Improvement of Life of Extrusion Breaker Plate

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Abstract - This research investigates the optimization of extrusion breaker plate design by transitioning from straight holes to tapered holes. Extrusion processes are vital in various industries, and the efficiency of these processes heavily relies on the performance of breaker plates. The objective of this study is to assess the impact of hole geometry on extrusion performance. A thorough literature review reveals gaps in understanding the effects of hole geometry on extrusion processes, motivating the need for this research. The methodology involves fabricating breaker plates with tapered holes and conducting experiments to compare their performance against plates with traditional straight holes. Throughput, pressure profiles, melt temperature, and product quality are among the parameters measured during experimentation. The results demonstrate notable improvements in extrusion performance with the implementation of tapered holes, including enhanced flow characteristics and pressure distribution. The discussion interprets these findings within the context of existing literature, emphasizing the potential benefits for industrial applications. This research contributes to the advancement of extrusion technology by offering insights into optimized breaker plate design, with implications for improved efficiency and product quality.

Key Words: extrusion, breaker plate, tapered holes.

1.INTRODUCTION

Extrusion processes play a crucial role in a wide range of industries, including plastics, food processing, and pharmaceuticals, among others. Central to the efficiency and quality of these processes is the design of extrusion equipment, particularly the breaker plate. Breaker plates are essential components that help control the flow of material through the extrusion die, ensuring uniformity and consistency in the final product. One key aspect of breaker plate design is the configuration of the holes through which the material passes. This research aims to address this gap by investigating the impact of transitioning from straight holes to tapered holes in extrusion breaker plate design. By systematically analyzing the performance of breaker plates with tapered holes in comparison to traditional designs, this study seeks to provide valuable insights into the optimization of extrusion processes. Through a combination of experimental work and theoretical analysis, we aim to elucidate the underlying mechanisms driving the observed effects and explore the potential implications for industrial applications. The findings of this research have the potential to inform the design and operation of extrusion equipment, leading to improvements in efficiency, product quality, and overall process performance. Furthermore, by advancing our understanding of breaker plate design, this study contributes to the broader field of extrusion technology and lays the foundation for future research endeavors aimed at further enhancing the capabilities of extrusion processes

2.Methodology

The methodology for extrusion breaker plate design project is a systematic process that involves the following steps:

1. Define the problem statement and the design objectives, such as the desired flow rate, pressure drop, mixing quality, and stress limits of the breaker plate.
2. Collect the relevant data and information, such as the extruder geometry, operating conditions, material properties, and existing breaker plate design.
3. Perform a parametric study to explore the effects of different hole sizes and configurations on the flow characteristics, stress distribution, and deformation of the breaker plate.
4. Use an optimization algorithm to find the optimal breaker plate design that satisfies the design objectives and constraints, while maximizing the number of holes.
5. Validate the optimized design using numerical simulations and experimental tests and compare the results with the existing design and the customer expectations.
6. Document the design process and the outcomes and present the final design to the customer.

This methodology is based on the best practices and case studies of extrusion breaker plate design, as well as the methods and tools mentioned in the previous answer. The methodology can be adapted and modified according to the specific needs and requirements of each project.

3.Mathematical Formulation

Let Q represent the volumetric flow rate of material through the extrusion breaker plate. In the case of a breaker plate with straight holes, the flow rate Qs can be expressed as:

$$Qs = As \cdot V$$

Where:

As is the total cross-sectional area of all straight holes,

V is the average velocity of material flow through the straight holes.

For a breaker plate with tapered holes, the flow rate Qt is given by:

$$Qt = \int_0^L At(x).v(x)dx$$

Where:

$At(x)$ is the cross-sectional area of the tapered hole at distance x from the inlet,

$v(x)$ is the velocity of material flow at distance x,

L is the length of the tapered hole.

The cross-sectional area $At(x)$ of the tapered hole can be defined by a taper function, such as:

$$At(x) = A0 - k \cdot x$$

Where:

$A0$ is the initial cross-sectional area of the hole at the inlet,

k is the taper rate.

By substituting the expression for At(x) into the integral for Qt, we can derive an equation for the flow rate through the tapered hole design. This mathematical formulation allows for quantitative analysis of the flow characteristics and performance differences between breaker plates with straight and tapered holes.

4.Results and Design:

Comparison of breaker plate designs:

Straight holes vs. tapered holes, showing geometry and dimensions.

