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THE EFFECT OF FORMING SPEED ON THE POSITION OF NECKING DURING SHEETS METALS FORMING PROCESS

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Abstract- The sheet forming processes play a major role in the industrial applications because they are easily performed with low cost. Many parameters contribute in the sheet forming such as: forming speed, strain rate, strain hardening, and temperature. Researchers keep investigating sheet forming processes to improve the formability of sheets without any problems. In this research, the effect of the forming speed on the position and size of the necking of biaxial-stretched specimens was experimentally investigated using aluminum alloy sheets of AA2024, and AA1100. The results proved the effectiveness of the forming speed on the formability of the selected sheets. The position and the size of the necking changed with changing the forming speed. During the stretch forming process, AA2024 sheets resulted with better formability than AA1100 sheets showing maximum depth forming of 18.5 mm and 15 mm, respectively.

Keywords: Tool Speed, Necking Position, Forming Path, AA2024, AA1100.

1. INTRODUCTION

Many manufactural engineers have investigated the impact of some parameters on the formability of sheets during sheet forming processes Many factors can affect the forming process such as strain rate, thermal stress, sheet type, strain path, deformation properties. Stretch forming process includes applying of bending and stretching to form three-dimension parts [1], [2]. This process finds a wide range of applications in locomotive industry, aerospace industry, and modern architecture [2]. Using of the stretch forming process easily leads to the occurrence of defects in the deformed product [3]. Necking in a sheet metal during the stretch forming has made a lot of interest for scientists and manufactural engineers.

Yang and Cai [3] developed a method to apply a distributed loading instead of the traditional loading method in the stretch forming process. They claimed a smaller thickness reduction in the distributed loading. The impact of the tool roughness and sheet thickness on the formability of steel sheets were studied by Kumar et al [4] using hydro-mechanical drawing process, also the numerical solution was performed by finite element method, and validated with the experimental results. The theoretical results were close to the experimental data [4].

Satish et al [5] studied the effect of the punch speed on the formability for two different thicknesses of AA5182-O sheets using deep drawing process. Also, they used strain plane forming with temperature and compared their results with finite element results to show the validation of the theoretical results [5]. The stretch bending ratio was calculated by Balod [6] for three types of sheet metals using the stretch bending process. In addition, the theoretical solution was obtained using the finite element method, The AA3103 sheet showed the highest formability among the other sheet metals [6].

The impact of the punch speed on the formability of stainless steel SS304 sheet was studied by Fathi and et al [7] using stretch forming process. A theoretical model via ls-dyna software was compared with the experimental data. They concluded that the punch speed is an effective factor on the forming limit diagram. Choi and Huh [8] investigated the influence of the punch speed on the spring back for two types of steel sheets during the bending process; these results were compared with the finite element numerical results. Their findings were abstracted as: the value of the spring back increases with increasing the punch speed [8].

Balod [9] researched the formability of an AA5182 / Polypropylene/ AA5182 sandwich sheet theoretically using three yield criteria. He discovered that Barlat yield theory represents the best-matching solution than the other yield criteria [9]. The effect of the punch stroke on the deformation of the sheet metals were studied numerically by Akinlabi and Akinlabi [10] using finite element method via constructing a model for all equipment of U-bending forming and sheet metal. Their results showed that the formability of sheets increases due to the punch stroke [10]. The influence of some parameters on the sheet deformation was researched by Khalil et al [11] focusing on the surface quality. They found that the surface roughness affects the incremental forming of the sheet metals [11]. Ken-ichi Manabe and et al [12] investigated the tool speed and holding force during the deep drawing forming process; they used theoretical elementary method to find the fracture and wrinkle limits. Then, the results were compared with the experimental results. They concluded that the experimental deep drawing results well agree with theoretical solution [12].

The aim of this research is to investigate of the effect of the forming speed on the formability of AA2024 and AA1100 sheets during the stretch forming process below the melting temperature of the welded metals. Some examples of the solid-state welding: electrical resistance welding, friction welding, friction stir welding, explosive welding, etc.

2. CHEMICAL COMPOSITION AND MECHANICAL PROPERTIES

In the current work, aluminum alloy sheets of AA2024 and AA1100 with thickness of 1 mm were adopted in the experimental work. Table 1 shows the major chemical elements of the AA2024 and AA1100 sheets.

Table 1. Chemical analysis for AA2024 and AA1100 sheets

Metal	Cu%	Mg%	Zn%	Mn%	Fe%	Si%	Al%
AA 2024	4.902	1.291	0.14	0.631	0.23 8	----	Bal.
AA 1100	0.15	--	0.09	0.05	0.92	0.97	Bal.

