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FLUID PRESSURE ANALYSIS AND PROCESS STABILITY IN SHEET HYDROFORMING WITH DIE FOR STEEL SHEETS

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Abstract:
To increase the process stability and improve the product quality in the sheet hydroforming with die process, it is crucial for identifying and analyzing the dependence of forming pressure on process parameters. The effects of process parameters (blank holder force, frictional condition) on the forming fluid pressure were thoroughly studied experimentally. The main objective is to establish a relationship between the forming fluid pressure and several factors such as blank holder force and friction between die and sheet. The results demonstrate that the maximum fluid pressure increases with increasing blank holder force and friction. Finally, this relationship aims to support calculations and design data and provide control during the SHF-D process.

Key words: hydroforming, sheet hydroforming with die, fluid pressure, process parameters, steel

INTRODUCTION

Metal sheet products from various industries must possess specific geometrical features and properties to meet the market requirements. Manufacturing such products requires special methods and techniques. The hydroforming with die (SHF-D) process is a method of transforming sheet into required shape using high fluid pressure. The fluid acts as the energy-transmitting medium, replacing conventional punch to transfer the load and realize the final forming, as illustrated in Figure 1 [1, 2, 3].

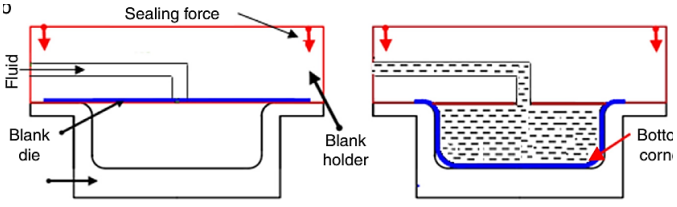


Fig. 1 Sheet hydroforming with die
Source: [1].

The hydroforming technology comprises several advantages, such as improving the sheet formability, increasing surface quality and dimensional accuracy, reducing spring-back, capability of forming complex shapes, cost efficiency, suitability for thinner and lightweight sheets, better rigidity and stiffness of products [4, 5, 6, 7]. Despite the benefits offered by this technology, it has certain limitations. However, the main drawbacks of SHF technology are that a higher cycle time, more complexity in precise control and maintaining of high process pressures and prevent oil leakage, and higher forming force and a higher blank-holding force are needed in comparison with those found of conventional deep drawing [8, 9].

It combines the advantages of both the conventional deep drawing technique and forming by assisting fluid [10, 11, 12, 13]. In die sheet hydroforming, the thin wall product formation is greatly affected by various technological parameters. Among these parameters, the forming fluid pressure (P) plays a vital role. This pressure applies on the blank directly, drawing the blank closely to the die's profile. Hence, it is crucial to maintain a sufficiently high value for this parameter in order to achieve the desired shape of the product. When the fluid pressure is excessively high, it causes the product to undergo excessive thinning. On the other hand, if the pressure is too low, the product fails to take desired shape, specially at the bottom corners leading to lower in dimensional accuracy and quality of product. Furthermore, this fluid pressure is significantly affected with other workpiece, tool, process parameters [1, 14, 15].

LITERATURE REVIEW

Numerous impressive studies have explored SHF-D technology, with a significant focus on studying the effect of forming liquid pressure parameters on the product quality and forming process. The design of a hydroforming die has been investigated in detail by Vasile [16]. That study presented new concepts behind designing a hydroforming die in sheet metal forming process with simple design and

