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# THE INFLUENCE OF BLANKHOLDER GAP ON DEEP DRAWING PROCESS USING FINITE ELEMENT METHOD

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**ABSTRACT**

*The aim of use blankholder gap (BHG) is to regulate the flow of material in the cavity of the die. In this paper, the effect of blankholder gap on parameters of process such as forming load, strains and stress distributions and occurrence of wrinkling in the cup wall were analyzed numerically. Finding thebest BH gap for the die and the material which use in this study. Different values of (BHG) to arrange (0.5 -3 mm) were used and also without (BHG). 3D model of deep drawing was used and analyzed based on FEM. The best forming distance for the blankholder is between 1 to 1.5 times sheet thickness. The results showed that when the gap is larger than 0.75 mm, the wrinkles will occur and the drawing force increased.*

**Key words:** deep drawing, blank holder gap, wrinkling, FEM..

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## 1. INTRODUCTION

Deep drawing is an important process of sheet metal forming. In this process, a flat sheet is drawn by punch into the die cavity to produce a cup without localized thinning or fracture. Producing successful parts not rely on the sheet material only but on the die contact situation (workpiece-die set). The parameters of die design, which affect the failure or success of the forming process, are the die radii and punch, a clearance between die set, lubricant and the resistance mechanism to metal flow, such as blankholder gap (BHG), blankholding force (BHF), and draw bead. As the sheet is radially drawn inwards, the flange subjected to radial tension and circumferential compression then later may occurring of wrinkling on the flange, if the drawing hight are big, or if the high ratio of diameter to thickness. a blankholder generally applied appropriate pressure on the sheet to wrinkling preventing [1,2]. Thus, it is important to overcome this drawback in deep drawing process. many studies on control of blankholder in sheet stamping have been executed in the last years. Kenichi *et al* [3] presented a combination of a control system employ blankholder fuzzy control and punch speed for the deep drawing process to enhance the formability and productivity of the forming prcess. Vedat and Omer [4].invested the effects of blankholder and die shape to obtain a successful products in deep drawing process using five kinds of die shapes and BH to to decrease (BHF) by adding an angle for both die and (BH) and raise deep drawing ratio. M. Gavas and M.Izciler [5]. Presented a new design of a blankholder system with spiral spring to decrease friction area, to authorize the material flow in direction of the straight sides towards the corner, to conduct efficient lubricant between blankholder and sheet and to prohibit concentration of the deformation on corners. T. Yagami *et al* [6]. studied the effect of blankholder motion control by algorithm developed to conduct forming with enhanced material flow. Karem M. Younis [7] studied experimentally the change in thickness of the drawn cup wall by using constant blankholder gap (BHG) (0.5 and 1 mm) and variable blankholder force (BHF) to clamped down the sheet metal during drawing operations. A. Hosseini and M. Kadkhodayan [8] presented a study on the concept of BHG. A local and global optimization method was used to determine the optimized (BHG) curve in enhancing the distribution of thickness equally of forming parts based on neural networks and simulated annealing algorithm to find a global optimized BHG profile. mechanism of divided blank-holder which consists of four segments has been achieved by M.A. Hassan *et al* [9] and BH parts can radially moving under axial pressure to enhancing the formability of products. recently, sheet metal forming simulation became a powerful tool for die design process due to high capability to deal with complicated problems. Several studies have focused on the use of finite elements in the analysis of the appearance of wrinkles during the deep drawing process. Prediction of variable BHF of conical cup drawing using Adaptive FEM simulation accomplished by Z.Q. Sheng *et al*[10]. FEM simulation with analytical study to examine the maximum VBHF to prevent cracking during deep drawing presented by Susila Candra *et al* [11]. W. R. Wang *et al*[12] presented approach of integrated FEM with PID controller to conduct closed-loop forming simulation which trajectories of optimal BHF were determined for each separated binder. the result showed the proposed method good effect to avoid tearing and wrinkling during forming.

In this paper, the deep drawing process of cylindrical cup made from low carbon steel is used to examine the effect of BHG , which defined as the space between the die and the blankholder surface. with a different simulation clearance of BHG to produce the wrinkling defects of the deep drawing process by FEM. The material is modeled using yield criteria for Hill's 48 which have been shown the ability to appear the phenomenon of wrinkling [13].

