

A TISZTA ALUMÍNIUM AEROSOL ÜTŐ EXTRUDÁLÁSSAL TÖRTÉNŐ GYÁRTÁSÁNAK NUMERIKUS SZIMULÁLÁSA

NUMERICAL SIMULATION OF IMPACT EXTRUSION FOR PURE ALUMINUM AEROSOL CAN MANUFACTURING

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ABSTRACT

Impact extrusion is a supreme manufacturing process for seamless aerosol can. Reducing can thickness and eliminating of decrease in mechanical properties after the internal coating is critical problems of current aerosol can industries. Through selecting highly strength aluminum alloy, there is a possibility of extrusion inhomogeneous wall thickness to manufacture thinner and strengthen aerosol can. Deform 2D is optimistic FEM software to model and simulate inhomogeneous wall thickness, as a result, it can acquire defect-free can shoulder at the necking stage.

1. INTRODUCTION

Aerosol cans are thin wall aluminum cans used as the packaging of cosmetics, chemicals, pharmaceuticals, foodstuffs, and household products. In 2015, about 7.7 billion aluminum aerosol cans were produced worldwide [1].

Aerosol cans manufacturing process consists of the following stages (figure 1) [4]:

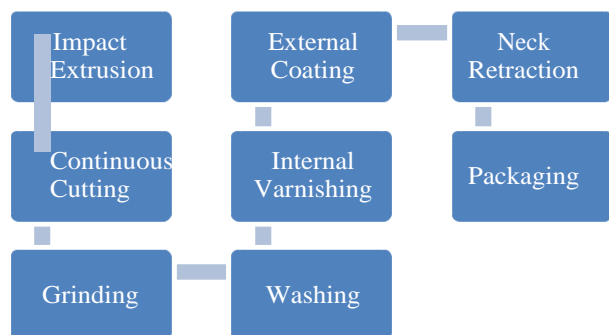


Figure 1: Manufacturing process stages

2. LITERATURE REVIEW

Few publications have been investigated related to numerical simulation of the extrusion process and aerosol can manufacturing.

One might cite the work carried by Abrinia and Kaveh Gharibi an investigation on axisymmetric finite element simulation of backward extrusion process for thin-walled lead can manufacturing using ABAQUS. The simulation

was considered different punch head profile and fillets for different can thicknesses [5].

F. Belblidia and T.N. Croft., carried out on Simulation-based aerosol can design under pressure and buckling loads. They used Ansys was used as a finite element software to simulate aerosol can seeks to predict the level of pop-up and burst pressure levels for can buckling. Numerical findings are assessed against experimental trials for the reliability of such a simulation-based approach for can design [6].

Yahya Mahmoodkhani, and Mary A. Wells., published on Numerical modeling of the material flow during extrusion of aluminum alloys. Using DEFORM 2D simulation of the hot extrusion process for AA3003 aluminum alloys was investigated. In this investigation, the temperature, strain rate, and strain distribution in the billet/extrudate at any position in the container and die have been predicted. Validation of the numerical model, by comparison to industrial data, has been developed and validated [7].

László Péter KISS also investigated the effect of various imperfections on the buckling of an aerosol can. The commercial Abaqus finite element software was used with the Static, Riks step to trace the equilibrium path in order to predict buckling load. In this article, the effect of small errors of material, geometry, tool angle on the load-bearing abilities of an aluminum aerosol can is investigated [8].

2.1 Aerosol can materials

The most commercially popular aerosol can materials are pure aluminum alloy (99.5% or 99.7% purity level) [1]. To some extent, other types of aluminum alloy were investigated by different scholars.

Stanislav Kores and Jozef Medved modified the standard aluminum for the development of AlMn0.3 alloy and AlMn0.6 alloy. Through this alloy, decreasing of mechanical properties of the material after internal coating decreased by 15.9 % and from the AlMn0.6 alloy by 6.5 % with compared to 99.5 % or 99.7% purity level aluminum alloy [2].

Kores, Stanislav introduced AlMn0.6 alloy with the addition of 0,115 Zr for aerosol can manufacturing. The addition of Zr raises the recrystallization threshold of the material above 300 °C and alloying elements Fe, Mn, Ti and Si form intermetallic phases which strengthen the aluminum matrix [9]. Through this invention, the minimal decrease in mechanical properties after internal

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coating as well as 3-5 bar higher deformable and burst pressure was achieved [9].