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modular shape. The experiments demonstrated the capability of that design to produce different shapes made from different materials in hydroforming with die, at low costs and appropriate quality. Vasile et al. [17] developed a new custom build hydroforming concept to investigate the sheet ability of steel alloy for forming by die hydroforming process. Numerical model was built and material definition data were introduced. The experimental results have been compared with the simulation ones for validation of this unique hydroforming setup developed. That study proves the ability of the developed hydroformed concept in the forming the different materials with different thicknesses, at low cost and high accuracy. Study on design and development of an experimental setup for forming of square cups made of different materials in the punch less hydroforming process have been published by Modi & Kumar [18]. That study also involves a comparison between two distinct methods to apply blank holding force: constant BHF in two steps versus variable BHF. It is found that the variable BHF loading path give better results compared to employing a constant BHF. Qayyum [19] conducted various analytical, experimental, and numerical techniques of the deep drawing process followed by hydroforming process to produce a complex shape product (deep drawn cup with side cavity). Several parameters were examined to ensure suitable values determination for the process. Hu et al. [20] developed the SHF process to manufacture an automobile fuel tank by simulation firstly and experimental validation was then performed [21]. Discovered that increasing maximum pressure level up to a certain threshold reduces thinning in critical zones of the product. However, elevating the maximum fluid pressure more than this threshold does not further enhance the forming of the part in hydromechanical deep drawing process; instead, it leads to an increase in punch force. To model the forming fluid pressure in the SHF-D process, [22] conducted experimental research on forming circular cups manufactured from different materials, with different thickness (0.8 mm, 1.0 mm, 1.2 mm), within a specified range of blank holder forces. A mathematical equation was formulated to quantify the influence of each input on the forming fluid pressure. Modi et al. [23] optimized the forming fluid pressure for shaping square cups using the Taguchi method with AA 5182 alloy material sheet.

In this study, in order to improve the quality and increase stability during the hydroforming process, it is crucial for identifying and analyzing the dependence of the forming pressure on input parameters such as blank holder force, frictional conditions, and die height during the SHF-D process using deep drawing of square cup from low carbon steel alloy.

METHODOLOGY

Sheet material

In this work, low carbon steel sheet with thickness 0.5 mm was chosen as a blank material due to high formability, inexpensive, and available [24, 25]. The chemical composition of the 1006 AISI steel alloy utilized in this work is listed in Table 1.

Table1

Chemical composition of (1006) AISI, content in [wt%]

	C %	SI %	Mn %	P %	S %	Cr %	Ni %	Mo %	Al %
Test	0.0636	0.0355	0.195	0.016	0.006	0.0177	< 0.005	< 0.004	< 0.002
AISI	≤ 0.08	≤ 0.04	0.25-0.4	≤ 0.04	≤ 0.05				

This chemical composition was studied according to ASTM E415 standard by using spectrometer device (SPECTROMAXx, German, AMETEK). It is important to note that this alloy was supplied in the form of a rolled sheet produced by cold rolling.

MATERIAL PROPERTIES

Standard specimens were prepared using water jet machining process (water jet machine with model no.3020, Yonoda, China) along the 0°, 45°, 90° to the rolling direction (RD) respectively and designed according to ASTM A370 standard [26]. The uniaxial tensile tests have been conducted on the Universal Testing Machine (UTM) model (WDW200E) at room temperature. During the testing, the specimens were stretched unit fracture with crosshead speed which was kept constant at 5 mm/min, giving an initial strain rate of 0.0017 s^{-1}. The tensile specimen with dimensions according to ASTM A370 standard are shown in Figure 2.

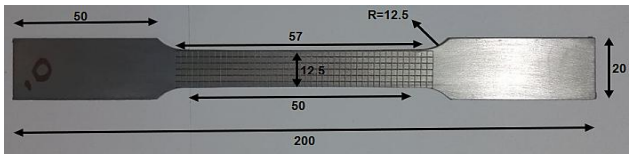


Fig. 2 Standard uniaxial tensile specimen, all dimensions in (mm)

The universal testing machine with 200 kN capacity and a range of ram speed of (0.05-500) mm/min was used in the tests shown in Figure 3 [26, 27].



Fig. 3 Computerized controlled tensile testing machine WDW-200E

The mechanical properties of the low carbon steel alloy used (1006) AISI are listed in the Table 2.