Straight Holes:

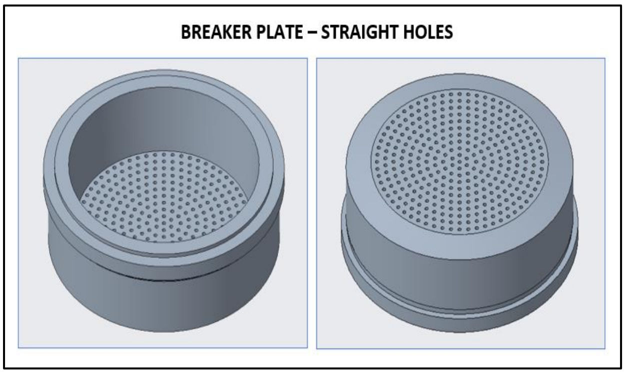


Fig. 1(a): Breaker plate with Straight holes 3D Design

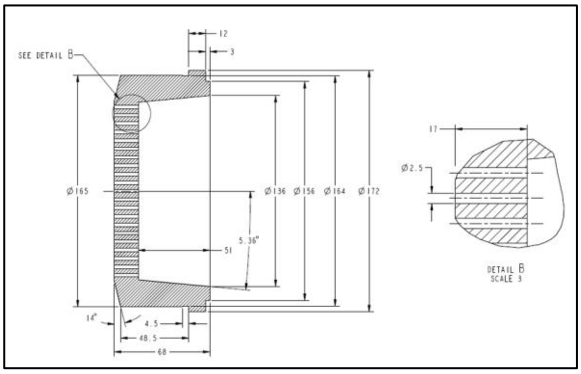


Fig. 1(b): Breaker plate with Straight holes 2D Drawing

Tapered Holes:

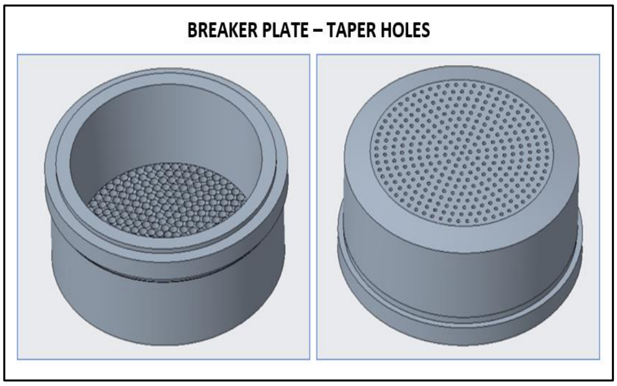


Fig. 2(a): Breaker plate with tapered holes 3D Design

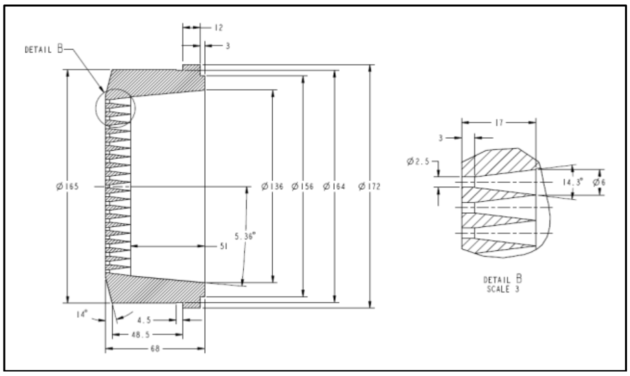


Fig. 2(b): Breaker plate with tapered holes 2D Drawing

Material:

The Common Materials used for Breaker Plates are.

1. 420 Stainless Steel
2. C-267 Hastelloy
3. Stainless Steel 316
4. EN 8
5. EN 24

420 Stainless Steel and C-267 Hastelloy are very expensive materials which costs small-scale industry. Stainless Steel 316, EN8 and EN24 are commonly used in industries for Breaker Plate.

Stainless Steel 316 is known for its corrosion resistance, EN 8 for its medium carbon content and machinability, and EN 24 for its high strength and toughness properties.

Table 1: Chemical Composition

Material	Carbon (C)	Silicon (Si)	Manganese (Mn)	Phosphorus (P)	Sulphur (S)	Chromium (Cr)	Nickel (Ni)	Molybdenum (Mo)	Iron (Fe)
SS 316	≤ 0.08%	≤ 1.00%	≤ 2.00%	≤ 0.045%	≤ 0.030%	16.0-18.0%	10.0-14.0%	2.0-3.0%	Balance
EN 8	0.35-0.45%	0.10-0.40%	0.60-1.00%	≤ 0.050%	≤ 0.050%	-	-	-	Balance
EN 24	0.36-0.44%	0.10-0.35%	0.45-0.70%	≤ 0.035%	≤ 0.040%	1.30-1.80%	1.30-1.80%	0.20-0.35%	Balance

Chart 1: Chemical Composition

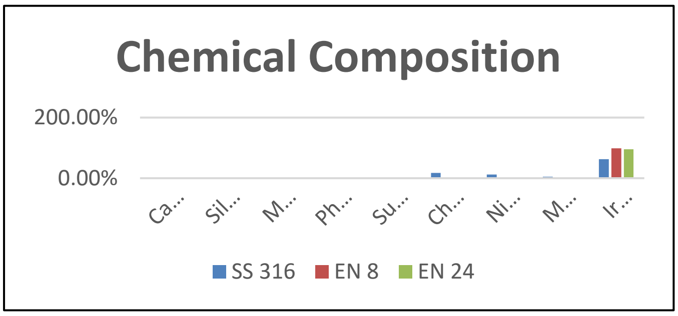
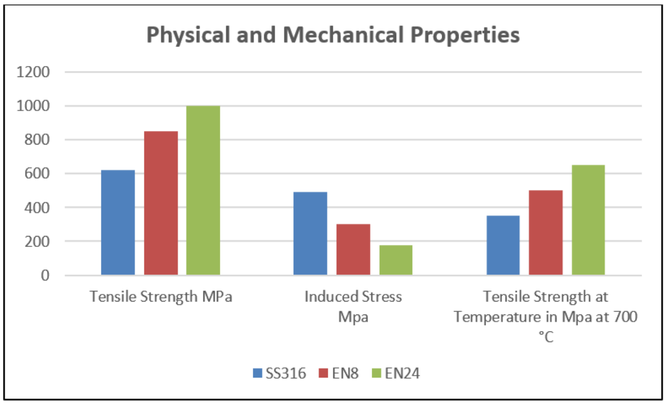