## 2. MECHANISM OF BHG

During the drawing process, the material is compelled to thickening and wrinkling; this increases friction and requires more force.The blank holder simply prevent occurring wrinkling and the sheet is drawn more easily, so, blankholder mechanism is a key role of flow the material sheet. In general, there are fundamentally two types of blankholder systems applied in deep drawing processes. firstly, a blankholder force (BHF), which is utilized mostly in the in simulation and experimental work, while the other is a blankholder gap (BHG). In deep drawing, a low (BHF) can cause wrinkling due to the redundant flow of material into the die, While there is tearing of the sheet when the BHF is of high value [4, 2,14]. Thus, it is important to select the suitable (BHF) to be used in the deep drawing process. other is a blank holder gap (BHG), characterize as the constant space between the die surface and the blankholder as shown in Fig.1. The advantage of using the (BHG) is to reduce the forming force and make the design of the die set is simple. In this work, seven different values of BHG to arrange (0.5-3 mm) are selected to examine the effect of BHG on occurring wrinkles in the flange area. An FE model was built according to the initial experiments that uses BHF to prevent the wrinkles [15].

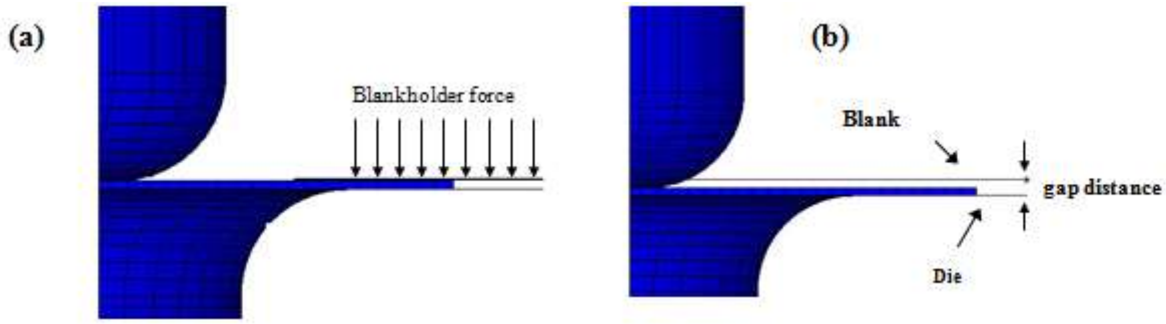


**Figure 1** Mechanism of blank holder (a) blankholder force (b) blankholder gap

## 3. NUMERICAL SIMULATION

### 3.1. Material model

Mild steel is chosen as the material for this work where this type is used for stamping application, such as automobile bodies, fuel tank and other application the mechanical properties listed in Table 1.

**Table 1** Mechanical properties

| Parameters | Units | Value |
|---|---|---|
| Young's modulus | GPa | 200 |
| Tangent modulus | Gpa | 0.5 |
| Yield strength | Mpa | 200 |
| Poisson's ratio | __ | 0.3 |
| Thickness | mm | 0.5 |
| $r_0$ | | 1.56 |
| $r_{45}$ | | 1.26 |
| $r_{90}$ | | 2.12 |

### 3.2. FE model

For simulating the deep drawing operation, a commercial FEA software package was used. 3D 8-node structural solid element of SOLID45 was selected for the sheet. The punch, die and blankholder was assumed as "rigid bodies". Automatic contact procedure in Ansys was selected to acheiving the complex interaction between the tooling and blank. For rigid (tool set) - flexible (blank) contact 3D 8-node quadrilateral target element of TARGE 170 was selected to modeling 3D target (tool set) surface, which were appropriated with the deformable sheet represented by 3d 8-node contact element of CONTA174. The target surfaces and contact constructed a "contact pair", which was used to represent sliding contact and between the surface of the tool set and workpiece (blank). The pilot node option was used to control of the punch movement. The geometry of FE model is shown in table (2). because of the symmetry problem, only modeling one-half of the tooling set due to symmetry. The finite element model, as shown in Fig. (7), is achieved according to the dimensions which are used in the experimental work [13] table (2). The sheet is assumed as a deformed body. The tooling set (die,punch, blankholder) is assumed as rigid bodies.

