TEAM 10: MALAWI WASHING MACHINE

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Abstract

Hospitals in the African nation of Malawi require a washing machine that can be manufactured locally. Electricity is scarce, meaning a human-powered washing machine is the most viable option for use in the hospitals. The machine must be easily constructed, use materials readily available, and be capable of holding multiple sheets. This machine will provide a sanitary method of cleaning fabrics, a critical need at hospitals. The machine will be designed, built, and tested at Wright State University. Instructions for the final design will be sent to Malawi where construction and utilization will occur.

The design consists of a frame, container, power delivery system, and agitator. The frame is constructed from metal tubing and serves to both hold the container in place and ensure proper power is delivered. The container is a 55-gallon drum which holds both the sheets and agitator, and it is drainable once a cycle is finished.

Power is delivered through a hand crank. The development of the power delivery system went through many iterations, with initial designs utilizing a ratchet-and-pawl strategy. However, the ratchet mold was untenable due to time constraints and difficulty of construction. A ratchet was devised using threaded rods through the central agitator's shaft. The rods would serve as teeth and were to be impacted by a stepper. After actual testing, the power was not transmitted effectively enough to be viable, and power delivery moved to a hand crank instead. Tests of the hand crank proved to be easy on the operators, and power was both transmitted and maintained properly. Further iterations of the hand crank were made as necessary.

The agitation is performed using various PVC tubes, connectors, and joints. The PVC forms a central shaft with fins extending outward to churn the chlorinated water. Both the number and shape of the fins were assessed on multiple test parameters, and the results of each trial were used to differentiate the designs. The final agitator utilizes four fins, each consisting of two pipes joined with a pair of elbows. These fins are oriented at 90-degree offsets down the length of the shaft.

Design

The Malawi Washing Machine consists of three primary design constituents:

- Frame
- Agitator
- Power Mechanism

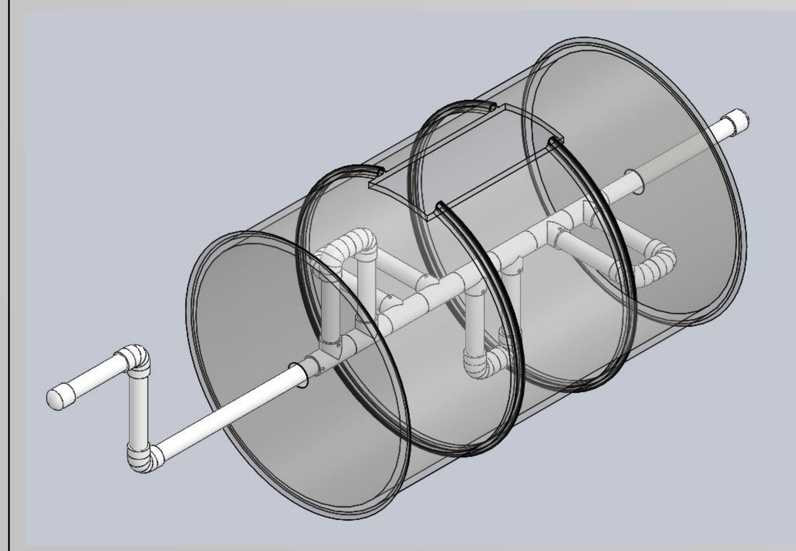

Figure 1: Drum with Agitator

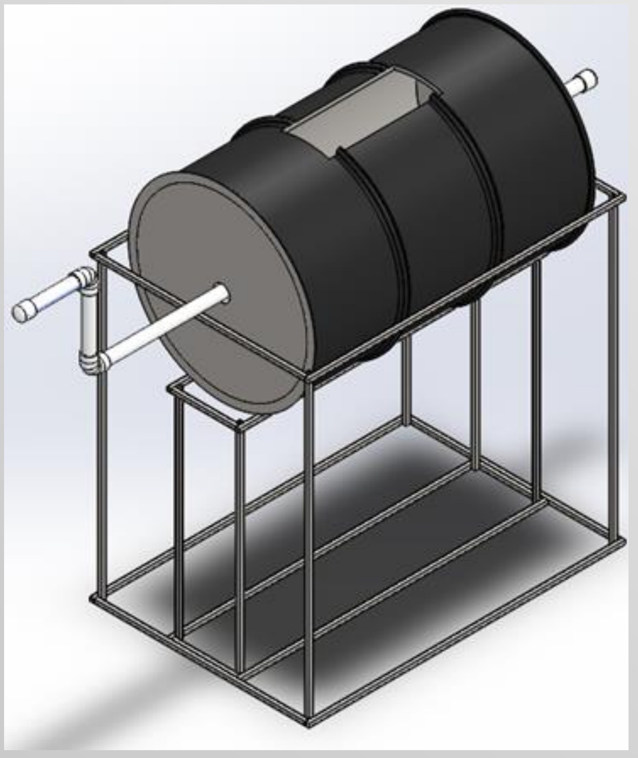

Figure 2: Washing Machine Assembly

Frame

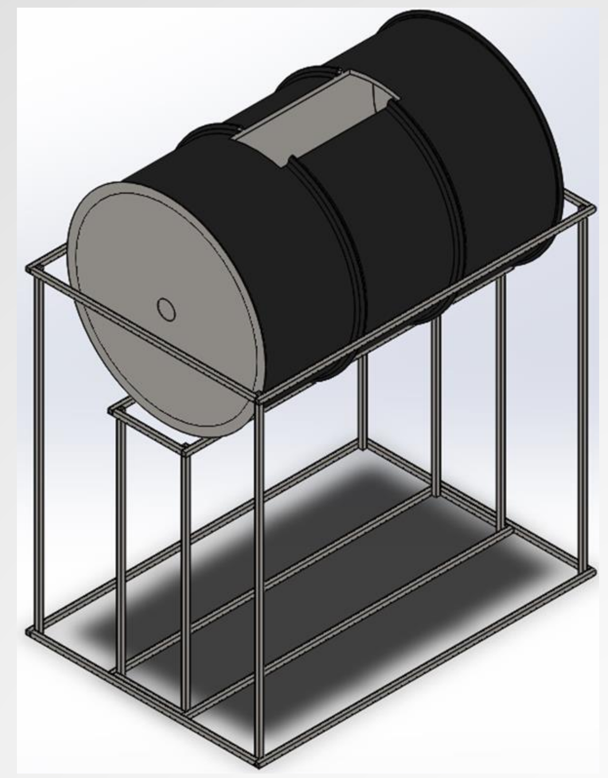

Figure 3: Frame Assembly

- Test frame was built using wooden planks.
- Final frame is made from metal tubing.
- Inner box elevates drum.
- Outer box prevents lateral movement.
- Either plastic or metal drum can be used.

Figure 4: Wooden Frame

Figure 5: Wooden Frame with Drum

Agitator

- Agitator is composed of PVC.
- Three agitators were designed with different fin shapes, quantities, and orientations.
- Bi-Fin agitator (named for each fin's two supports) was selected based on weight, agitation, ease of assembly, and communicability.

Figure 6: Agitators

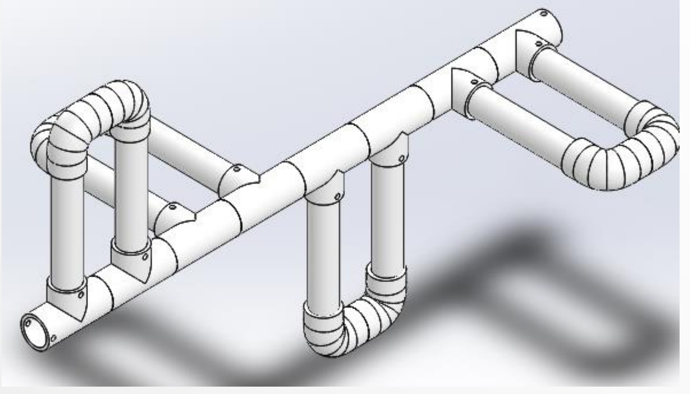

Figure 7: Bi-Fin Agitator

- Fins are bolted in place to allow piece replacement.
- Central shaft and fins are glued for durability.

Budget

Total Funds	**$1,000.00**
Total Expenses	$444.78
Remaining Funds	$555.22

Table 1: Budget

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Power Mechanism

Figure 8: Ratchet Mold

Figure 10: Stepper

- Various powering methods were designed.
- Multiple molds were made to form a concrete ratchet.
  - Proved ineffective
- The next ratchet was built from threaded rod and powered by a stepper.
  - Proved too difficult to operate
- Hand crank replaced an inefficient ratchet.
- Direct transmission allowed for easier powering.

Figure 9: Threaded Rod Ratchet

Figure 11: Hand Crank

Conclusions

Through testing and experimentation, a washing machine was designed using only materials available in Malawi. The Malawian people are accustomed to making structures and machines by hand, so welding and working with PVC are not concerns. This makes both the PVC piping and metal tubing clear choices for build materials.

PVC pipes of various sizes are used to carry water from a nearby river to the hospital, meaning the required PVC joints and cement are readily available. The pipes are versatile and lightweight, making PVC the ideal option for the washing machine's agitator. Several different agitators were tested and evaluated on effectiveness of agitation, weight, communicability, and construction. It was shown that the Bi-Fin agitator provided the most practical advantages.

Metal tubing was found to be the ideal material selection for the frame of the washing machine. Tubing of various sizes is both easily obtainable and strong enough to support both a load of laundry and either a metal or plastic drum.

The power mechanism required several iterations to find the most effective option. Various types of molds were tested to fashion a ratchet with minimal success. Molds either solidified quickly but held little detail, or they showed appropriate detail but took an impractical length of time to solidify. To replace the use of a mold, a ratchet was built using threaded rods fixed through a PVC pipe. A stepper was then designed and served to provide a force on the ratchet, causing the agitator to spin. However, the torque applied by the stepper bent some of the threaded rods, and the overall power transmission proved inefficient. A different form of powering was required to operate the washing machine. A hand crank was chosen to drive the agitator, allowing for the torque to be applied directly to the shaft. The hand crank is constructed from PVC, which is highly durable and easily attaches to the shaft. The crank proved to be very effective and only requires a small amount of force to power the washing machine.

The design for the Malawi Washing Machine has proven to be simple to communicate, easy to construct out of available materials, and capable of washing multiple sheets concurrently.