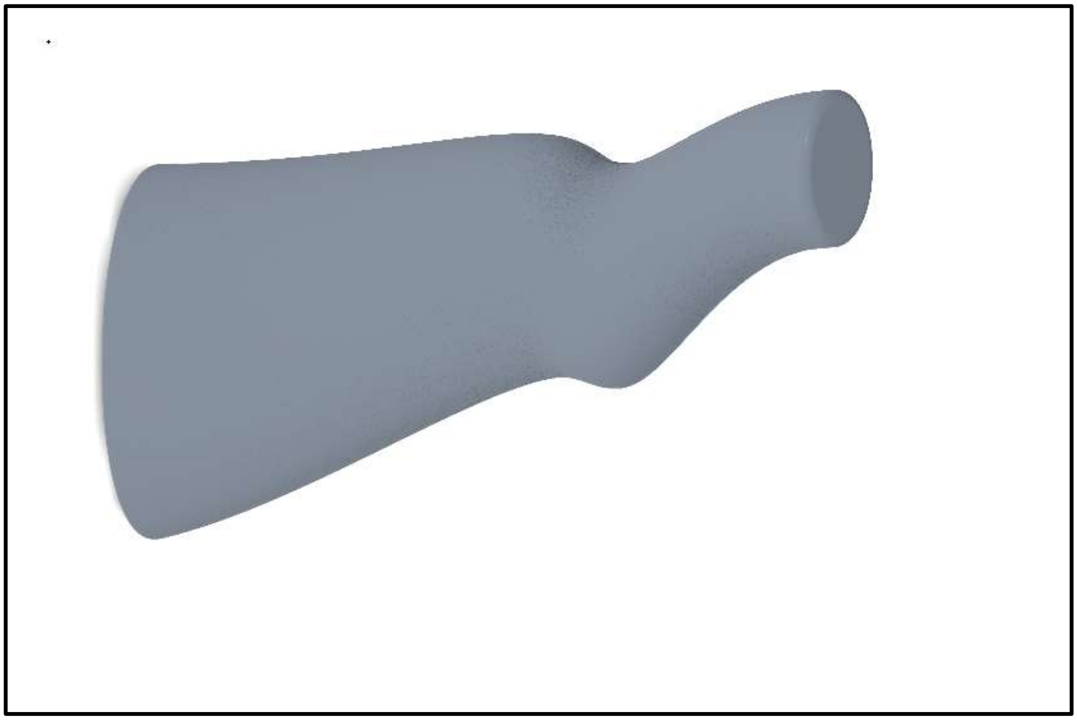
Blow Molded .22 Rifle Stock



By: Michael Quinn, Keegan Watkins, Payton McKee

Penn State Behrend

April 30th, 2025

Contents

Abstract

This project focuses on the design and development of a blow-molded .22 caliber rifle stock, aimed at reducing material costs while maintaining the strength and durability traditionally expected in firearm components. By utilizing High-Density Polyethylene (HDPE) and extrusion blow molding techniques, the design achieves lightweight construction, structural reliability, and cost efficiency. Finite element analysis (FEA) was conducted to compare HDPE and Polypropylene (PP), confirming HDPE's superior toughness despite PP demonstrating lower deformation. The Bekum XBlow 100 extrusion blow molding machine was selected for production due to its precision parison control and compatibility with aluminum tooling. Blow molding was evaluated against injection molding, rotational molding, and thermoforming, and was identified as the optimal manufacturing process based on performance, cost, and production efficiency. This work demonstrates a practical approach to modernizing firearm stock production, leveraging advanced polymer processing techniques for high-volume, durable consumer products.

Introduction – Product Description and Details

The blow-molded .22 rifle stock is designed to reduce material usage while maintaining the structural strength and durability of a traditional solid gun stock. This design prioritizes lightweight construction without compromising performance, aiming to deliver a cost-effective alternative for recreational and competitive firearm applications. The product will feature ergonomic contours, a textured grip, and integrated mounting points for compatibility with standard rifle components.

Figure 1: Wooden .22 Stock

Historically, rifle stocks have been made from solid wood or injection-molded thermoplastics, both of which offer strength and rigidity but come with trade-offs. Wooden stocks, while traditional, are heavier and more expensive to machine. Injection-molded designs improve weight and manufacturing efficiency but require high tooling costs and often rely on thick, solid wall sections, increasing material use. The development of blow-molded stocks represents a significant advancement by leveraging hollow geometries that reduce weight and cost without compromising performance. This innovation allows manufacturers to meet strength requirements while optimizing for material efficiency, rapid production, and ergonomic customization. [1]

Figure 2: Injection Molded .22 Rifle Stock

Blow molding is a highly suitable manufacturing method for the .22 rifle stock due to its ability to produce lightweight, hollow structures with complex geometries and uniform wall thickness. The process is especially advantageous for reducing material costs without compromising the mechanical strength needed for firearm support components. In contrast to solid injection molded stocks, blow-molded parts can achieve similar stiffness and durability with a fraction of the material, significantly lowering production costs and cycle times.

Blow Molding Application

Extrusion blow molding allows for flexible design freedom, enabling the integration of reinforcement ribs, ergonomic surfaces, and mounting inserts directly into the part. It also accommodates rapid prototyping and high-volume manufacturing with relatively low tooling costs compared to injection molding. Additionally, the smooth, seamless surface produced by blow molding reduces the need for secondary finishing operations. These benefits make blow molding the optimal process for a rifle stock that must be strong, affordable, and lightweight.

Design Details

Creo Parametric Version 8.0.8.0 was used to model the .22 Rifle Stock. The critical design parameters for the .22 stock include uniform wall thickness ranging from 6 mm +/- .05 mm to ensure strength and comfort. Additional reinforcement near the hinge area enhances durability for repeated use. A minimum draft angle of 1 degree facilitates part removal from the mold, while shrinkage of approximately 2-3% must be accounted for in the mold design.

Design for manufacturability is achieved by avoiding sharp corners to reduce stress concentrations and improving mold release. A slight texture on the seating surface enhances comfort and aesthetics while ensuring an easy-release mold surface. The proposed design is shown in Figures 3-4.