2.2. Current challenges of Aerosol can manufacturing

When manufacturing of aerosol can, the decrease in mechanical properties after internal coating at high temperature as well as achieving higher deformable and burst pressure aerosol can is challengeable. At the same time reduction of can thickness is very crucial in order to reduce the cost of an aerosol can. But improving the extrusion process to achieve defect-free shoulder at the necking stage is mandatory.

2.3 Finite element simulation of extrusion process

The finite element method (FEM) is a powerful numerical tool for the design (optimize) of a backward extrusion process. It helps to reduce the cost of process trials and times [10] [6].

Numerical simulations are therefore an ideal tool to achieve the desired (and optimum) impact extrusion for aerosol can design and manufacturing to reduce manufacturing time and cost [6]. Both strain and stress distribution influenced by area reduction of backward extrusion should be properly investigated. Die geometry, extrusion velocity, lubrication, workpiece material, and accuracy also important parameters to design cold backward extrusion [11].

Unlike general purpose FEM codes, DEFORM 2D/3D is impeccable for deformation modeling and simulation of backward extrusion. A user-friendly graphical user interface provides easy data preparation and analysis for manufacturing engineers. It is a fully automatic and optimized system, fitted for the metal extrusion process [12].

3. NUMERICAL SIMULATION OF AEROSOL CAN

Due to the symmetry of the workpiece, the half cross-section and an axisymmetric backward extrusion model was analyzed in Deform 2D FE software. The type of simulation was Lagrangian incremental, as well as the direct iteration method were selected. The material model was defined as plastic. Punches and dies were assumed to be rigid due to negligible elastic deformation whereas the sample material was considered as deformable in the model.

In this study, the work material was commercially pure aluminum, DIN A199.7 [12]. The mechanical properties of the work material are summarized in Figure 2. Figure 3 illustrates the arrangement of the die, punch, and billet for the simulation established by simple geometry in CAD software.

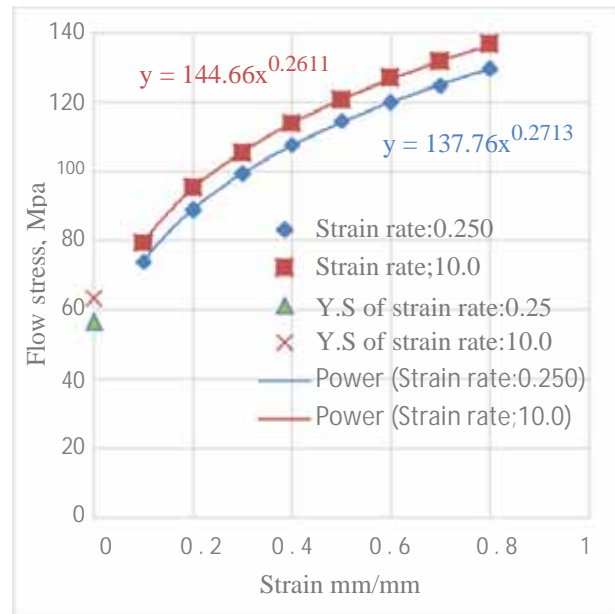


Figure 2: Mechanical properties of DIN A199.7

The dimension of the workpiece was 8.3 mm thickness with 24.5 mm diameter. The punch was inserted at 8.7 mm into the die to get initial position of the process. At the initial position, there is a 0.1 mm gap between the punch and workpiece interface. The displacement of the punch into the die after started the extrusion process was 9.3 mm to remain 0.5 mm bottom thickness of can. The total inserted length of the punch into the die to accomplish the extrusion process was 18 mm. At a die depth of 11.6 mm, extrusion of the wall started with 0.4 mm thickness up to a die depth of 13.86 mm. From die depth of 14.2 mm until the processes stopped, 18 mm, extrusion of the wall with 0.33 mm thickness was followed. Between 13.86 mm and 14.2 mm, depth of die taper wall thickness distribution between 0.4 mm and 0.33 mm was investigated.

The relationships among the length of the can, the thickness of the can, and die depth from Deform 2D simulation have been shown in figure 4. In figure 4 the simple scale picture was put to show where the measurement of length, zero-length, of the bottle started. The effective strain distribution of Deform 2D simulation at extrusion started, at extrusion of wall thickness transition zone, and at the finishing of the extrusion process have been shown in figure 5, 6, and 7. The number of grid elements of wall thickness at extrusion started, intermediated, and finished was three, two, and one respectively. Finally, very fine and uniform wall thickness was investigated.