Table 2
The mechanical properties of the (1006) AISI steel alloy

Specimen orientations	Offset yield strength MPa	Ultimate strength MPa	Elongation at fracture %	Reduction in area %	Strain hardening exponent	Strength coefficient MPa
0˚	225	361	21.5	48	0.208	438
45˚	221	356	23	52	0.228	431
90˚	241	394	20	47	0.21	446

ANISOTROPY TEST

Tabulated results in Table 2 show that the 1006AISI low carbon steel is nearly an anisotropic material. It is therefore of major importance to conduct anisotropy test to determine the plastic anisotropy coefficients (r-values). Additionally, the plastic strain ratio (r-value) serves as an indicator of a sheet metal capacity to withstand the thinning or thickening when it is deep drawn into a part such as a cup. Therefore, it is a measure of sheet metal drawability. To determine the magnitudes of the r-value, the tensile test specimens are first prepared for each direction (0°, 45°, 90°) to the RD and subjected to an elongation of 20% form the total elongation required to fracture specimens as per ASTM E517 standard (test method for identifying the plastic strain ratio of metal sheet). In this study, a manual approach was used, prior to testing the specimen, the gauge length region was marked with grid of square elements of 2 mm × 2 mm dimensions. Then, the test was stopped when the elongation reached 20%. Finally, the final dimensions of the square elements (width and length) were measured to determine r value.
The anisotropic parameters of 0.5 mm thick (1006) AISI steel sheets are listed in Table 3.

Table 3
The anisotropic parameters of (1006) AISI steel sheets

Anisotropy parameters	r_0	r_{45}	r_{90}
Value	1.46	1.16	1.93

The experiments show that the drawability in 90° direction is more than other directions in the sheet used. This may be taken into account when placing blank over the die cavity to ensure that the direction with the highest r-value of the blank coincides with the regions subjecting the highest thinning during forming process.

EXPERIMENTAL SETUP

A sheet hydroforming setup was fabricated and developed to produce cup shaped parts under high fluid pressures. The experimental diagram of the SHF-D setup is presented in Figure 4.

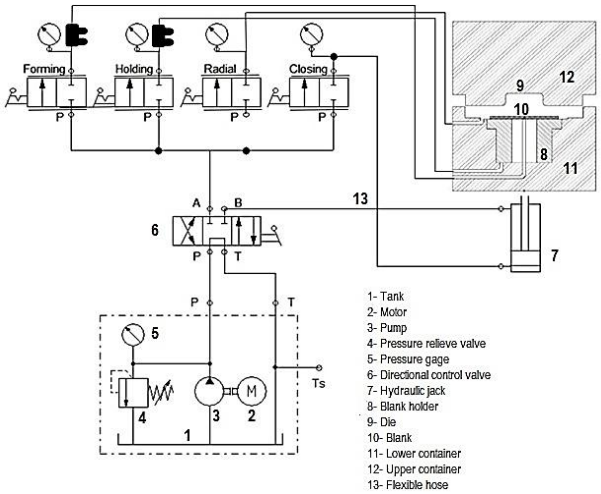


Fig. 4 Diagram of experimental system of the SHF-D setup

The newly developed experimental setup that used in this work is depicted and modeled in the Figure 5.

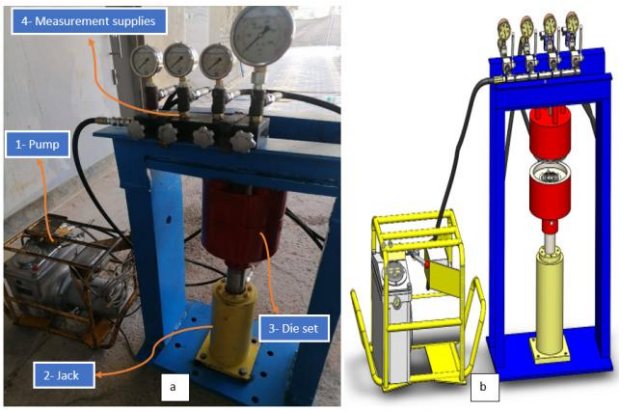


Fig. 5 Used Experimental setup, a) actual picture, b) schematical modelling

Advantages from several previous literature is taken in the design and manufacturing aspects of this experimental setup [28, 29, 30].

