Blow Molded Weight Plate

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Contents

Introduction:

Since the pandemic, the number of people who work out has increased substantially. New studies have shown that gym use is currently almost double what it was in pre-pandemic years. For some, crowded gyms are unappealing, and they would rather workout alone in the comfort of their own home. Home gym equipment can take up a lot of space, which can be another deterrent for those interested in fitness. Plates are heavy and hard to store in apartments where space is already limited.

Outdoor training has also seen a significant rise in popularity, as it provides a flexible and cost-effective alternative to gym memberships. People of all ages are taking advantage of outdoor environments to exercise, often incorporating equipment such as drag sleds to build strength and conditioning. While they are effective, drag sleds rely on multiple heavy weight plates to function, which limits their portability and convenience. Transporting plates to parks, fields, or other outdoor locations is impractical, and without them, the sled cannot be used effectively.

Weight Sled Setup: MIRAFIT

To address these limitations, a water-filled weight design was selected. This approach allows the user to adjust the weight by simply adding or removing water, enabling a single product to serve multiple resistance levels. When empty, the product is lightweight and compact, making it easy to store in confined spaces or transport to outdoor locations

The proposed design also has strong applications for student athletes across all levels of competition. Strength and conditioning is a critical component of athletic development, yet access to proper equipment is often limited outside of organized team environments. Many student athletes rely on school weight rooms, which may have restricted hours, limited availability, and usually insufficient equipment to accommodate all users. This creates gaps in training consistency, particularly during off-seasons, school breaks, or for athletes without access to private facilities. Additionally, the design improves accessibility for schools and athletic programs with limited budgets. Instead of investing in large quantities of fixed-weight plates, a smaller number of adjustable units can serve a wider range of athletes and training scenarios

A water-filled weight provides a practical solution to these limitations by offering a portable and adaptable training option. Athletes can easily transport the empty unit to fields, tracks, or home environments and fill it on-site, eliminating the need to carry heavy traditional weights. This is especially beneficial for exercises such as sled pushes, drags, and resisted sprints, where adjustable resistance is essential for progressive training. By allowing users to modify the load quickly, the system can accommodate athletes at different strength levels, from younger students to more advanced competitors, without requiring multiple sets of equipment.

Blow Molding Application:

Blow molding is the most appropriate manufacturing process for the proposed water-filled weight due to its ability to efficiently produce hollow, lightweight, and seamless plastic components. The design of the weight relies on an enclosed internal volume that can be filled with water, making a hollow structure essential. Blow molding is specifically intended for this type of geometry, allowing the part to be formed in a single operation without the need for internal cores or secondary assembly. This results in a fully enclosed component with no joints or seams that could introduce potential leak paths, which is critical for maintaining long-term water retention.

From a production standpoint, blow molding offers significant advantages in terms of cycle time and cost efficiency. Compared to processes such as rotational molding, blow molding operates with faster cycle times and is better suited for high-volume manufacturing. This makes it a more practical choice for a consumer product that may require large production quantities. Additionally, the process uses relatively low material pressure and allows for consistent wall formation, enabling the production of parts that are strong enough for the intended application while minimizing excess material usage.

Another key advantage of blow molding is its ability to control material distribution throughout the part. Areas that experience higher stress, such as handles or connection points, can be designed to retain more material, while less critical regions can remain thinner. This targeted material usage improves overall durability without significantly increasing weight or cost.

Blow molding is also widely used with polyethylene, a material that provides excellent impact resistance, chemical resistance, and environmental durability. These properties are essential for a product that will be repeatedly filled, transported, and exposed to outdoor conditions. The compatibility between polyethylene and blow molding further supports the selection of this process, as it ensures reliable processing and consistent product quality.

Overall, blow molding aligns directly with the functional requirements, geometry, and production needs of the water-filled weight. Its ability to create a seamless, hollow structure at high production rates with efficient material usage makes it the most suitable and practical manufacturing method for this application.

Design Details:

The water filled weight has been designed specifically for blow molding. This leads to several key design considerations that were incorporated to ensure manufacturability, durability, and functional performance. The geometry and process parameters were selected to support efficient production while maintaining good mechanical properties and functionality.

A draft angle of 5 degrees has been applied to each side of the part. Draft angles are essential in blow molding because they allow the molded component to be removed from the mold without excessive friction or deformation. Draft reduces the risk of part sticking and helps preserve the surface finish of the product. The selected 5-degree value is consistent with common blow-molding design practices and ensures reliable mold release with the added .005 inch depth diamond shaped texture.