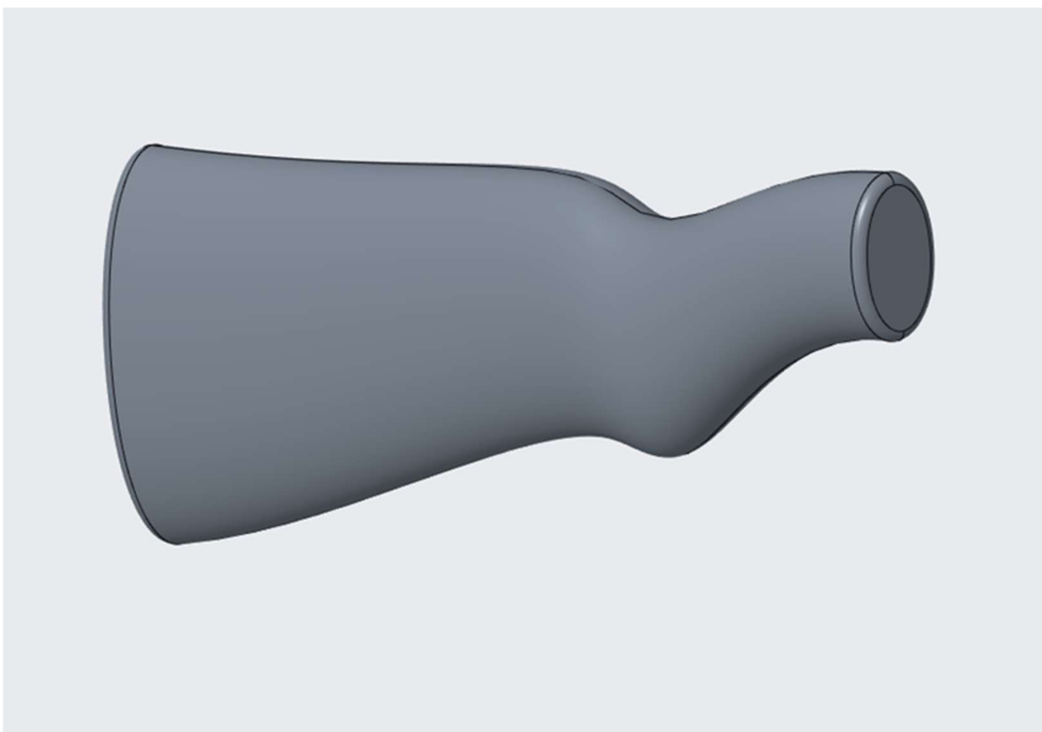


Figure 3: Isometric view

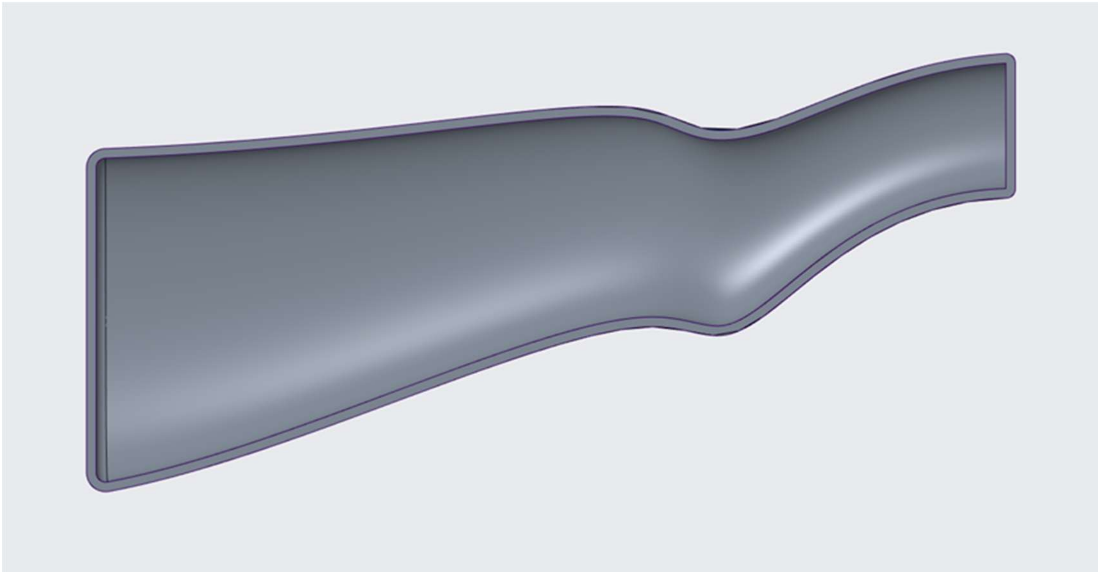


Figure 4: Section View across midplane with a wall thickness of .125 inches

Design Specifications

1. Design Specifications Recoil Performance – FEA simulations will be used to validate maximum equivalent stress and deflection. The average free recoil energy of a .22LR cartridge is .12 ft-lbs. This simulation will be completed at 5 ft-lbs to ensure a large factor of safety.[2]
2. Thermal Stability – The stock must retain structural integrity across an operational temperature range of -20°C to 60°C, resisting deformation, softening, or stiffness loss. This will be validated via simulation; testing aligns with ASTM D638 (tensile properties) and MIL-STD-810G (environmental resilience), ensuring compliance with global durability requirements.[3,4]
3. Chemical Resistance – The stock must resist degradation from standard firearm cleaning agents and oils without discoloration or material fatigue. HDPE's chemical resistance is considered sufficient for these requirements.
4. Material Purity – The selected resin must be free of fillers, contaminants, or recycled content that could compromise mechanical integrity or appearance.
5. Compliance Standard – The rifle stock must meet ASTM D4329 standards for UV exposure and long-term outdoor durability.[5]

Material Selection

Polyolefins such as polyethylene and polypropylene are the most commonly used materials in blow molding due to their low cost, durability, and ease of processing. Their ability to form hollow shapes with consistent wall thickness and good impact resistance makes them especially well-suited for structural consumer products.

Two materials were considered for the blow-molded .22 rifle stock: High-Density Polyethylene (HDPE) and Polypropylene (PP). Both exhibit excellent chemical resistance and good moldability, but they differ in mechanical performance and suitability for firearm applications.

HDPE is a robust, impact-resistant material with high tensile strength and excellent toughness, making it ideal for absorbing recoil energy and resisting drop impact. It offers excellent dimensional stability, and low moisture absorption, and maintains its mechanical properties in a variety of climates.[6] HDPE is widely used in blow-molded containers, tanks, and automotive components due to its high strength-to-weight ratio and reliability.

Polypropylene is stiffer and slightly lighter than HDPE and offers superior performance in high-temperature environments. However, its lower impact resistance and higher brittleness, particularly in cold conditions, pose challenges for use in an outdoor firearm accessory. While PP offers good rigidity and chemical resistance, it is more prone to cracking under repeated stress, which could compromise performance during recoil events.

To validate HDPE as the superior material, an ANSYS finite element analysis (FEA) will be conducted comparing both materials under equivalent load conditions representative of firearm recoil. The simulation will evaluate deformation and stress concentration, with the expectation that HDPE's higher impact resistance and lower deflection under load will outperform PP.

Based on these factors, HDPE is selected as the preferred material due to its superior balance of strength, toughness, and processability. It is expected to maintain shape and structural reliability over the product's lifespan without requiring excessive wall thickness or reinforcement. FEA results presented later in the report will further support this selection.

Mold Design

The mold for the blow-molded .22 rifle stock will be constructed from aluminum to reduce cycle times and provide good thermal conductivity for faster cooling. A two-part mold design is proposed, with the parting line positioned along the vertical midplane of the stock. This allows for consistent wall thickness around the cheek rest, and grip, while also simplifying demolding.

The mold will include precision-machined pinch-off areas at the muzzle and buttstock ends to seal the parison and create clean parting edges. Strategic use of vent holes will be included near deep-draw sections such as the trigger mount zone to reduce the risk of voids or incomplete expansion.

A two-piece aluminum mold with parting lines positioned for easy demolding is necessary. Figures 5 and 6 show the preliminary designs for a mold split showing the A and B sides of the mold, with proper draft applied.