**Table 2** Parameters of deep drawing process

| Parameter | Value |
|---|---|
| The Punch diameter (mm) | 43 |
| The die diameter (mm) | 44.3 |
| The punch profile radius (mm) | 6 |
| The die profile radius (mm) | 6 |
| The blank size (mm) | 78 |
| Sheet thickness (mm) | 0.5 |

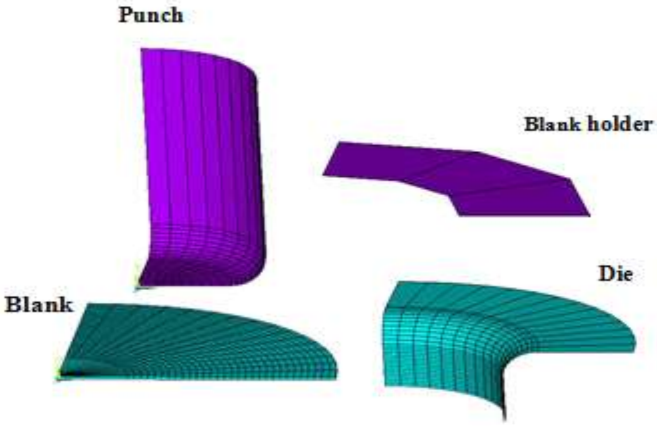


**Figure 2** FE model of the tool used in the simulation.

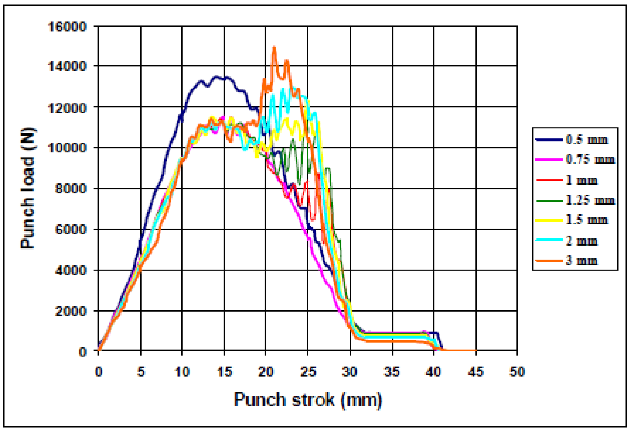


**Figure 3. Comparison of punch load curves of the drawn cup for variable BHG value**

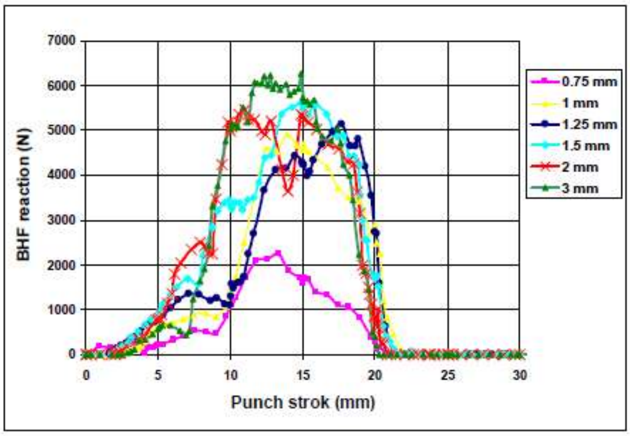


**Figure 4. The effect the BHG on reaction force that applied on BH.**

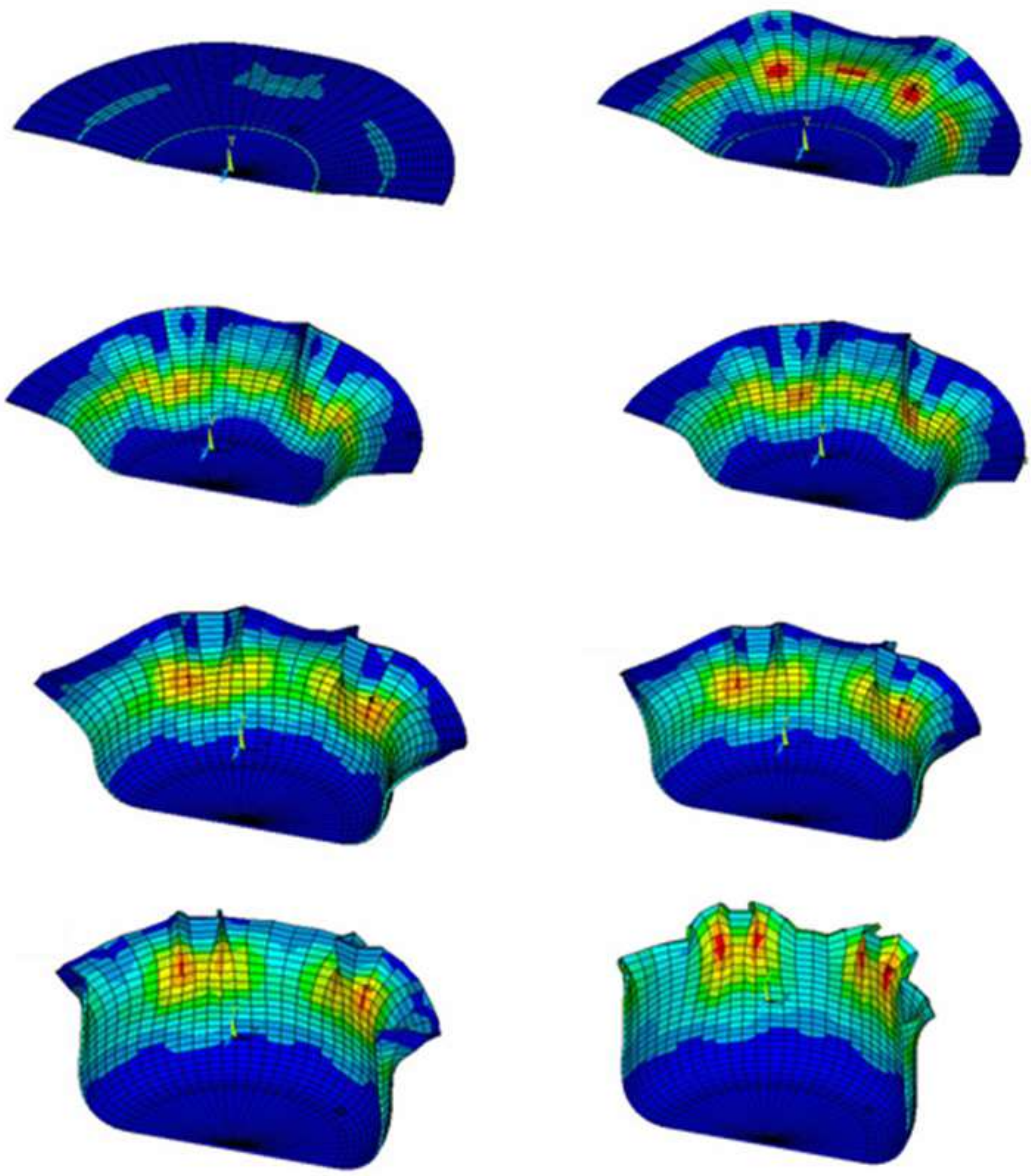

**Figure 5** Simulation of wrinkles occurring in deep drawing process without Blank holder

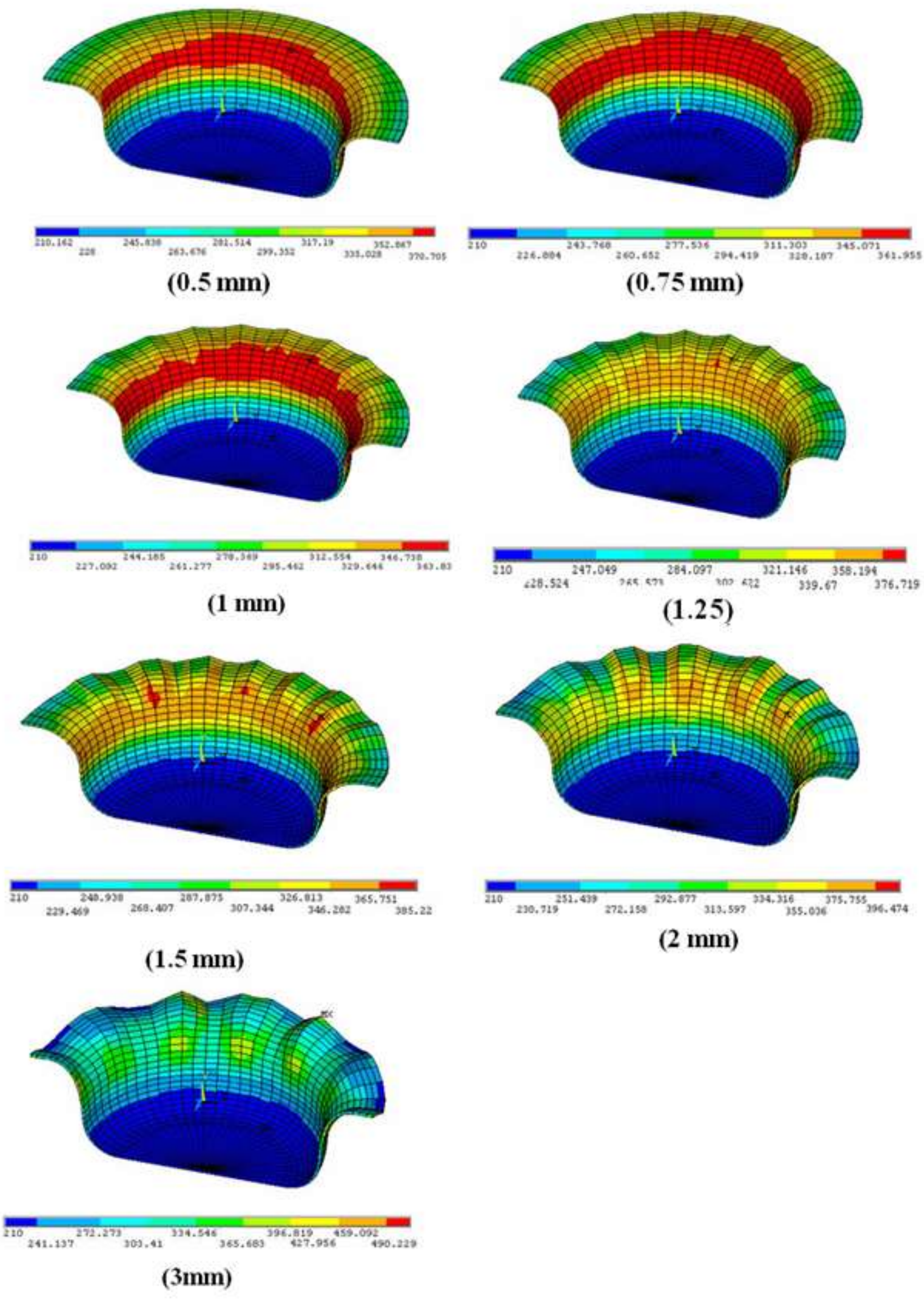


**Figure 6** Distribution of equivalent plastic stresses in drawn cups with different blank holder gap

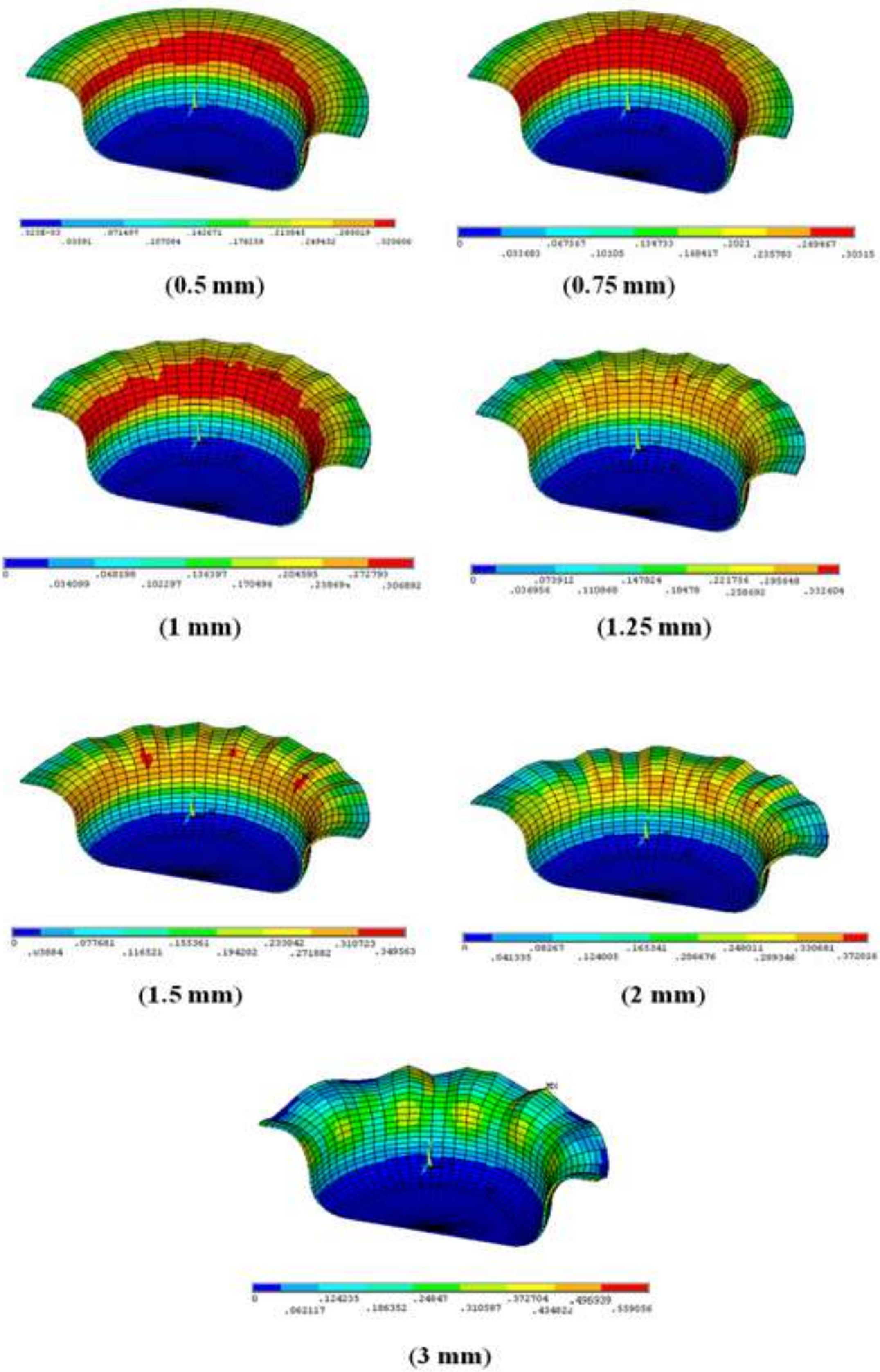


**Figure 7** Distribution of equivalent plastic strains in drawn cups with different blank holder gap.