All fillets in the design include a radius of 0.5 inches. Radii are critical in blow molded parts because sharp corners can create stress concentrations and uneven material distribution during inflation of the parison. By using a 0.5 inch radius throughout the design, stress is distributed more evenly, improving impact resistance and reducing the likelihood of cracking or failure during use.

The mold will use a cavity core configuration that forms a 2-inch hole in the center of the weight. This hole is created directly in the mold, eliminating the need for secondary machining or post-processing operations. Incorporating this feature into the molding process simplifies manufacturing and improves dimensional consistency between parts.

A wall thickness of 0.25 inches has been specified to provide optimal impact resistance. Uniform wall thickness is a major design goal in blow molding because it promotes consistent cooling and reduces the risk of warpage or weak spots. The chosen thickness balances durability with efficient material usage, supporting the functional requirement of a reusable water-filled product.

Process parameters were also established to guide parison and die sizing. A blow-up ratio of 5:1 was selected, resulting in a calculated parison diameter of 3.2 inches. Considering the HDPE die swell ratio of 1.2, the required die diameter is 2.67 inches. These calculations ensure that the molten tube expands to the correct final dimensions during molding and that the finished part meets its intended size and structural requirements.

The parting line will run around the circumference of the part, splitting the component into symmetrical halves. This placement simplifies mold construction and helps maintain uniform material distribution during inflation. A diamond shaped external texture with a depth of 0.005 inches has also been added to improve grip during handling, enhancing usability without significantly affecting manufacturing complexity. Finally, venting features ranging from 0.001 to 0.003 inches have been incorporated to allow trapped air to escape during molding, ensuring complete surface formation and preventing defects.

Together, these design choices align the geometry of the water filled weight with established blow-molding practices. The combination of proper draft, radii, wall thickness, process sizing, and surface features supports efficient manufacturing while promoting strength, durability, and consistent product quality.

Mold & Tooling Details:

The mold will be machined from Aluminum T6061 or T7075 for its excellent thermal conductivity and lower cost, with Beryllium-copper inserts located specifically at the pinch-offs to improve durability and cooling in those high-wear areas Cooling channels will be machined into both mold halves near the cavity surface, with extra cooling placed near the thick hub area and around the four core pins to ensure uniform cooling and reduce cycle time. There will be a draft angle because the part will naturally shrink away from the cavity walls as it cools. Parting line vents of 0.002”-0.004” depth will be machined to allow trapped air to escape, preventing surface defects on the flat faces of the plate. The part weight is 4.65 lbs. with a part volume of 663.5 in^3.

TO produce this gym plate, an accumulator head intermittent extrusion blow molder is required because it can hold a large volume of melt for large items and provides fast extrusion of large parisons with short suspension time, resulting in little sag and better control of wall thickness. A center feed die head with parison programming (vertical wall distribution system) will be used to dynamically adjust the die gap during extrusion, placing more plastic in the thick center hub area and less in the thinner web between the bolt holes. The blow pressure will be a nominal 80 psi to fully inflate the parison into all features, including around the four core pins that create the holes. The material is HDPE, which has good melt strength for accumulator EBM.

The through-hole will require a core pin that the parison blows around, and the pin must have a suitable draft angle and be made of hardened steel or beryllium-copper to withstand repeated closing forces. No asymmetric wall thickness control methods such as SFDR, PWDS, or RWDS, are needed due to the axisymmetric nature of the part, making the vertical wall distribution system sufficient. The mold will contain cooling channels located in the mold halves, and cooled air will be circulated through the blow pin to reduce cooling time.

Manufacturing Details:

A blow molding operation is used for the water filled weight. The goal of the design is to allow the part to be produced in a single, repeatable molding cycle with minimal secondary operations. All geometry, sizing, and process parameters were selected to support extrusion blow molding using HDPE while ensuring consistent material distribution and reliable production.

Manufacturing begins with extrusion of a molten HDPE parison. The extruder will produce a hollow tube sized parison specifically for the final part geometry. Based on the selected blow-up ratio of 5:1, the required parison diameter is 3.2 inches. Because HDPE experiences die swell during extrusion, a swell ratio of 1.2 was considered, resulting in a required die diameter of 2.67 inches. These calculations ensure the extruded tube expands to the correct size when inflated, allowing the finished part to meet the intended dimensions and wall thickness.

Once the parison reaches the correct length, the two-piece cavity-core mold closes around the molten tube. The mold pinches the bottom of the parison closed and seals the top around the blow pin. The blow pin then introduces compressed air, inflating the softened plastic outward until it conforms to the internal mold cavity. During this stage, the parting line located around the circumference divides the mold into symmetrical halves, allowing balanced expansion and uniform material flow across both sides of the weight.