RESULTS AND DISCUSSION

To evaluate the effect of each parameter on the maximum forming fluid pressure, it is important to study of each parameter individually while keeping the other parameters constant. Therefore, the following general parameters were chosen: closing pressure = 30 MPa, dry condition, and a circular blank made of 1006 AISI low carbon steel sheet of 0.5 mm thickness and of 110 mm diameter. Additionally, the selected product was a square cup with flange of 40 mm side length, 20 mm height and all corners equaled to 5 mm.

EFFECT OF BLANK HOLDER FORCE

The blank holder force (BHF) is one of the key parameters in the SHF-D process, playing a significant role in the success of the hydroforming process. It has a direct effect on the fluid pressure and the forming modes occurring, which determine the degree of drawing, stretching, and thinning during the hydroforming process. Moreover, it is effective in preventing instability at the sheet flange. Due

to its significance, it was chosen as a critical factor for research in this study.

A comprehensive analysis was conducted on the forming process of a square cup using low carbon steel alloy sheet (1006 AISI) with a thickness of 0.5 mm and a diameter of 110 mm within the range of blank holder force of 10-180 KN. To evaluate the influence of BHF on the maximum forming pressures, six levels of BHF (10 kN, 30 kN, 80 KN, 130 KN, 150 KN and 180 kN) were chosen in hydroforming. In each experiment, the BHF acting on the sheet flange is kept constant during the forming process, and the fluid pressure required for forming is gradually increased from zero to the peak value that the system can sustain to form the desired part. So, for each experimental part with an identical size and shape under different BHF values, the forming pressure is measured.

Figure 6 illustrates the influence of BHF on the maximum fluid pressure under the aforementioned conditions.

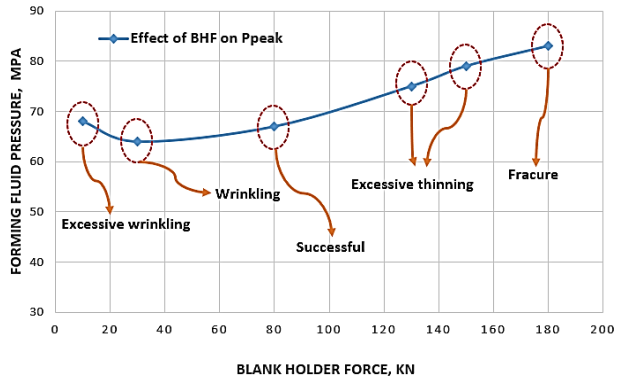


Fig. 6 Effect of BHF on the P_{peak}

The figure clearly indicates that the forming pressure P is significantly influenced by BHF. The curve depicting this relationship can be divided into two distinct regions: the first region shows a decrease in P with increasing BHF, while the second region demonstrates an increase in P with increasing BHF. This phenomenon can be explained as follows:

First region (10-30 kN): In the initial period of this region (10 kN), when BHF is very small, excessive wrinkles occur at the flange, leading to increased thickening and rigidity in that area of the sheet. Consequently, it becomes challenging to draw the material from the flange into the die, resulting in a high value of P. After this period, as the blank holder force continues to grow, it reduces instability in the workpiece at the flange and facilitates material flow into the die. So, forming pressure rather lowers compared to (10 kN), but the slightly wrinkles still appear at the formed cup.

Second region (30-180 kN): If BHF continues to increase the wrinkles would suppress, and the forming pressure starts to rise again. A higher BHF imposes greater constraints on the material flow during the initial stages of draw-in, leading to an increase in forming fluid pressure. Furthermore, when BHF reaches its maximum values, the forming pressure also reaches its highest values. This elevated forming pressure affects the workpiece, resulting in excessive thinning, ultimately fracture at the corners of the die's bottom.

EFFECT OF FRICTION

Most SMF processes, such as deep drawing and sheet hydroforming, prefer low friction. These processes involve overcoming the frictional forces in order to draw the blank into the die to form a part with minimal stretching. Friction plays a crucial role in determining the necessary fluid pressure and energy required to deform the sheet material in SHF-D process. Hence, controlling the friction between the tool and the sheet is essential.