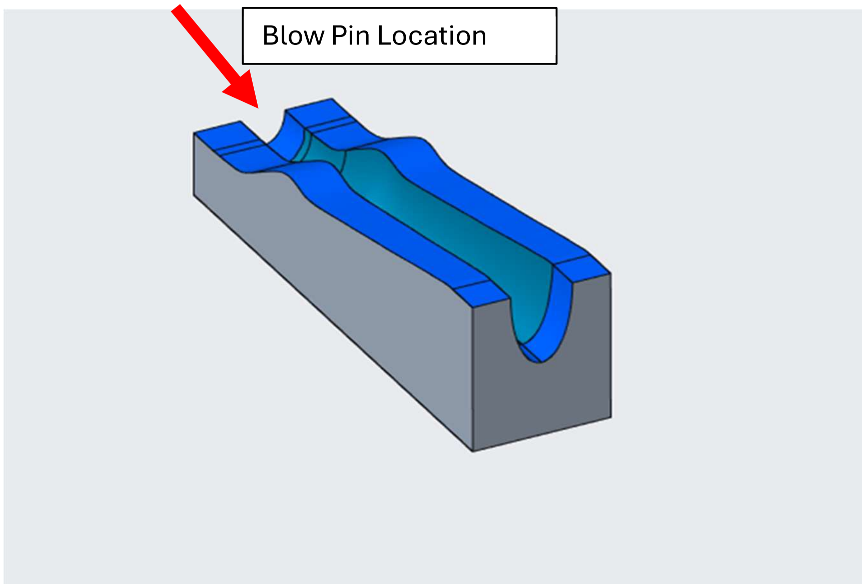


Figure 5: A side of the mold

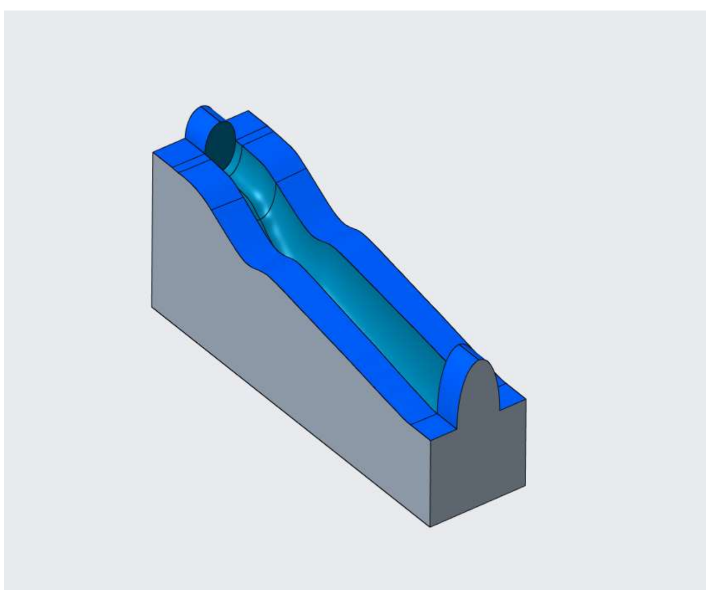


Figure 6: B side of the mold

Draft Analysis

A draft analysis was conducted using a 1-degree draft angle, incorporating a split draft hinge at the parting line to ensure proper mold release and minimize defects. The 1-degree draft angle was selected to facilitate the demolding process while maintaining the structural integrity of the part.

The split draft hinge at the parting line was implemented to prevent undercuts and ensure a clean separation between mold halves, reducing the risk of sticking or material tearing during demolding. This design consideration helps maintain consistent wall thickness around the hinge area while allowing for proper venting and cooling. This is seen in Figures 7 and 8.