The mold cavity contains several integrated features that are formed directly during inflation. A core feature with Beryllium Copper pinch offs creates the 2-inch diameter center hole as the part is molded, eliminating the need for any drilling or machining after molding. External diamond shaped texture with a depth of 0.005 inches is also molded directly into the surface to improve grip. Incorporating these features into the mold reduces post-processing and shortens the overall production cycle.

Sharp corners are eliminated during inflation using 0.5-inch radii on all corners and a uniform wall thickness target of 0.25 inches. Rounded geometry allows the parison to stretch evenly as air pressure expands the material against the mold walls. This prevents localized thinning and ensures consistent cooling. Uniform wall thickness is critical during the cooling phase because it allows heat to dissipate evenly, reducing the likelihood of warpage or residual stresses.

As the inflated part cools within the mold, small venting features ranging from 0.001 to 0.003 inches allow trapped air to escape. Proper venting ensures the molten plastic fully contacts the mold surface and prevents surface defects or incomplete formation. Once the material has solidified sufficiently, the mold opens and the part is ejected.

After removal, the only required post molding step is trimming the excess flash that forms at the pinch off and parting line. Because the center hole and external texture are molded in place, no additional machining or finishing operations are required. The result is a hollow, seamless component ready for filling and final use.

Overall, the manufacturing process follows a straightforward sequence of parison extrusion, mold capture, air inflation, cooling, and flash trimming. The design intentionally integrates all functional and aesthetic features into the mold so the part can be produced efficiently in high volume with consistent quality and minimal secondary processing.

Manufacturing cycle:

The extrusion stage is expected to require approximately 8 seconds to form the parison, followed by mold closing and air inflation in roughly 7 seconds. Because the design specifies a relatively thick 0.25-inch HDPE wall, cooling becomes the dominant portion of the cycle and is estimated to require 30 seconds to allow the material to solidify without warpage or residual stress. Mold opening, part ejection, and trimming of pinch off flash are expected to add an additional 10 seconds.

Combining these stages results in an estimated total cycle time of approximately 55 seconds per part. This value aligns with typical extrusion blow molding cycle times for medium sized HDPE hollow parts and reflects the balance between sufficient cooling, reliable mold release, and efficient high-volume production.

Technical Issues and Possible Problems:

While the proposed blow molded water-filled weight provides a practical and manufacturable solution, several limitations and potential areas for improvement have been identified.

One of the primary concerns is the structural performance of the part under repeated loading conditions compared to the conventional metal plates. Although HDPE offers good impact resistance, the hollow design introduces the possibility of localized deformation, particularly around high-stress regions such as the center hub and threaded fill port. Under dynamic loading conditions, such as sled pushes or drops, stress concentrations may lead to creep or long-term material fatigue. The uniform wall thickness of 0.25 inches improves manufacturability but may not be optimal for all load-bearing regions. Additional material or localized thickening in critical areas could improve durability.

Another limitation is the sealing mechanism used for the water fill port. The current design includes a threaded cap, but repeated use, cross-threading, or debris contamination could compromise the seal and lead to leakage. This is especially critical since the product is intended for outdoor use, where dirt and wear are unavoidable. Incorporating a gasket or O-ring seal would significantly improve reliability and reduce the risk of water loss during use.

The use of water as the source of weight also introduces performance trade-offs. Unlike solid plates, the internal fluid can shift during movement, resulting in a dynamic load that may reduce stability during exercises such as sled pulls. While this may provide some training benefits, it can also negatively affect user control and consistency. Internal baffling features could be considered to reduce fluid movement and improve overall performance.
Environmental conditions present additional challenges. Exposure to low temperatures could result in water freezing inside the part, which could cause potential cracking of the HDPE shell. Conversely, high temperatures may increase internal pressure slightly and accelerate material degradation over time. While HDPE has good environmental resistance, these conditions should be considered in the design.

From a manufacturing standpoint, although extrusion blow molding is well-suited for this geometry, maintaining consistent wall thickness remains a challenge, particularly around the central hole. While parison programming helps address this, improper control could lead to thinning in critical areas. Upscaling part size may be needed to achieve the correct volume for 25 pounds of weight. This introduces variability that may affect part performance

Finally, compared to traditional solid weight plates, the proposed design may have limitations in perceived durability and user acceptance. Consumers may associate hollow, water-filled products with lower strength or quality. Additionally, the need to fill and empty the product adds an extra step that may reduce convenience for some users.

