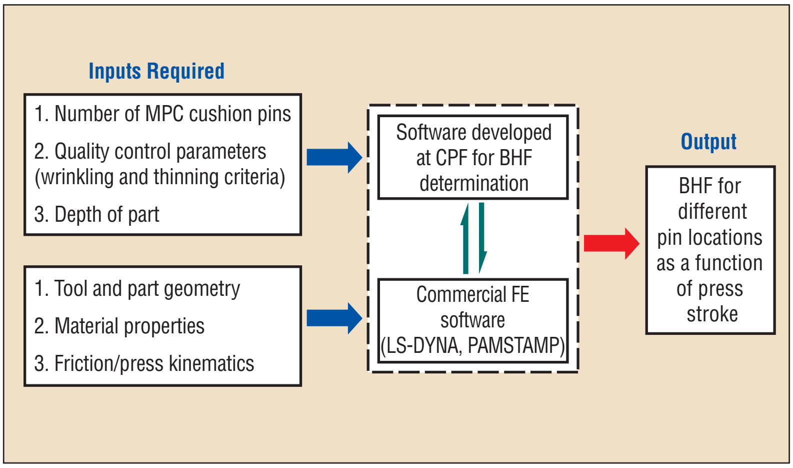


**Figure 1**

Methodology to estimate BHF in MPC die cushion systems involves numerical optimization techniques coupled with FE simulation. Tool geometry, sheet material properties, and process conditions are necessary inputs for accurate simulation.

### BHF Prediction Methodology

The CPF has developed a methodology to predict BHF in each MPC cushion pin for all four possible configurations (see **Figure 1**). The methodology combines numerical optimization techniques with finite element (FE) simulation to estimate the BHF needed to form a wrinkle-free part with minimal thinning.

This estimated optimal BHF profile determined from FE simulations serves as an excellent starting point for die tryouts, which can considerably reduce die development time.

### BHF Prediction in Sample Parts

The methodology has been used to predict BHF for MPC systems with hydraulic or nitrogen cylinder cushions, as well as for single-point cushion systems.

An automotive liftgate inner panel was successfully formed with minor wrinkles using the developed methodology. It should be noted that an aluminum-alloy liftgate inner panel initially could not be formed using a conventional single-point system despite repeated tryouts. This demonstrates how an MPC system can enhance the conventional stamping process to form autobody panels from lightweight materials.

Using this methodology, the CPF estimated BHF for different sheet materials and thicknesses (see **Figure 2**). Liftgate panels in **Figure 3a** were formed successfully from three different materials and sheet thicknesses in the same die, without any physical modifications. **Figure 3b** shows a sample BHF profile (with BHF varying in location over blank holder surface and changing with punch stroke) used to successfully form a 1-mm-thick A6111-T4 aluminum-alloy sheet.

BHF profiles were similarly estimated for bake-hardened steel (BH210, t = 0.8 mm) and high-strength steel (DP500, t = 0.8 mm). In both cases, the use of an MPC system resulted in a robust stamping process that can account for variations in incoming sheet material and thickness.[1]

MPC technology also can be used in sheet hydroforming. Estimated BHF profiles for sheet hydroformed parts using MPC systems were discussed in the April 2006 issue, p. 26.

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*Note*

*1. H. Palaniswamy, A. Thandapani, M. Braedel, and T. Altan, "Optimal Programming of Multi-point Cushion Systems for Sheet Metal Forming," 56th CIRP General Assembly, Kobe, Japan, 2006 (in press).*

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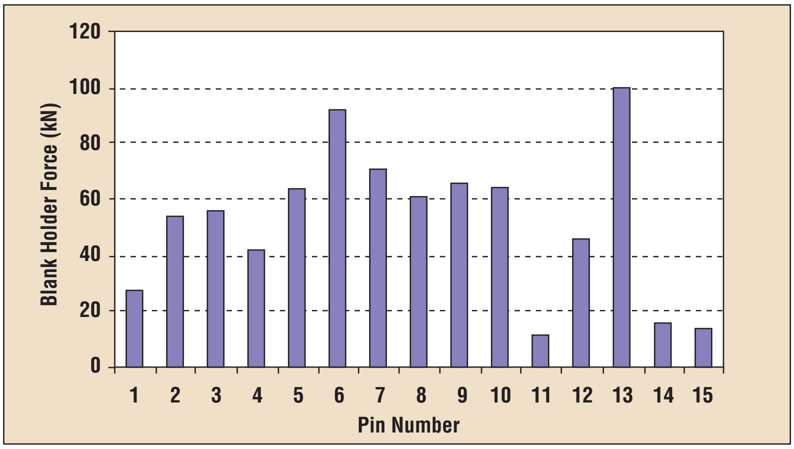
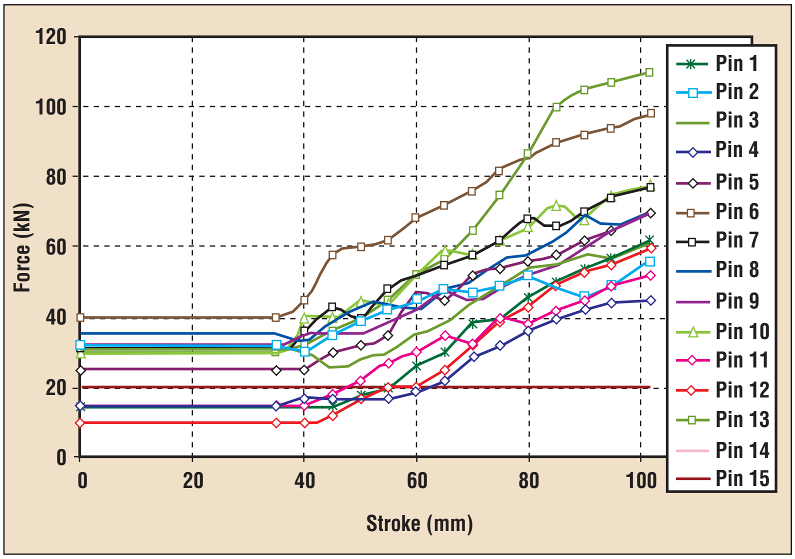



## Figure 2

Estimated BHF is constant over the punch stroke to form this 1mm-thick A6111-T4 aluminum alloy.

## Figure 3a

With MPC a liftgate panel was formed successfully from three different materials and sheet thicknesses in the same die, without any physical modifications.




## Figure 3b

This BHF profile, this time with BHF varying in location over the blank holder surface and changing the punch stroke, successfully formed the aluminum-alloy sheet.