# 4. RESULTS AND DISCUSSION

From the numerical simulations in Fig.6, 7 it has been clear that no wrinkling can be observed when using BHG with small value. The BHG has an influence on the distribution of equivalent plastic stresses and strains. For BHG of 0.5 and 0.75 mm, uniform distributions of stresses and strains can be observed, this lead to no wrinkles are the appearance of flange area. When increase gap value, this facility the material to flow rapidly at the initial stage of drawing. With absence prevention in a progressive drawing, extreme compressive stresses are generated that causes a local buckling to the sheet, then the metal flow becomes difficult into the die. From Fig 6, 7 observed that the number of wrinkles reduces with increase the BHG value and the volume of wrinkles are increasing with the increase the BHG value.

Fig.3. Shows the comparison of punch load curves of the drawn cup for variable BHG value. It is noted from the figure the punch load decrease with increase the BHG value. This due to when using the BHG, the pressure that applied by BHF is removed and the area between blankholder and sheet has been reduced and leads to reduce friction effect. With progressive of drawn the punch load is increased because the excessive compressive stress is generated and this leads to occur of wrinkles at flange area and thickness of cup wall become larger than the clearance between (punch – die) set, there for more force required to further the sheet at die noise and more force required to against ironing phenomenon that happened between the blank and wall die. From Fig.3 can be predicted occurs the wrinkles when the punch force is to rise once again with an oscillatory shape. This indicates there are hindering to drawing and bending the metal at die noise and this agreement with reference [7].

Fig.4 shows the effect the BHG on reaction force that applied on BH by the sheet. It's clear from the curves increases reaction force with increase BHG. That due to occur wrinkles on flange area. When increases the BHG the height of wrinkles is increase this lead to press the metal on BH and concentrate on small areas. The best results were obtained from the BHG equal to 0.75 because of least value for both load punch and BH force reaction.

# 5. CONCLUSIONS

In this study, an influence of using the blankholder gap on deep drawing process was investigated. The shape and number of wrinkles, drawing force, strains and stress distributions at cup wall were analyzed, the experiments were performed with FE simulation. In deep drawing, the phenomenon of wrinkling is a major defect. In the flange zone, the sheet subjected to tangential compressive stress leads to occurring the wrinkling where need in this situation to more blank holder force. Blankholder ranges in simulation work from 1 to 6 times the thickness of initial sheet. The occurrence of wrinkling can be predicted from the punch load curve and the contour shape of the drawn cup at any stroke. The BHG has an influence on the distribution of equivalent plastic stresses and strains. For small BHG, the uniform distributions of stresses and strains can be observed, this lead to no wrinkles are the appearance of the flange area. The results of the simulation indicate that the wrinkles number reduces with increase in the BHG value and the volume of wrinkles is increasing with the increase the BHG value. The BHG has an effect on both punch force and BHF. If the gap is larger than 0.75 mm, the wrinkles will occur and the drawing force increased. The final cup quality is affected highly by the blankholder gap. Finally, the blank holder considers an important role in controlling the material flow during forming in deep drawing process by applying force on the sheet metal.

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