The mechanical properties of AA2024 and AA1100 sheets were derived from the tensile test results. Table 2 shows the effective mechanical properties for the two metallic alloys.

Table 2. Mechanical properties of AA 2024 sheets

Metal	Tensile strength (MPa)	0.2% Proof stress (MPa)	Elongation (%)
AA2024	460	322	18
AA1100	204	107	13

3. EXPERIMENTAL PROCEDURE

The stretch sheet metal forming process was used to determine the effect of the forming speed on the deformation of AA2024 and AA1100 specimens. A punch of 50 mm in diameter was used with a blank holder and a die to perform the stretch forming for the specimens. The maximum applied load was three tons.

Biaxial-stretched specimens were used to study the effect of the forming speed on the necking position and size. Figure 1 illustrates a comparison between three plastically-deformed specimens with different forming speeds. As shown, the position and size of the necking for specimens differs with changing the forming speed as it will be explained in the results.

4. RESULTS AND DISCUSSIONS:

The results obtained in this work were represented in Figures 2-6. These results indicate the effect of the selected parameters on the formability of AA2024 and AA1100 aluminum alloys sheets. The selected parameters were: forming speed, necking size, and forming depth.

Figure 2 illustrates the impact of the forming speed on the forming depth of AA2024 sheets experimentally using stretch forming process. The forming depth increases on decreasing the forming speed. The maximum forming speed reaches 22 mm/min at a forming depth of 8 mm.

Figure 1. the position and size of the necking for three different specimens using different forming speeds

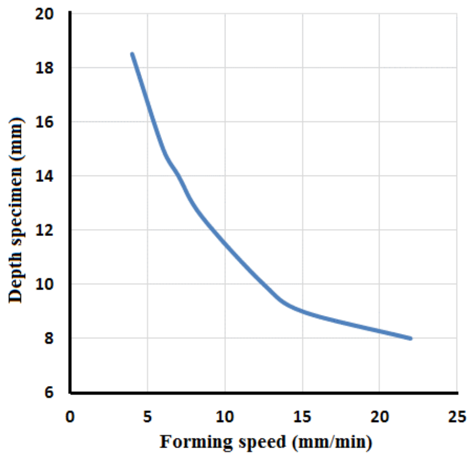

Figure 2. forming speed with forming depth for AA 2024 sheet

Figure 3 shows the effect of the forming speed on the necking position for AA2024 sheets. The distance between the necking position and the specimen center increases as the forming speed decreases. Also, the maximum forming speed is 22 mm/min while the maximum distance between necking position and specimen center is 17.3 mm. The effect of the forming speed on the necking size is clear in Figure 4. As the forming speed increases the necking size increases too. This is because the fact that the movement of dislocations increases with increasing the forming speed. The maximum forming speed is 24.6 mm/min while the maximum necking size is 10.6 mm.

For the sake of comparison, experimental results were obtained for AA1100 sheets. The results of the forming speed and the depth of forming were projected in Figure 5. For all the forming speeds, the depth of forming for AA2024 sheets is higher than that of AA1100 sheets, i.e., AA2024 sheets have a better formability than AA1100 sheets which can be contributed to the fact that the dislocation movement is faster in AA2024 sheets than in AA1100 sheets. The maximum forming depth is 18.5 mm in AA2024 sheet comparing with 15 mm for AA1100 sheets.

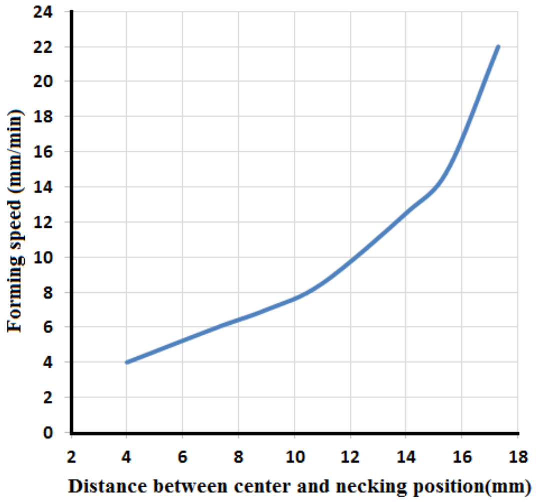

Figure 3. forming speed as a function of the distance between necking position and specimen center