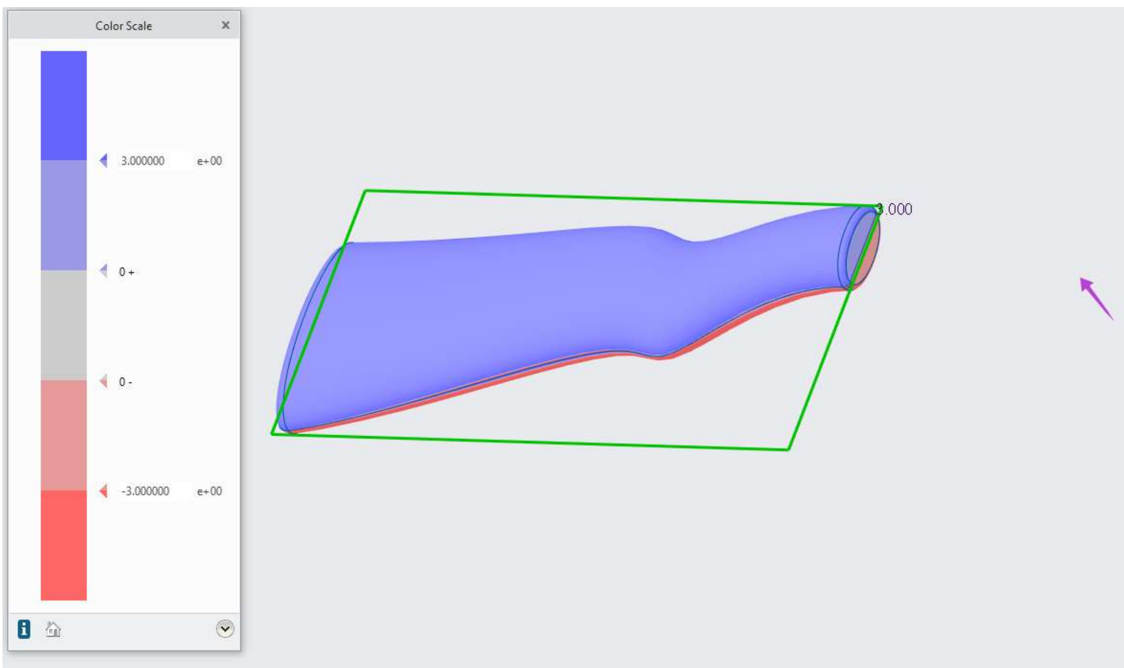


Figure 7: Top-side draft analysis

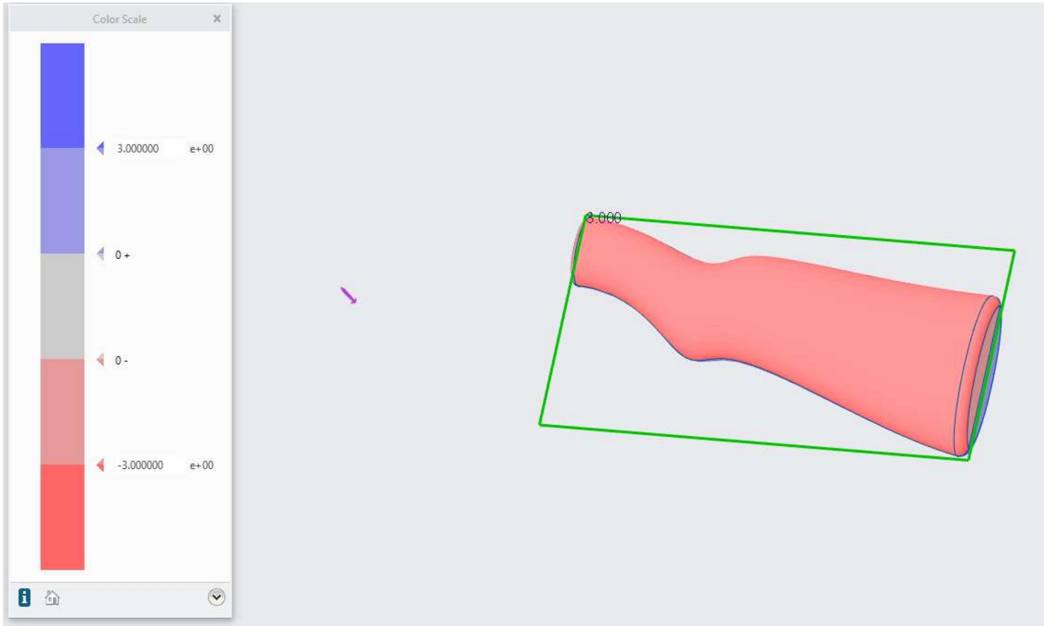


Figure 8: Bottom Side Draft analysis

Manufacturing Details

The manufacturing process begins with the extrusion of a molten parison, which is positioned between the two halves of an open mold. The mold then closes, pinching and sealing the ends of the parison. Compressed air is introduced, inflating the parison so that it conforms to the interior contours of the mold cavity.

Once the plastic takes the shape of the mold, the part is cooled using a combination of air and water-cooled channels within the aluminum mold. This controlled cooling process helps minimize warpage, shrinkage, and residual stresses. After sufficient cooling, the mold opens, and the rifle stock is ejected.

Trimming operations follow to remove flash from the pinch-off areas at both ends of the part. Any post-molding operations—such as drilling for hardware, adding inserts, or minor cosmetic clean-up—are performed at this stage.

Blow molding is the most appropriate process for this product due to its ability to create durable, hollow parts with uniform wall thickness and minimal material usage. Unlike injection molding, it does not require high clamping pressures or thick sections. It also eliminates the need for multi-part assemblies, allowing for single-piece construction that is lighter, more ergonomic, and more cost-effective.

Head Type

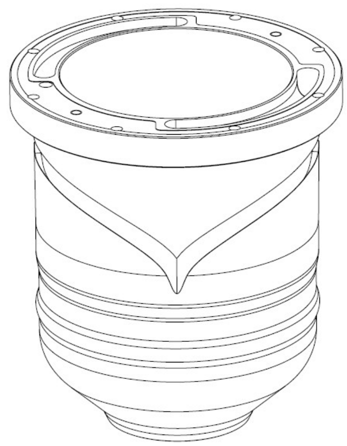


Figure 9: Heart Shaped Pinola

Pinolas are crucial to the design of an extrusion head, helping shape the plastic melt into a parison. Common types include the heart-shaped, spiral, ring distributor, and torpedo pinolas. The heart-shaped pinola is named for its heart-like flow channel, which directs the melt into a parison. In multilayer extrusion, multiple pinolas are nested together.[7]

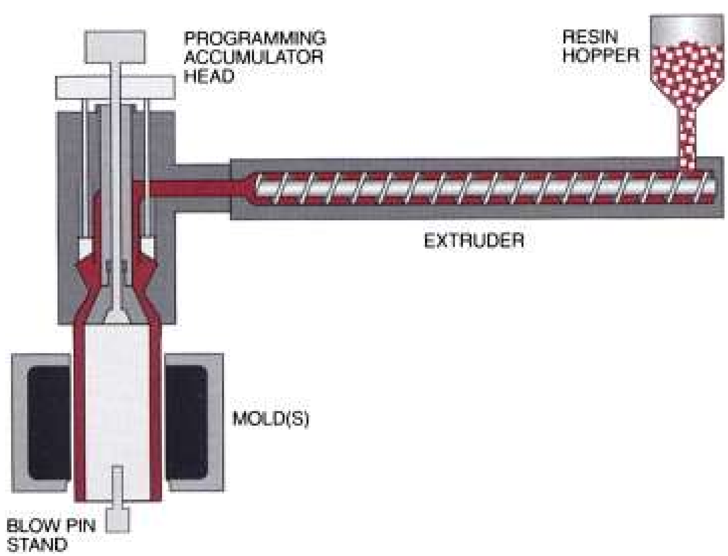


Figure 10: Extrusion Blow Molding Process

Extrusion blow molding is a manufacturing process used to create hollow plastic parts by extruding a tube of molten polymer, called a parison, and then inflating it within a mold cavity to form the desired shape. This method is ideal for producing durable, lightweight, and complex parts with uniform wall thickness. It is widely used for industrial containers, automotive components, and consumer products due to its flexibility, fast cycle times, and cost-effective tooling compared to other molding processes.[8]

Comparison to Other Manufacturing Processes

Table 1: Common Plastics Manufacturing Processes (values given in imperial units)

Property Name	Blow Molding	Injection Molding	Rotational Molding	Thermoforming
Shapes	Thin-walled: Cylindrical, Thin-walled: Cubic, Thin-walled: Complex	Thin-walled: Cylindrical, Thin-walled: Cubic, Thin-walled: Complex (Flat)	Thin-walled: Cylindrical, Thin-walled: Cubic, Thin-walled: Complex	Thin-walled: Cylindrical, Thin-walled: Cubic, Thin-walled: Complex
Part size	Envelope: Up to 105 ft^3	Envelope: 0.01 in^3 - 80 ft^3 Weight: 0.5 oz - 55 lb	Envelope: Upto 670 ft^3	Area: 0.04 in^2 - 300 ft^2
Materials	Thermoplastics	Thermoplastics (Composites, Elastomer, Thermosets)	Thermoplastics	Thermoplastics
Surface finish - Ra (μin)	250 - 500	4 - 16 (1 - 32)	6 - 60	60 - 120 (16 - 120)
Tolerance (in.)	± 0.04 (± 0.01)	± 0.008 (± 0.002)	± 0.04 (± 0.016)	± 0.04 (± 0.008)
Max wall thickness	0.015 - 0.125 (0.01 - 0.24)	0.03 - 0.25 (0.015 - 0.5)	0.1 - 0.25 (0.02 - 0.50)	0.015 - 0.15 (0.002 - 0.25)
Quantity	100000 - 1000000 (1000 - 1000000)	10000 - 1000000 (1000 - 1000000)	100 - 1000 (1 - 8000)	10 - 1000 (1 - 100000)
Lead time	Days	Months (Weeks)	Days	Days
Advantages	Can form complex shapes with uniform wall thickness, High production rate, Low labor cost, Little scrap generated	Can form complex shapes and fine details, Excellent surrface finish, Good dimensional accuracy, High production rate, Low labor cost, Scrap can be recycled	Can produce large parts with uniform wall thickness, Low tooling and equipment cost, Little scrap generated	Can produce very large parts, High production rate, Low cost
Disadvantages	Limited to hollow, thin walled parts with low degree of asymmetry, Poor control of wall thickness, Poor surface finish, Few material options, High tooling and equipment cost	Limited to thin walled parts, High tooling and equipment cost, Long lead time possible	Limited to hollow, thin walled parts, Cannot form fine details, Low production rate	Limited shape complexity, Limited to thin walled parts, Scrap cannot be recycled, Trimming is required
Applications	Bottles, containers, ducting	Housings, containers, caps, fittings	Storage containers (tanks, vessels, bins), housings	Packaging, open containers, panels, cups, signs

Compared to injection molding, blow molding requires significantly less tooling investment and offers superior efficiency for producing large, hollow parts. Injection molding delivers higher precision and tighter tolerances but involves higher pressure, heavier molds, and longer setup times. Injection molded stocks may be stronger in localized areas but typically demand more material and post-assembly.[9]

Rotational molding is another viable method for hollow parts, but it involves much longer cycle times and less dimensional control than blow molding. While it offers uniform wall thickness and low internal stress, it lacks the production speed and surface finish quality of blow molding, making it less efficient for high-volume rifle stock production.