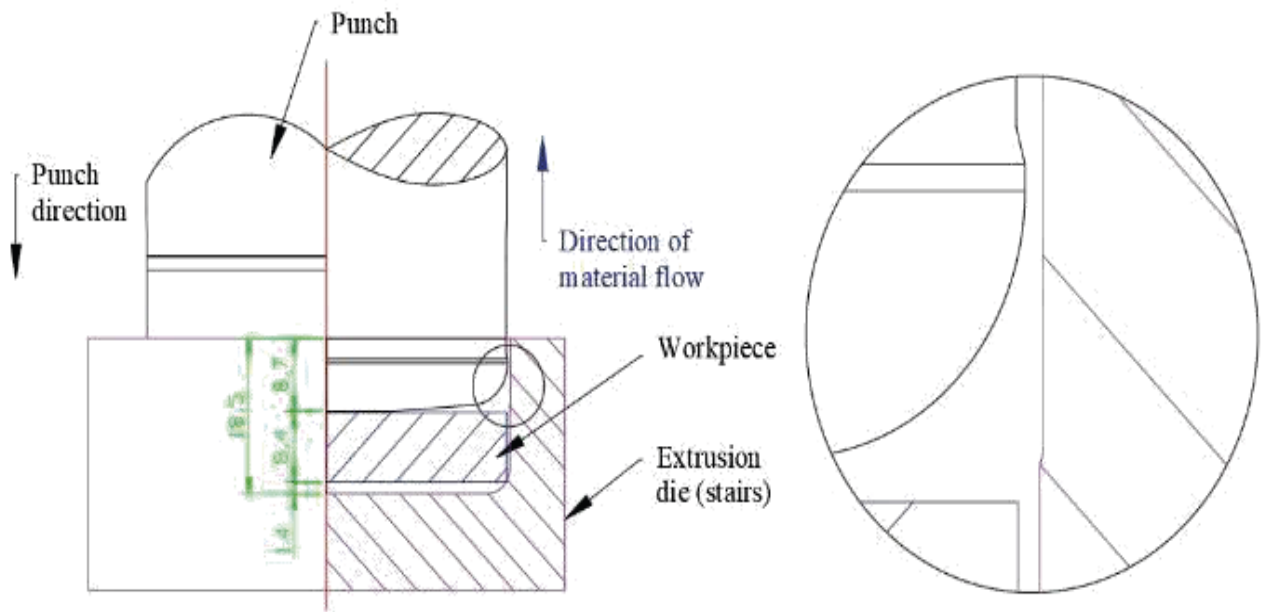


Figure 3: Punch, workpiece and die arrangement

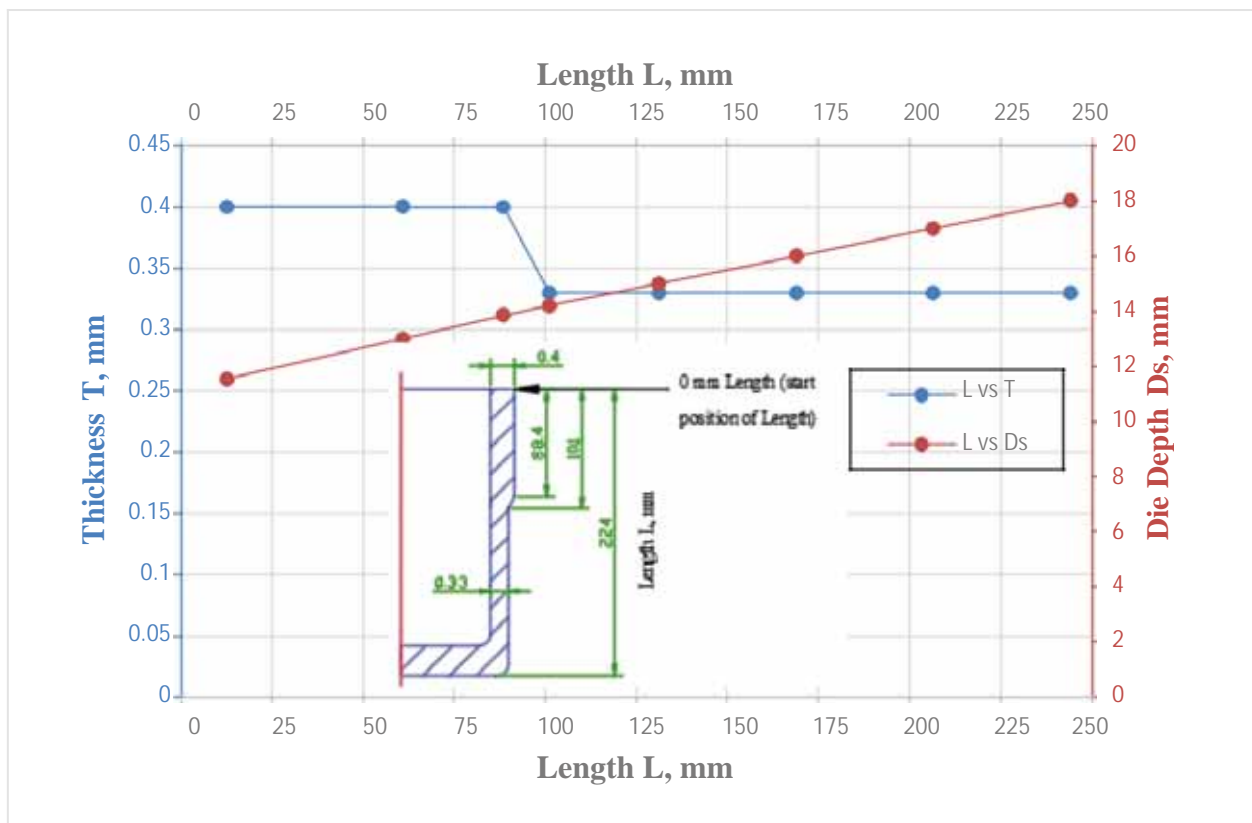


Figure 4: The relationships among the length of can, thickness of can and die depth

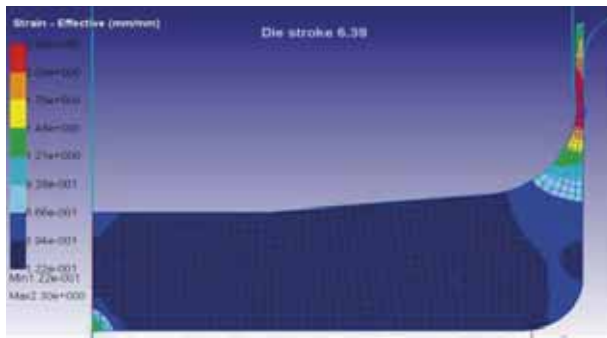


Figure 5: effective strain distribution at extrusion started

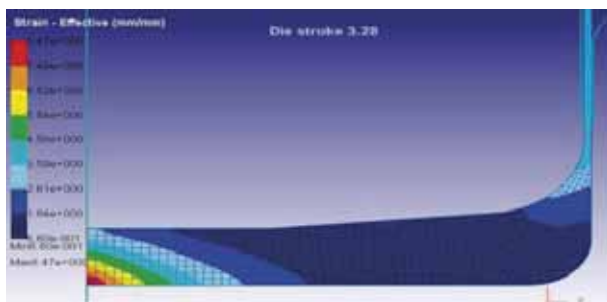


Figure 6: effective strain distribution at extrusion of wall thickness transition zone

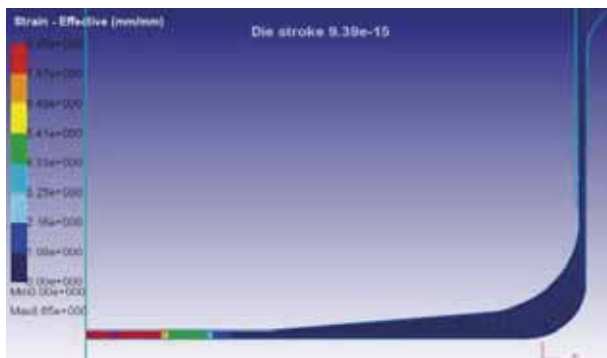


Figure 7: effective strain distribution at finishing of extrusion process

4. CONCLUSION

Subtling aerosol can material by highly strengthen aluminum alloy is important in order to face the decrease in mechanical properties of the aerosol can after internal coating as well as achieving higher deformable and burst pressure. Through highly strengthen alloy can, there is the possibility of reducing can thickness as well to reduce the cost of aerosol can.

Modeling, simulation, and analyzing of inhomogeneous wall thickness aerosol can with the experimental study is vital to improve the necking process to acquire defect free can shoulder. DEFORM 2D is ideal FEM codes to model and simulation of impact extrusion of aerosol can with inhomogeneous wall thickness distribution.

5. REFERENCE

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