Heuristic optimization of cooling channel design in the hot stamping die for hot stamping process

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Abstract. In hot stamping process, similar die is used as in cold stamping process but with additional cooling channels. The cooling channel systems are integrated into the die design to control the cooling rate for quenching process of hot blanks. During quenching process, the die is effectively cooled to achieve the optimum cooling rate and homogeneous temperature distribution on hot blanks. In this paper, heuristic method with finite element analysis (FEA) of static analysis and thermal analysis are applied to determine the cooling channel size, pitch size between channels and channel distance to the blanks surface. This static analysis identifies either the tool able to stand the pressure applied or not, while the thermal analysis is to ensure the die obtains the high cooling efficiency with homogenous temperature distribution. In this heuristic method, each parameter of the cooling channels inside the die are optimized and benchmarked with traditional Taguchi method. The results showed that the heuristic method coincides with Taguchi method even better and achieved the acceptance error between FEA in temperature distributions.

Introduction

The development of hot stamping to produce ultra-high strength parts especially in automotive has been developed since years. This process undergo several important process such as forming, quenching and austenization in order to achieve final product with tensile strength about 1500 MPa of yield strength. In hot stamping, there are exists in two different types of methods which are direct and indirect method [1]. For this paper, the method of indirect is chosen due to simple die design and suitable for complex die design. It starts when the blank is cut off then heated the blank inside the furnace up to 900°C. Then, the blank must be transferred quickly to the hot stamping tool to avoid the part is cooled before forming. After that, the blank is formed and cooled simultaneously by the water cooled die for 5-10s. Due to the contact between the hot blank and the cool tool, the blank is cooled in the closed tool [2].

Since the process requires the tool to cool down the blank rapidly, a cooling system must be integrated into the tool. The optimum design of cooling channel such as diameter, pitch and distance to loading surface of cooling was introduced by [3-7], in order to achieve maximum cooling rate and homogeneous temperature distribution of the hot stamped part. There have some optimization method that is used by the researcher. Hoffmann et al. [3] and Steinbeiss et al., [8] utilized Evolutionary Algorithm as optimization method. Meanwhile, Jiang et al. [5], Kumar et al. [6] and Lui et al. [7] used heuristic method in numerical simulation and theoretical analysis was employed by Zhong et al. [4]. All the method leads to the optimization of the geometric design of the cooling system. The result shown the cooling system with cooling ducts near to the tool contour is currently well known as an efficient solution [3-7]. For the diameter of cooling channel, small diameter is suggested as the amount of cooling channel can be increase and result the improvement of cooling performance [8]. For current case, based on practice by Miyazu (M) Sdn. Bhd, the