Thermoforming is generally used for thin-walled, single-surface parts and cannot produce fully enclosed structures like a rifle stock. It is fast and inexpensive for simpler geometries but lacks the structural robustness and design flexibility of blow molding for this application.

Machine Selection

Figure 11: Bekum XBLOW 100

The rifle stock will be produced using the Bekum XBlow 100 extrusion blow molding machine. This advanced platform supports precision parison control and offers flexible configuration for long, narrow parts like firearm stocks. The machine is capable of:

- Multi-layer extrusion with up to 8 parison points for optimized wall thickness
- Handling molds up to 500 mm wide and 600 mm tall
- Operating at high efficiency for medium- to high-volume production
- Integrating fast cycle times and accurate mold indexing with aluminum tooling

The XBlow 100 is ideally suited for consumer and industrial parts requiring tight dimensional consistency and moderate structural loads. With the aluminum mold configuration, the system will ensure consistent quality, reduced cycle times, and a clean flash profile around the parting line. A technical datasheet for this machine is included in the Appendix.[10]

Advantages and Disadvantages of Extrusion Blow Molding

Blow molding provides several advantages for manufacturing a rifle stock. The process is ideal for forming complex, hollow geometries in a single piece, which reduces the number of components, streamlines assembly, and minimizes opportunities for mechanical failure at joints. It also delivers excellent material efficiency by allowing thinner walls where possible, without compromising structural performance.

The cost of tooling is lower than injection molding, and production rates are fast due to rapid cycle times and simplified trimming. In addition, the seamless surfaces created by blow molding improve product aesthetics and reduce the risk of stress concentrators found at seams or fastener joints.

However, there are trade-offs. Blow molding offers less precision and surface detail than injection molding and may require additional post-processing for tight tolerance features like insert sockets or mounting hardware. Controlling wall thickness throughout irregular geometries can be challenging, requiring careful parison programming and mold design. Additionally, due to the air-inflation process, undercuts and sharp internal corners are difficult to mold, limiting certain design options.[11]

Finite Element Analysis (ANSYS)