To investigate the effect of friction on forming fluid pressure, three lubrication conditions were used: dry, engine oil, grease. The blank holder force was set at 80 kN, and the aforementioned conditions remained the same in all experimental tests. Figure 7 illustrates the variation in peak fluid pressure (P_{peak}) under different frictional conditions. The graph clearly demonstrates that P_{peak} increases as friction at the blank-die interface increases.

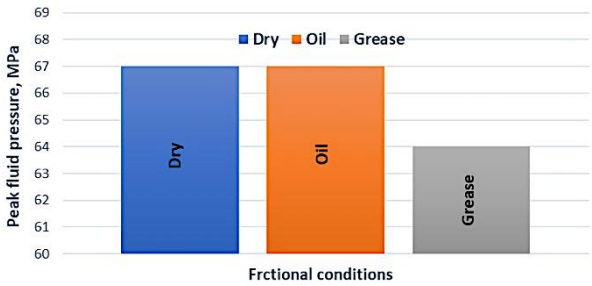


Fig. 7 The variation in peak fluid pressure (P_{peak}) under different frictional conditions

It can be inferred that in the case where no lubricant (dry condition) is used, a high frictional force develops between the sheet and die surface. This force hinders the movement of the material into the die, thereby increasing the forming fluid pressure required to overcome this resistance. The peak fluid pressure (P_{peak}) reached 67 MPa in this particular case and did not decrease even when engine oil was employed. This can be attributed to, the liquid oil at the contact surface between the sheet and the die may be displaced by the large blank holder force. As a result, there is a possibility that a portion of the workpiece under the blank holder may lack sufficient lubrication. This can create difficulties to draw the sheet into the die and shape it without a substantial increase in fluid pressure. While, when a thin polythene sheet is coated with a small amount of grease as a solid lubricant was applied to cover the sheet's flange, the P_{peak} significantly decreased to 64 MPa due to lowering in the frictional resistance.

Based on the results obtained from previous studies that explain the effects of various parameters on forming fluid pressure in the SHF-D process, it is possible to determine the suitable values of input variables. These values are essential for achieving successful cups as shown in Figure 8.



Fig. 8 cups formed by this experimental setup

CONCLUSIONS

The researchers developed the experimental setup was specifically manufactured for hydroforming with die process and was verified this setup's capability to form square cups with specific dimensions. The effects of BHF and frictional conditions on the peak fluid pressure were studied. The results clearly indicates that the forming pressure P is significantly influenced by BHF. When BHF is very small, excessive wrinkles occur at the flange, leading to increased thickening and rigidity in that area of the sheet. Consequently, it becomes challenging to draw the material from the flange into the die, resulting in a high value of P. If BHF continues to increase the wrinkles would suppress, and the forming pressure starts to rise again. A higher BHF imposes greater constraints on the material flow during the initial stages of draw-in, leading to an increase in forming fluid pressure. Furthermore, when BHF reaches its maximum values, the forming pressure also reaches its highest values. This elevated forming pressure affects the workpiece, resulting in excessive thinning, ultimately fracture at the corners of the die's bottom. Moreover, the liquid oil at the contact surface between the sheet and the die may be displaced by the large blank holder force. As a result, there is a possibility that a portion of the workpiece under the blank holder may lack sufficient lubrication. This can create difficulties to draw the sheet into the die and shape it without a substantial increase in fluid pressure. While, when a thin polythene sheet is coated with a small amount of grease as a solid lubricant was applied to cover the sheet's flange, the P_{peak} significantly decreased to 64 MPa due to lowering in the frictional resistance. Finally, due to that the forming mechanism in the SHF-D process (drawing stage) is rather similar to that find in the traditional deep drawing process. Therefore, the obtained changes in the P value depending on the BHF value and friction value in this study are analogous to the changes occur in the punch force in the traditional deep drawing test as described in several previous researches.

REFERENCES

[1] F.T. Feyissa, D.R. Kumar, "Enhancement of drawability of cryorolled AA5083 alloy sheets by hydroforming," *J. Mater. Res. Technol.*, vol. 8, no. 1, pp. 411-423, Jan. 2019, doi: 10.1016/j.jmrt.2018.02.012.