Future design improvements could include reinforcing ribs in high-stress areas, improved sealing mechanisms, internal baffling to control fluid movement, and validation testing such as drop tests and fatigue analysis. Addressing these limitations would enhance both the functional performance and market acceptance of the product.

Design Images:

Figure 2: Isometric View

Figure 1: Right-side-up View

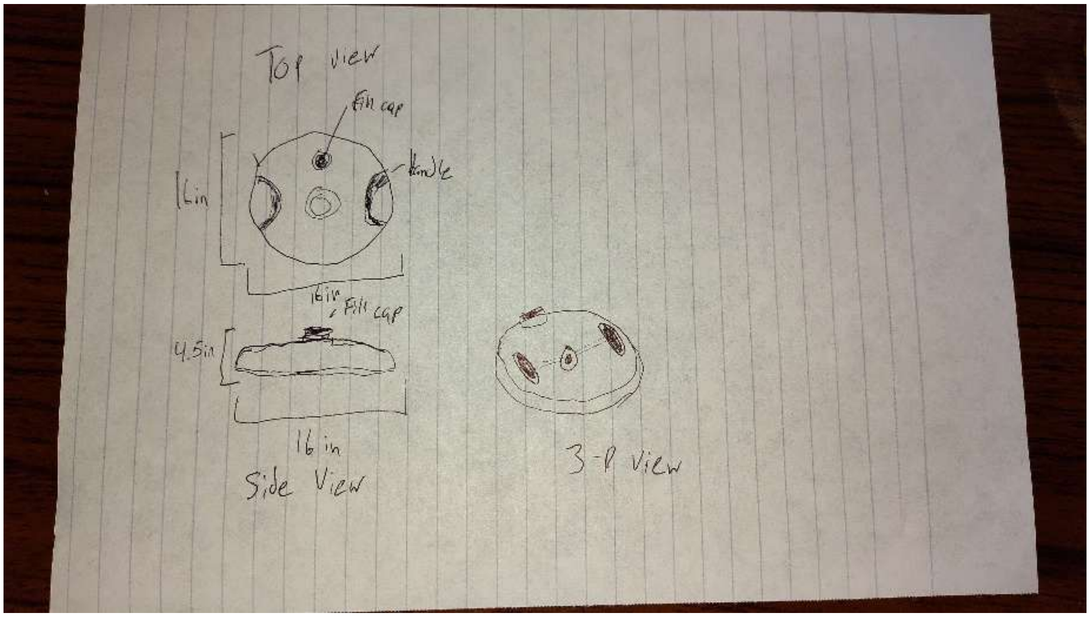

Figure 3: Original Sketch

Figure 4: B-half of mold

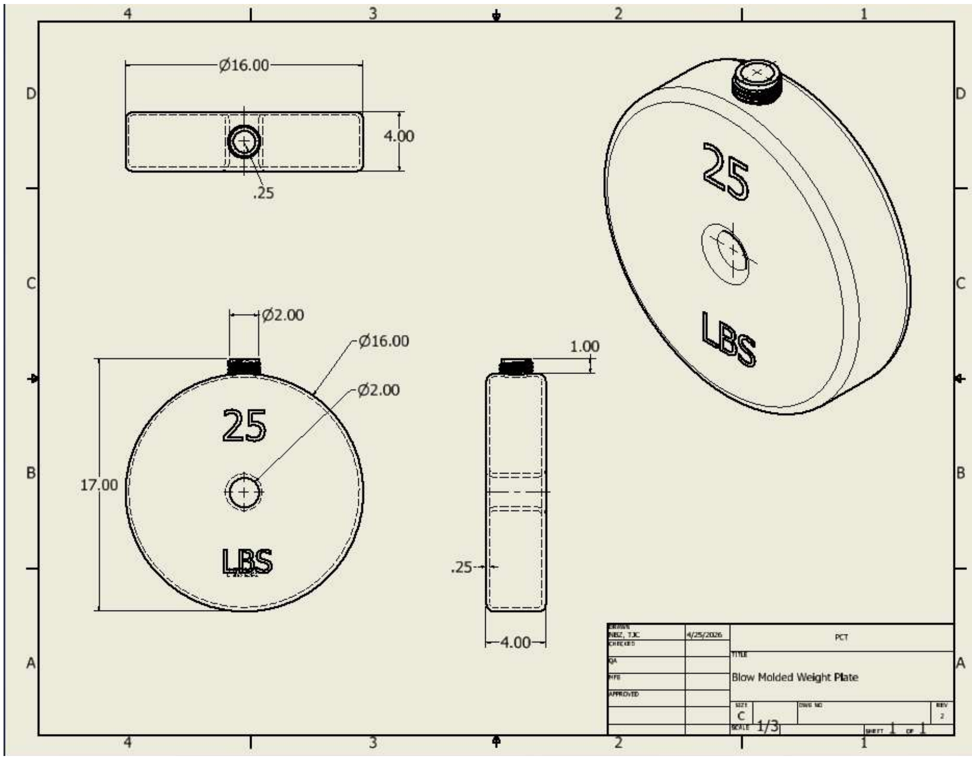

Figure 5: 2-D Drawing

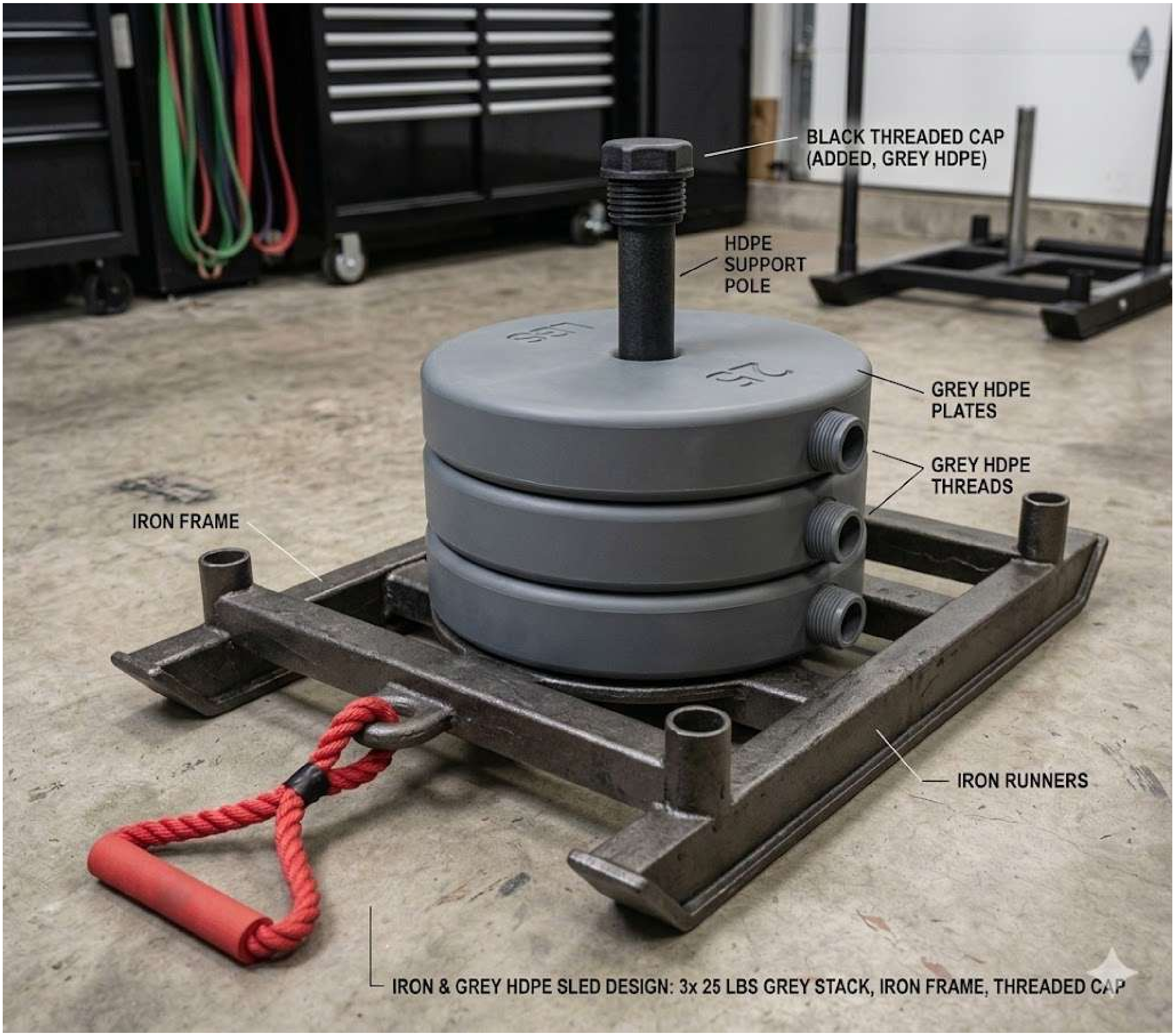

Figure 6: Product Rendering (Nano Banana Pro- Google Gemini)