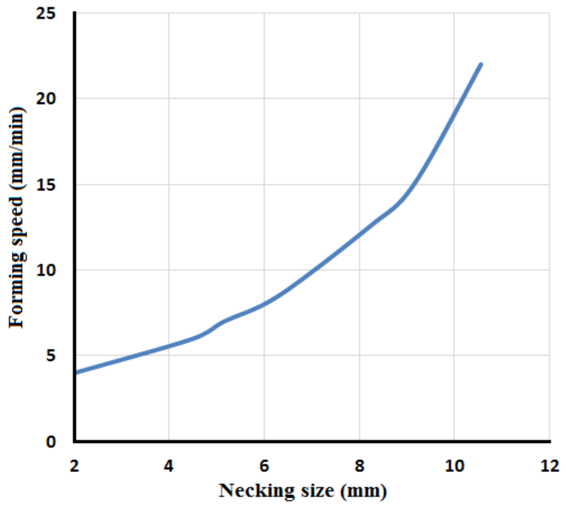

Figure 4. the effect of forming speed on necking size

Figure 6 represents another comparison between AA2024 and AA11000 sheets for the forming speed and the necking position. AA2024 sheets have larger distance of necking position than AA1100 sheets at the same forming speed. The results of AA1100 sheets lie to the left, which means that the formability of AA2024 sheets is better than that of the AA1100 sheets. The maximum necking position reaches a value of 17.3 mm at a forming speed of 22 mm/min for AA2024 sheet compared with a value of 14 mm for AA1100 sheets at the same forming speed.

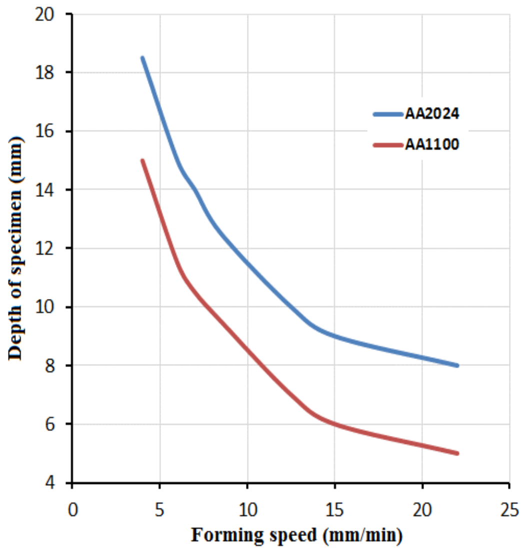

Figure 5. Comparison between AA2024 and AA1100 sheets for specimen depth

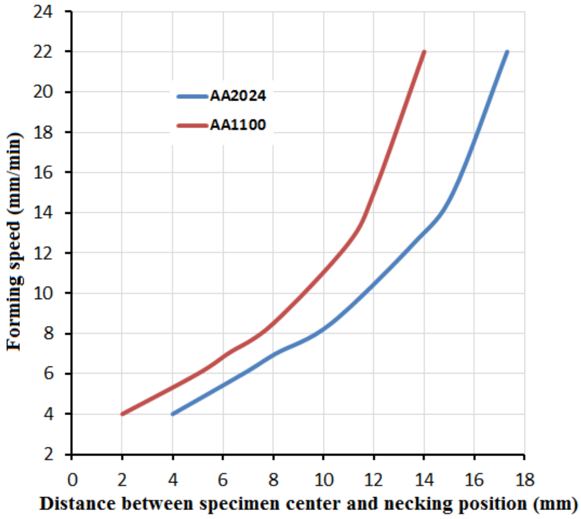

Figure 6. Comparison between AA2024 and AA1100 sheets for necking position

5. CONCLUSIONS

During this research work, the impact of the forming speed on the position and size of the necking in AA2024 and AA1100 metal sheets were investigated using stretch sheet forming process. The following main points can be summarized:

1. The formability of sheets strongly depends on the forming speed. The sheet formability increases as the forming speed decreases for all of the involved sheet metals.
2. The position of necking in the deformed sheets changes in accordance with the forming speed. The position of necking closes to the top middle in the deformed sheets as the forming speed decreases.
3. Comparing with AA2024 sheets, the results of AA1100 sheets shifted to the left for the necking position. This indicates the fact that the formability of AA2024 sheets is higher than AA1100 sheets.

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BIOGRAPHIES

Anas Obeed Balod was born in Mosul Iraq. He obtained the B.Sc. degree in Mechanical Engineering and the M.Sc. degree in Production and Metallurgy Engineering from Mosul University, Mosul, Iraq in 1996 and 2005, respectively. He received his Ph.D. in Mechanics of Materials from Leicester University, London, UK in 2018. He is working as Lecturer in Department of Mechanical Engineering at Mosul University, Mosul, Iraq. He has been contributed in publishing more than 9 articles in various journals. He is a member of academic staff of mechanical engineering at Mosul University and Iraqi engineers' association.

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