[2] F. Forouhandeh, "A Comparison Between Two Methods of Sheet Hydroforming By Simulation," *Evol. Mech Eng*, vol. Volume 2, no. Issue-2, pp. 4-7, 2018, doi: 10.31031/EME.2018.02.000534.

[3] Q. Guo, L. Lang, K. Li, P. Jiang, J. Jiang, and . Zhang, "Research on the hydroforming regularity and process optimization control of complex aluminum alloy part with variable cross-section size," *Procedia Manuf.*, vol. 50, no. 2019, pp. 332-336, 2020, doi: 10.1016/j.promfg.2020.08.062.

[4] M. Tinkir, M. Dilmeç, M. Türköz, H.S. Halkaci, "Investigation of the effect of hydromechanical deep drawing process parameters on formability of AA5754 sheets metals by using neuro-fuzzy forecasting approach," *J. Intell. Fuzzy Syst.*, vol. 28, no. 2, pp. 647-659, 2015, doi: 10.3233/IFS-141346.

[5] Y.M. Hwang, K.I. Manabe, "Latest hydroforming technology of metallic tubes and sheets," *Metals (Basel).*, vol. 11, no. 9, pp. 1-8, 2021, doi: 10.3390/met11091360.

[6] C. Bell *et al.*, "Enabling sheet hydroforming to produce smaller radii on aerospace nickel alloys," *Int. J. Mater. Form.*, vol. 12, no. 5, pp. 761-776, 2019, doi: 10.1007/s12289-018-1446-z.

[7] L.-L. Xia, S.-H. Zhang, Y. Xu, S.-F. Chen, B.B. Khina, A.I. Pokrovsky, "Deformation characteristics and inertial effect of complex aluminum alloy sheet part under impact hydroforming: experiments and numerical analysis," *Adv. Manuf.*, vol. 11, no. 2, pp. 311-328, 2023, doi: 10.1007/s40436-022-00430-0.

[8] S.H. Zhang, J. Danckert, "Development of hydro-mechanical deep drawing," *J. Mater. Process. Technol.*, vol. 83, no. 1-3, pp. 14-25, 1998, doi: 10.1016/S0924-0136(98)00039-9.

[9] M. Hosseinzade, H. Mostajeran, M. Bakhshi-Jooybari, A.H. Gorji, S. Nourouzi, and S.J. Hosseinipour, "Novel combined standard hydromechanical sheet hydroforming process," *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, vol. 224, no. 3, pp. 447-457, 2010, doi: 10.1243/09544054JEM1650.

[10] G.-A. Costin, C. Afteni, I. Iacob, V. Păunoiu, N. Baroiu, "An Overview on Sheet Metal Hydroforming Technologies," 2018, doi: 10.35219/tmb.2018.08.

[11] V. Năstăsescu, G. Bârsan, S. Marzavan, "EFG method used in deep drawing numerical simulation," *International Conference KNOWLEDGE-BASED ORGANIZATION Vol. XXVI No 3. 2020.*, pp. 136-143, doi: 10.2478/kbo-2020-0128.

[12] T. Trzepieciński, H.G. Lemu, Ł. Chodoła, D. Ficek, I. Szczęsny, "Modelling Anisotropic Phenomena of Friction of Deep-Drawing Quality Steel Sheets Using Artificial Neural Networks," *Adv. Mater. Sci.*, vol. 21, no. 3, pp. 31-42, 2021, doi: 10.2478/adms-2021-0016.

[13] M. Abbadeni, I. Zidane, H. Zahloul, Z. Madaoui, "Comparative study of conventional and hydromechanical deep drawing processes based on finite element analysis," *Frat. ed Integrita Strutt.*, vol. 13, no. 49, pp. 282-290, 2019, doi: 10.3221/IGF-ESIS.49.28.

[14] N.T. Thu, N.D. Trung, "Effect of technological and geometrical parameters on formation of radius region at cylindrical product bottom in hydrostatic forming," *J. Korean Soc. Precis. Eng.*, vol. 36, no. 9, pp. 891-900, 2019, doi: 10.7736/KSPE.2019.36.9.891.