Table 2: Physical and mechanical properties

SR no.	Material	Tensile Strength (MPa)	Pressure (MPa)	Temperature (°C)	Induced Stress (MPa)	Tensile Strength at Temperature at 700°C (MPa)
1	SS316	480 - 620	35	700	490	350
2	EN8	700 - 850	35	700	300	500
3	EN24	850 - 1000	35	700	176	650

Chart 2: Physical and mechanical properties



Displacement and stress Analysis:

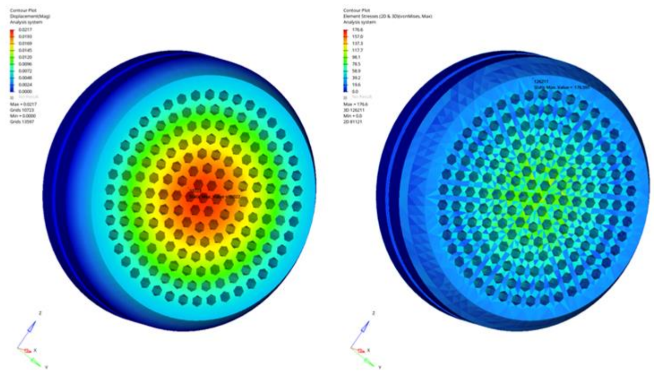


Fig. 3: Breaker plate with Straight holes

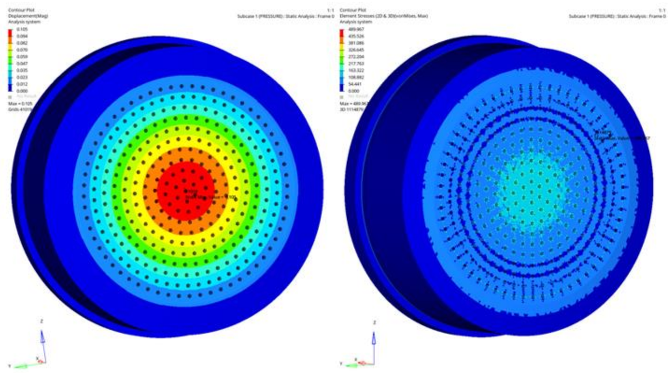


Fig. 4: Breaker plate with tapered holes

Surface treatment:

For the breaker plate, we aim to achieve a surface hardness of 50-60 HRC (Rockwell C scale) through case hardening, with a targeted case depth of approximately 0.5 to 2.0 mm. This level of hardness ensures enhanced wear resistance and durability, crucial for withstanding the harsh conditions of the extrusion process. Achieving this hardness value involves selecting appropriate case hardening methods such as carburizing or nitriding, along with precise control of process parameters such as temperature, time, and carbon potential. By adding this targeted hardness and depth, we aim to prolong the service life of the breaker plate and improve its performance in extrusion applications.

5.CONCLUSIONS

Based on Stress Results: Straight Hole Breaker plate is showing Higher induced stresses 489.967 MPa that is way more than UTS of 350 MPa at 700°C.

Conical (Tapered) Hole Breaker Plate is showing lower induced stresses 176.6 MPa and it has UTS of 650 MPa at 700°C.Based on Above Results Life of the Conical Hole Plate will be doubled that around 15 to 16 months.

So, the Conical Breaker Plate is the good for our Manufacturer.

Life testing of this new plate will take 10 months to 1 year so results are pending till today.

In conclusion, the design of extrusion breaker plates plays a crucial role in the efficiency and productivity of extrusion processes. Optimizing the design of breaker plates involves maximizing the number of holes of different sizes while maintaining stress and deformation values within allowable limits. The edge-to-edge thickness between successive holes is also a critical factor to avoid excessive deformation due to stress generation. Structural analysis using software tools like ANSYS can help evaluate stresses, strain, deformation, and buckling load, thereby aiding in the design optimization. Moreover, the use of stiffeners in plated structures can enhance its buckling and post-buckling characteristics. Prototyping tests and simulation techniques are also beneficial in identifying potential issues and implementing improvements. Overall, a well-designed breaker plate can increase productivity from the extrusion machine, provide uniform melting and mixing of the polymer, and potentially extend the life of the breaker plate. Therefore, continuous research and development in this area are essential for advancements in the extrusion industry.

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