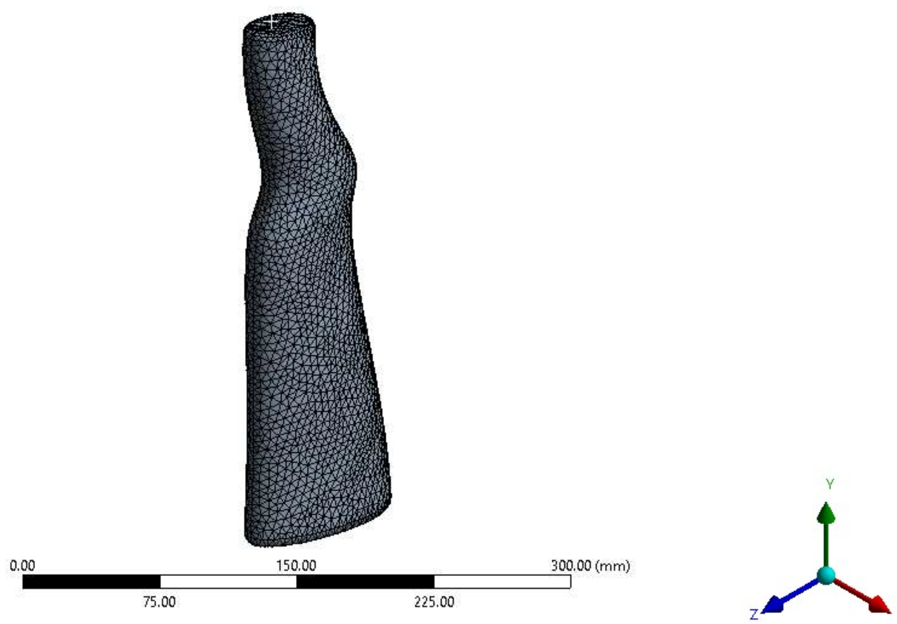


Figure 12: Mesh Plot of the .22 stock with 32625 nodes and 16343 elements

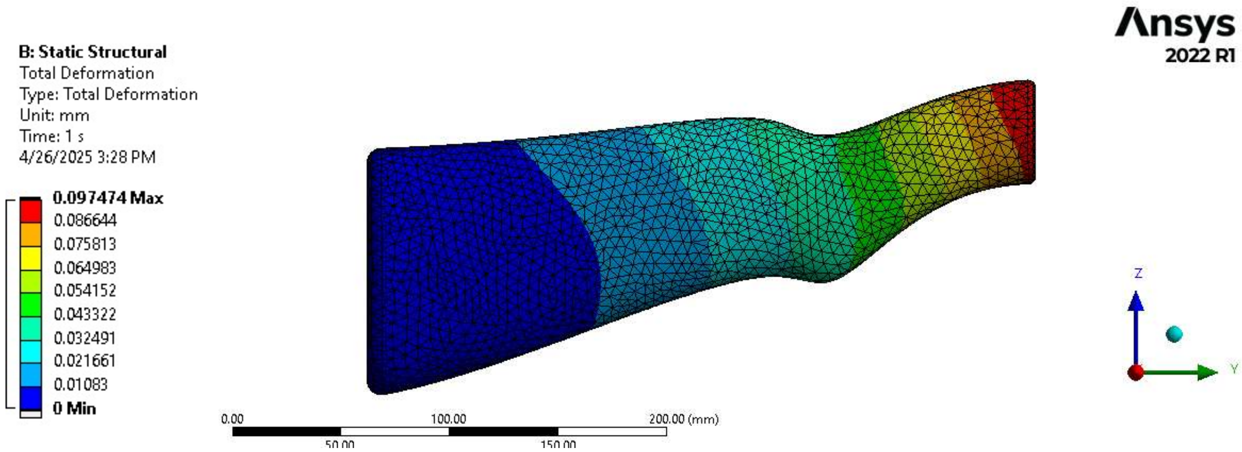


Figure 13: PP Total Deformation Plot

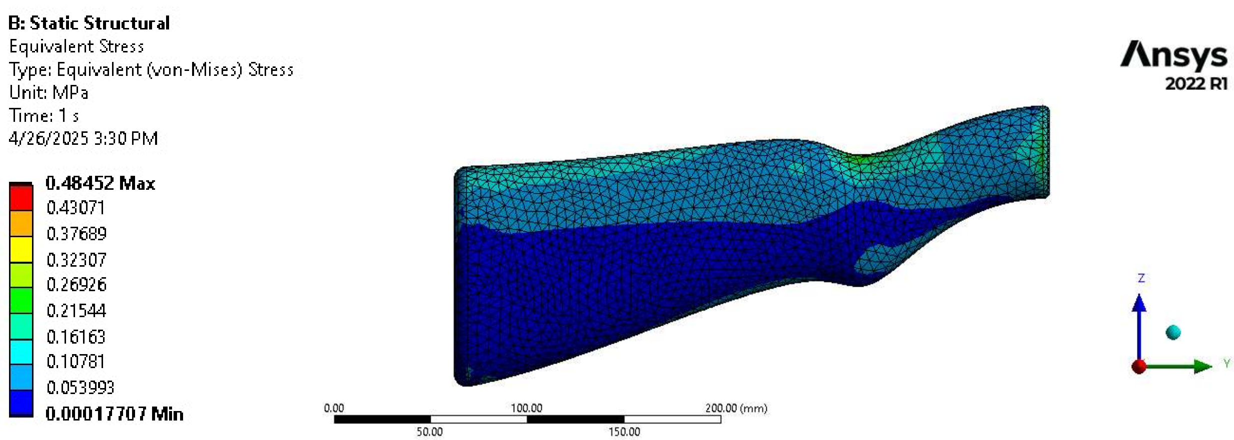


Figure 14: PP Equivalent Stress Plot

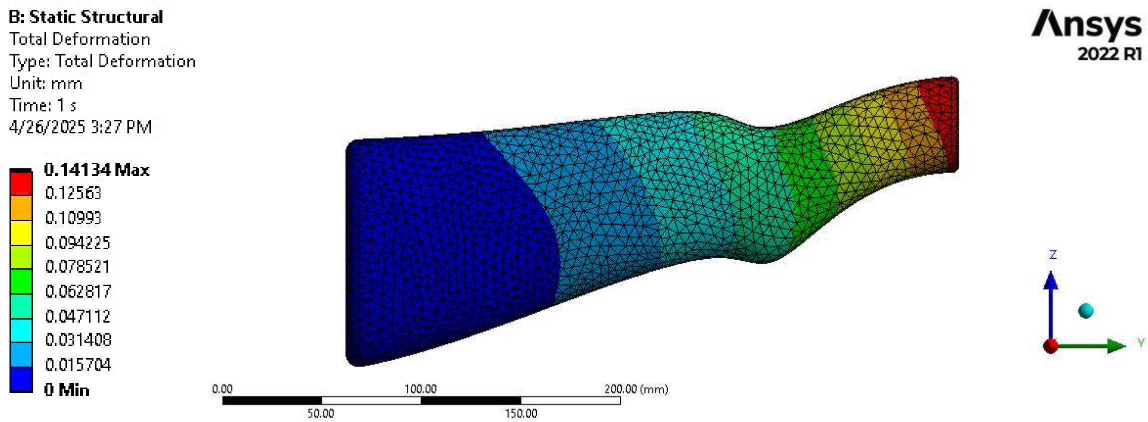


Figure 15: HDPE Total Deformation Plot

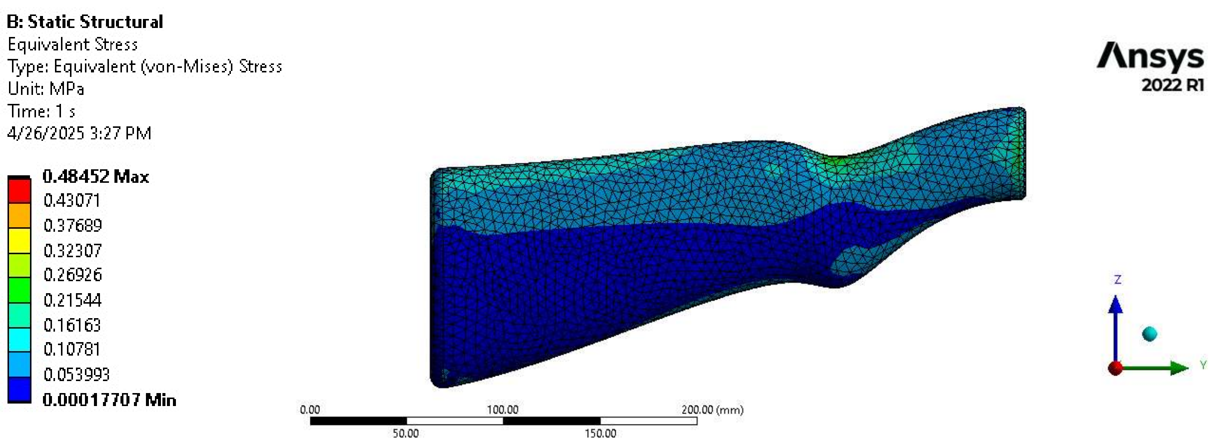


Figure 16: HDPE Equivalent Stress Plot

Table 2: PP vs HDPE Results

Property	PP	HDPE	Improvement
Max Stress (MPa)	.48 MPa	..48 MPa	No significant change
Max Deformation (mm)	0.097mm	0.141 mm	~31% reduction

Conclusions

Conclusions The FEA results indicate that Polypropylene (PP) experienced lower maximum deformation compared to High-Density Polyethylene (HDPE), despite both materials undergoing similar stress levels under loading. PP demonstrated approximately 31% less deformation, suggesting that it maintains its shape more effectively during recoil events.

However, while PP shows better rigidity in deformation, its higher brittleness and lower impact resistance—especially in colder environments—still pose concerns for long-term durability in a firearm application. HDPE, despite showing slightly higher deformation, offers superior impact strength, toughness, and resistance to cracking, which are critical for repeated outdoor use and accidental drops.

From a manufacturing perspective, HDPE's compatibility with extrusion blow molding further solidified its selection. Its lower melt viscosity ensures consistent parison control for uniform wall thickness (6 mm ±0.05 mm), while its minimal shrinkage (2–3%) simplifies mold design and reduces post-processing. PP's higher crystallinity and warpage tendencies would complicate achieving the rifle stock's complex geometry, increasing scrap rates.

Therefore, HDPE remains the preferred material for manufacturing the blow molded .22 rifle stock, balancing acceptable deformation levels with much higher resilience and long-term reliability.

Calculations

The material cost for the blow-molded rifle stock is $0.38 per unit, a value calculated from the density of HDPE and the Mass of the stock from ANSYS. The blown ratio, a critical factor to blow molding, allows the expansion of the parison from its initial surface area to the final blown geometry. This ratio ensures uniform nominal wall thickness (6 mm ±0.05 mm) by distributing material across the enlarged surface area during inflation. This is shown in Figure 22 and 23 of the Appendix.