[15] "On the High Fluid Pressure in Hydrostatic Forming for Sheet Metal," *Int. J. Precis. Eng. Manuf.*, vol. 21, no. 12, pp. 2223-2233, 2020, doi: 10.1007/s12541-020-00426-5.

[16] R. Vasile, "Designing a Die for Hydroforming," *ACTA Univ. Cibiniensis*, vol. 68, no. 1, pp. 7-11, 2016, doi: 10.1515/aucts-2016-0002.

[17] R. Vasile, S. Racz, O. Bologa, "Numerical and experimental analysis of the formability of 1. 4301," vol. 11, no. 2, pp. 89-94, 2025.

[18] "Development of a hydroforming setup for deep drawing of square cups with variable blank holding force technique," *Int. J. Adv. Manuf. Technol.*, vol. 66, no. 5-8, pp. 1159-1169, 2013, doi: 10.1007/s00170-012-4397-4.

[19] F. Qayyum, "Complex Shape Sheet Hydroforming," no. July, 2017, doi: 10.13140/RG.2.2.13352.26888.

[20] H. Hu, J.F. Wang, K.T. Fan, T.Y. Chen, S.Y. Wang, "Development of sheet hydroforming for making an automobile fuel tank," *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, vol. 229, no. 4, pp. 654-663, 2015, doi: 10.1177/0954405414554666.

[21] M. Salahshoor, H. Gorji, M.B. Jooybari, A. Gorji, M. Bakhshi-Jooybari, "Analysis of the effects of tool and process parameters in hydroforming process," *Comput. Mech. Mechatronics Eng.*, pp. 4-5, 2016, [Online]. Available: https://www.researchgate.net/publication/311543853

[22] T.K. Le, T.T. Nguyen, N.T. Bui, "Experimental modeling of pressure in the hydrostatic formation of a cylindrical cup with different materials," *Appl. Sci.*, vol. 11, no. 13, 2021, doi: 10.3390/app11135814.

[23] B. Modi, D.R. Kumar, "Optimization of process parameters to enhance formability of AA 5182 alloy in deep drawing of square cups by hydroforming," *J. Mech. Sci. Technol.*, vol. 33, no. 11, pp. 5337-5346, Nov. 2019, doi: 10.1007/s12206-019-1026-2.

[24] P.P. Date, K.A. Padmanabhan, "On the formability of 3.15 mm thick low-carbon steel sheets," *J. Mater. Process. Tech.*, vol. 35, no. 2, pp. 165-181, 1992, doi: 10.1016/0924-0136(92)90244-M.

[25] A. Jaber, A. Mohammed, K. Younis, "Improvement of Formability of AISI 1006 Sheets by Hydroforming with Die in Square Deep Drawing," *Eng. Technol. J.*, vol. 0, no. 0, pp. 1-9, 2023, doi: 10.30684/etj.2023.141104.1482.

[26] ASTM, "A370: Standard Test Methods and Definitions for Mechanical Testing of Steel Products," *ASTM Int.*, pp. 1-50, 2014, doi: 10.1520/A0370-11.2.

[27] "Standard Test Method for Tensile Strain-Hardening Exponents (n-Values) of Metallic Sheet Materials," *ASTM B. Stand.*, vol. 03, pp. 1-8, 2000, doi: 10.1520/E0646-07E01.2.

[28] T.T. Nguyen, N.D. Trung, "On the thinning variations in hydrostatic forming of sheet metal," *J. Mech. Eng. Sci.*, vol. 15, no. 1, pp. 7824-7836, 2021, doi: 10.15282/jmes.15.1.2021.17.0617.

[29] J.L. Serfontein, O. Damm, N. Sacks, W.T. Gerber, M.J. Botha, "Die Sheet Hydroforming of a Complex-Shaped Aa2024-W Aircraft Skin Panel – From Concept To Final Component," Stellenbosch University, 2021. doi: 10.7166/32-4-2502.

[30] T. Thu, "Influence of of blank holder pressure on product Influence blank holder pressure on product quality in the quality in the hydrostatic forming for sheet metal hydrostatic forming for sheet metal," no. 116, pp. 1-15, 2022.

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