ARCHIVES OF CIVIL AND MECHANICAL ENGINEERING 19 (2019) 11–19

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.elsevier.com/locate/acme

Original Research Article

A parametric investigation of roller hemming operation on a curved edge part

Selim Gürgen

Eskişehir Vocational School, ESOGU, 26110 Eskişehir, Turkey

ARTICLE INFO

Article history:
Received 19 February 2018
Accepted 30 July 2018
Available online

Keywords:
Roller hemming
Metal joining
Curved edge part
Wrinkling
Plastic deformation

ABSTRACT

This study presents the roller hemming operation of a curved edge sheet metal which is critical in terms of dimensional accuracy and deformation. The investigation is focused on the process parameters such as bending angle, sheet thickness and roller diameter to observe their influence on roll-in, deformation, undesired wrinkling formation and hemming force which are directly related to material reliability and visual quality in the operation. A set of numerical simulations was designed and through the regression analysis of the results, the magnitude of each input parameter was investigated. The verification of the numerical model was carried out using experimental results. In the light of the results, the influence of input parameters was discussed for designing proper roller hemming operations for curved edge parts.

1. Introduction

Hemming is a kind of sheet metal joining operation that consists of bending outer metal edges onto inner metal. The operation is extensively used in automotive industry due to improved visual quality among the joining operations such as welding, riveting and adhesive bonding. Operational defects are reduced using hemming operation in comparison to the other joining methods. Furthermore, part edges gain mechanical strength along hemming line due to strain hardening in the bending area of outer metal. Doors, sunroofs, hoods, wheel arches and tailgates are the main automobile components including closures for hemming operation.

Hemming is performed after flanging stage which forms a flange along outer metal edge. After flanging, the operation is realized with successive hemming stages. Last hemming stage is called final hemming and each stage before the final hemming is called pre-hemming stage. According to the conditions in the operation, hemming may include number of pre-hemming stages. Fig. 1 depicts a schematic representation of components in hemming operation.

After hemming operation, contour of outer metal introduces a displacement which is called roll-in if the outer part edge moves inward and roll-out if the outer part edge moves outward as seen in Fig. 2. Roll-in and roll-out affect the visual quality of finished parts and therefore, they should be controlled accurately. These values are preferred to be uniform and small along the hemming line. Roll-in tends to be seen on convex contours whereas roll-out tends to be seen on concave edges [2]. Besides, the process may include undesired deformations on the components since the operation is performed by plastic working. Wrinkling and splitting are the most common problems and tend to be formed on convex and concave edges respectively as shown in Fig. 3 [3–5].

E-mail address: sgurgen@ogu.edu.tr.
https://doi.org/10.1016/j.acme.2018.07.009

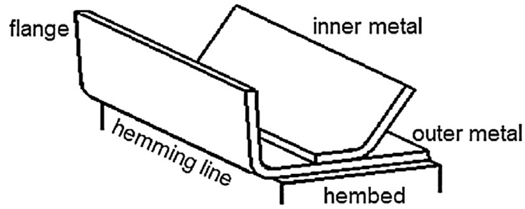

Fig. 1 – Components in hemming operation [1].

Fig. 3 – Wrinkling and splitting [3].

Hemming operation is performed on die and table-top systems which are called traditional methods. On the other hand, roller hemming is quite a recent technology using a roller which is guided by an industrial robot to complete the operation. Roller hemming is preferable due to the advantages of flexible manufacturing systems however, there is a lack of knowledge on the process due to the number of variable parameters in the operation. Previous studies generally focus on the traditional methods in hemming operation and roller hemming operation has been investigated using simple geometries such as straight edge and flat surfaces even though the components with complex geometries prevail the industrial applications.

Livatyali et al. [3–5] experimentally studied the table-top hemming operation of sheet metals and the effects of parameters on the operational defects were investigated. In their other studies [7,8], numerical simulations were employed to predict outputs related with the quality of components. Muderrisoglu et al. [9] studied the influence of flanging stage on the hemming quality. Experimental results were investigated to observe roll-in and roll-out formation in the table-top hemming operation of AA1050. Lin et al. [10] investigated the table-top hemming of AA6111 sheets with flat surface and straight edge geometry. The quality of the joints was evaluated in accordance with roll-in and roll-out values. Furthermore, a failure criterion was presented depending on the maximum surface strain. Zhang et al. [2,11] studied the traditional hemming operations in terms of joining quality. The influence of process parameters was investigated into springback phenomenon and visual defects in the operations. Le Maoût et al. [12] studied the traditional hemming operations of straight edge AA6XXX series sheets. Limits of the hemming operations were presented in consideration of the numerical analyses. The same research group studied the effect of part geometry on roll-in formation in the traditional and roller hemming operations in another study [13]. In their latest work [14], roller hemming operation was investigated taking into account the pre-strain history of components. Thuillier et al. [15] numerically investigated the table-top and roller hemming operations of Al-Mg alloy sheets with three different constitutive models. The variation of roll-in and roll-out values was compared with respect to the constitutive models. Gürgen [1] studied the effect of process parameters on the roller hemming operation of curved components and thus, the optimum conditions were suggested for the process. To improve the efficiency of production line in an automotive company, Gürgen et al. [6] investigated the roller hemming of an automobile tailgate. As a result, the proposed process parameters were adapted for the production line. Process parameters were also investigated by another research team and limit values were defined according to the numerical simulations [16,17]. Hu et al. [18] investigated the fracture behavior of straight edge aluminum alloy sheets and a fracture criterion parameter was determined with simulations and experiments.

In the present paper, roller hemming operation was performed on a curved edge FEE220BH sheet which is extensively utilized for automotive skin due to the characteristics of high formability and strength. Since the curved regions on the parts are critical in terms of dimensional accuracy and deformation in roller hemming, a curved edge part was selected to be investigated. Three process parameters such as bending angle, sheet thickness and roller diameter were chosen as variable in the operation and therefore, their influences on roll-in, deformation, undesired wrinkling formation and hemming force were investigated.

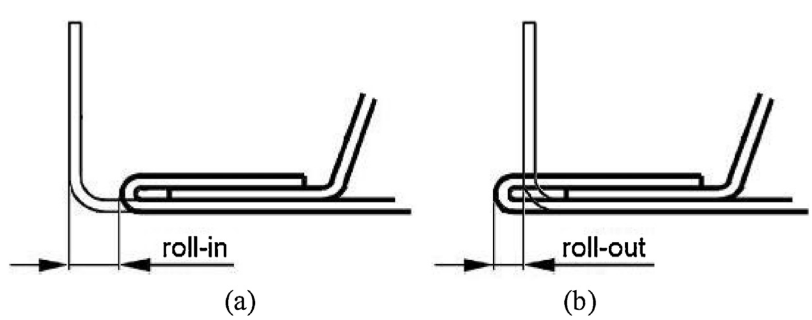

Fig. 2 – Displacement in hemming line; (a) roll-in and (b) roll-out [6].