Design Drawings

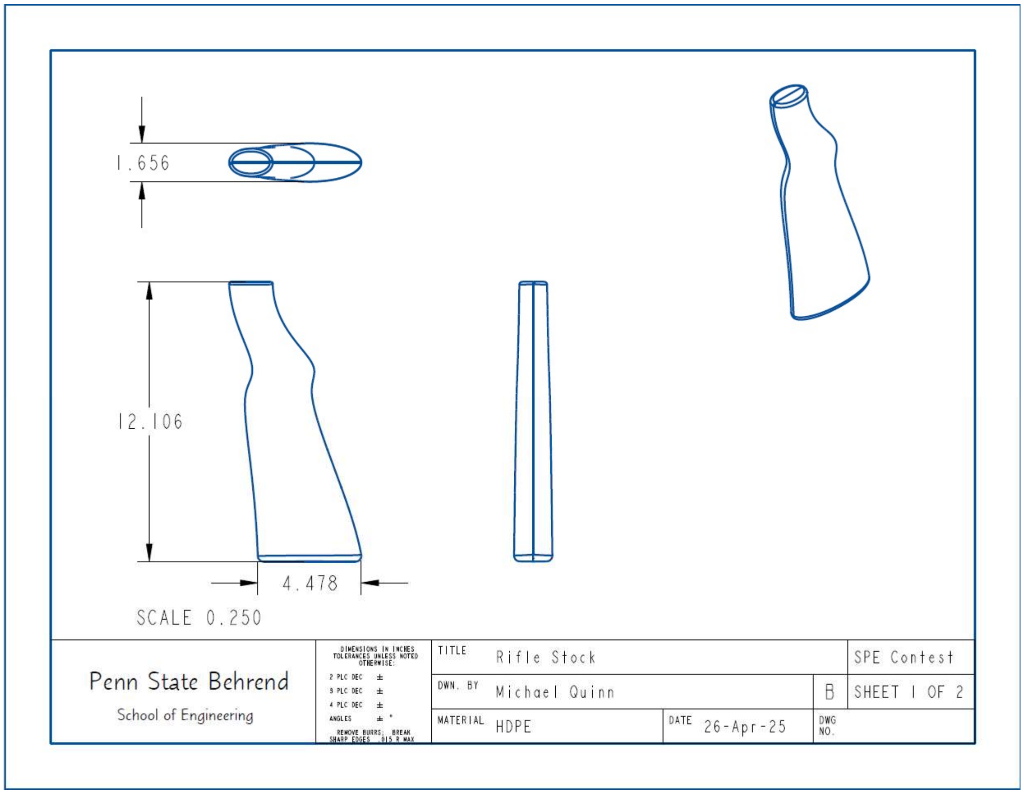


Figure 17: Drawing 1

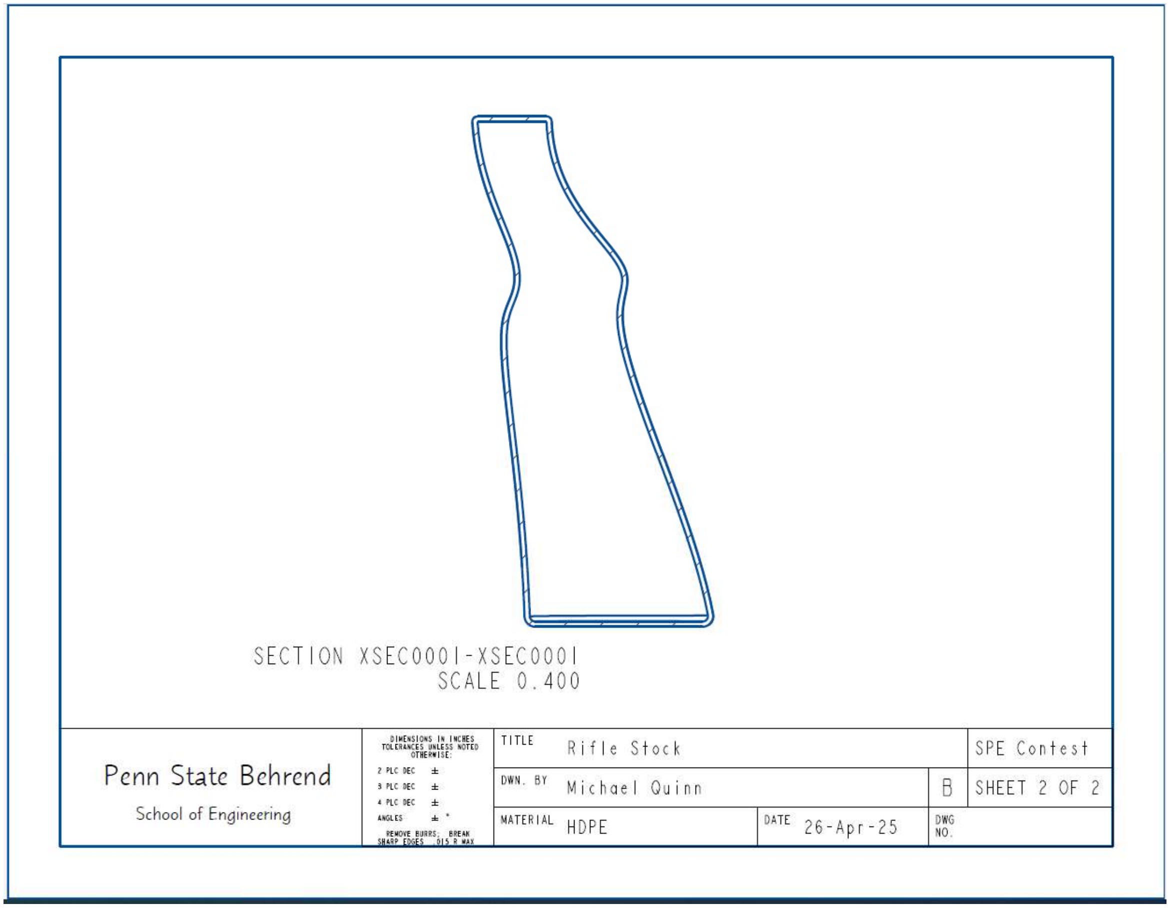


Figure 18: Drawing 2, with a wall thickness of .125in

References

1. Bourjaily, J. (2010, November 3). *The Ruger 10/22 Then and Now*. Shooting Times. https://www.shootingtimes.com/editorial/ruger-1022-history-then-now/99600
2. Backfire. (2024). Rifle Recoil Table: Updated for 2024 with all popular cartridges. Retrieved from https://backfire.tv/rifle-recoil-table/
3. ASTM International. (2022). ASTMD638-88 – *Standard Test Method for Tensile Properties of Plastics.* https://doi.org/10.1520/D0638-22
4. Department of Defense Test Method Strategy. (2008). Mil-Std.810G - *Enviromental Engineering Considerations and Laboratory Tests.* *https://www.atec.army.mil/publications/Mil-Std-810G/Mil-Std-810G.pdf*
5. ASTM International. (2021). *ASTM D4329 - Standard Practice for Fluorescent Ultraviolet (UV) Exposure of Plastics.* https://compass.astm.org/document/?contentCode=ASTM%7CD4329-21%7Cen-US
6. AZoM. High-Density Polyethylene (HDPE): Properties, Production, and Applications.: https://www.azom.com/article.aspx?ArticleID=8522=
7. Muller Technology. (2024). *Blow Molding 101*. Retrieved from https://www.mullerheads.com/blow-molding-101/
8. ScienceDirect. (2024). *Extrusion Blow Molding*. Retrieved from https://www.sciencedirect.com/topics/engineering/extrusion-blow-molding
9. Mennig, G., & Stoeckhert, K. (2013). *Mold-Making Handbook (3rd Edition).* Hanser. ISBN 9781569904466. https://www.sciencedirect.com/science/article/pii/B9781569904466500017
10. Bekum America Corporation. (2024). *Industrial Blow Molding Machines*. Retrieved from https://bekumamerica.com/products/industrial-machines/
11. CustomPartNet. (2024). *Process Comparison - Rotational Molding, Injection Molding, and Extrusion Blow Molding.* https://www.custompartnet.com
12. Quinn, M., Bruton, T. (2025). *Rotationally Molded Toilet Seat: A Cost-Effective and Hygienic Alternative to Traditional Designs*. Penn State Behrend. 2nd Place – SPE Rotational Molding Design Contest

Appendix

Technical Data Sheet

Moplen HP501H

LyondellBasell

Polypropylene, Homopolymer

Product Description

Moplen HP501H is a polypropylene homopolymer for use in injection and compression molding applications. *Moplen* HP501H exhibits a good stiffness/impact balance at ambient temperature. It provides good hinge performances on caps, as well as good environmental stress cracking resistance.
Moplen HP501H is used in caps, closures, sprayers, housewares and furniture.
Moplen HP501H is UL listed under file E31765.

Regulatory Status

For regulatory compliance information, see *Moplen* HP501H Product Stewardship Bulletin (PSB) and Safety Data Sheet (SDS).

This grade is not intended for medical and pharmaceutical applications.

This grade is supported for use in drinking water applications.

Status	Commercial: Active
Availability	Africa-Middle East; Europe
Application	Caps & Closures; Housewares
Market	Consumer Products; Rigid Packaging
Processing Method	Extrusion Blow Molding; Injection Molding; Thermoforming
Attribute	General Purpose; Homopolymer; Medium Impact Resistance; Medium Stiffness

Typical Properties	Nominal Value	Units	Test Method
Physical			
Melt Flow Rate, (230 °C/2.16 kg)	2.1	g/10 min	ISO 1133-1
Density, (23 °C)	0.90	g/cm³	ISO 1183-1
Mechanical			
Tensile Modulus	1450	MPa	ISO 527-1, -2
Tensile Stress at Yield	33	MPa	ISO 527-1, -2
Tensile Strain at Break	>50	%	ISO 527-1, -2
Tensile Strain at Yield	9	%	ISO 527-1, -2
Impact			
Charpy Impact Strength - Notched, (23 °C, Type 1, Edgewise, Notch A)	8	kJ/m²	ISO 179
Hardness			
Ball Indentation Hardness, (H 358/30)	72	MPa	ISO 2039-1
Thermal			
Vicat Softening Temperature, (A50)	154	°C	ISO 306
Heat Deflection Temperature B, (0.45 MPa, Unannealed)	90	°C	ISO 75B-1, -2

Notes

These are typical property values not to be construed as specification limits.

LyondellBasell
Technical Data Sheet
Publication Date: 4/23/2025

Page 1 of 3

Moplen HP501H
Recipient Tracking #:
Request #: 5717688

Figure 19: PP Data Sheet

Technical Data Sheet

LyondellBasell

Lupolen 5021DX

High Density Polyethylene

Product Description

Lupolen 5021DX is a high density polyethylene resin used in a wide range of processing methods. Typical customer applications include small blow molding of engineering parts, toys, packaging for consumer goods and for surfactants. It exhibits good chemical resistance and good ESCR as well as good flowability and organoleptic properties. *Lupolen* 5021DX is delivered in pellet form, contains antioxidants and has a broad molecular weight distribution.

Lupolen 5021DX is not intended for use in medical and pharmaceutical applications.

Regulatory Status

For regulatory compliance information, see *Lupolen* 5021DX Product Stewardship Bulletin (PSB) and Safety Data Sheet (SDS).

Status	Commercial: Active
Availability	Africa-Middle East; Asia-Pacific; Australia and New Zealand; Europe; South & Central America
Application	Bottles For Consumer Goods; Bottles for Industrial Use; Jerry Cans
Market	Consumer Products; Industrial Packaging; Rigid Packaging
Processing Method	Extrusion Blow Molding
Attribute	Antioxidant; Good Chemical Resistance; Good Flow; Good Organoleptic Properties; High ESCR (Environmental Stress Cracking Resistance)

Typical Properties	Nominal Value	Units	Test Method
Physical			
Melt Flow Rate			
(190 °C/2.16 kg)	0.25	g/10 min	ISO 1133-1
(190 °C/5.0 kg)	1.0	g/10 min	ISO 1133-1
(190 °C/21.6 kg)	22	g/10 min	ISO 1133-1
Density	0.950	g/cm^3	ISO 1183-1
Bulk Density	>0.500	g/cm^3	ISO 60
Mechanical			
Tensile Modulus	1000	MPa	ISO 527-1, -2
Tensile Stress at Yield	25	MPa	ISO 527-1, -2
Tensile Strain at Yield	9	%	ISO 527-1, -2
FNCT, (6.0 MPa, 2% Arkopal N100, 50 °C)	20	hr	ISO 16770
Impact			
Charpy Impact Strength - Notched, (-30 °C, Type 1, Edgewise, Notch A)	6	kJ/m^2	ISO 179
Tensile Impact Strength Note: notched, -30°C	100	kJ/m^2	ISO 8256
Hardness			
Ball Indentation Hardness, (H 132/30)	45	MPa	ISO 2039-1
Thermal			

LyondellBasell
Technical Data Sheet
Publication Date: 4/23/2025

Page 1 of 3

Lupolen 5021DX
Recipient Tracking #:
Request #: 5717689

Figure 20: HDPE Data Sheet

Single and double* station blow molding machines	XBLOW 100
Clamping Forces (kN)	1000
Clamping forces (US t)	112.4
Mold width, max. (mm)	1200
Mold Length, max. (mm)	1500
Mold Thickness	2 x 300 2 x 470
Mold opening path (mm)	850
Mold stroke (mm)	
Article production capability per mold, max. (l)	250

Figure 21: Machine Specification sheet

Initial Surface Area $SA_0 := 54.21\ in^2$

Blown Surface Area $SA_1 := 98.5\ in^2$

Blown Ratio $BR := \frac{SA_1}{SA_0} = 1.817$

Figure 222: Blow ratio equation

Part Cost per kilogram	$c := 2.21 \cdot \dfrac{1}{\mathbf{kg}}$
Desnity of HDPE	$\rho := 0.954\ \dfrac{\mathbf{gm}}{\mathbf{cm}^3}$
Volume of Stock	$V_s := 188.943\ \mathbf{cm}^3$
Mass of Stock	$m := V_s \cdot \rho = 0.18\ \mathbf{kg}$
Material cost per part	$P := c \cdot m = 0.398$

Figure 233: Price equation