PCTI

WASHING MACHINE AGITATOR

Mr. Saykali's PLTW Engineering Class

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PURPOSE

The astronauts in the ISS have no system of washing clothes, so they would throw away clothes that become dirty. To reuse their dirty clothes, a washing machine is needed.

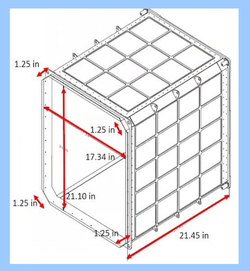
The purpose of the agitator in the washing machine is to remove dirt from the clothing by moving it around.

PROBLEM

Zero gravity and the surface tension of water prevents a standard washing machine from operating in space. With the zero gravity, types of soap/ chemicals that can be used, and the recycling of water, creating a washing machine for space is not an easy task. A normal washing machine agitator is dependent on gravity to slosh around clothing and water.

CRITERIA & CONSTRAINTS

- Needs to operate with 1 medium sized polo shirt
- Can handle all articles of clothing
- Agitate the clothing to remove dirt
- Can be a computer automated design
- Efficient, quick, and easy to use
- Receives power from an EXPRESS rack
- Cannot damage the clothes
- Minimal vibrations
- Cannot get clogged
- Has to fit in the ISS double-locker



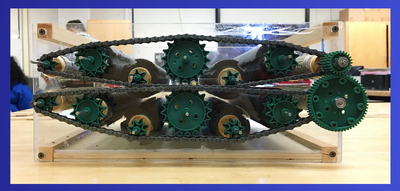
DESCRIPTION

This user-friendly washing machine agitator uses an off-set roller system to agitate clothing. There are two entrance and two exit rollers that pull in and out the shirt. The ten middle rollers are made to effectively agitate the clothing because they are cut to resemble a gear. This all works through the implementation of a chain and sprocket system to turn the axles.

CHANGES/ IMPROVEMENTS

BEFORE:

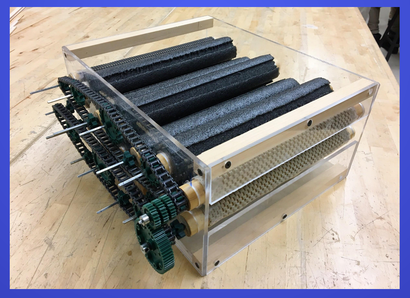
AFTER:

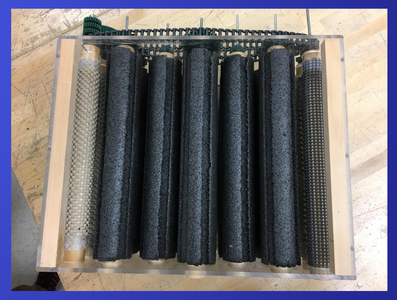


The initial gear design only used on chain in a zig-zag pattern. This did not work because there was too much tension within the chain. The new gear design uses two chains which reduced the drive force while still allowing for both to rotate at the same time, due to interlocking gears.

We used acrylic glass for the sides of the box, replacing the wood. This material reduced the friction caused from the wood on wood situation. Beeswax was also applied on the wooden axle to reduced the friction.

The dimensions of the overall prototype were adjusted to fit a shirt.



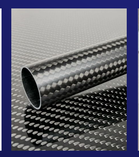


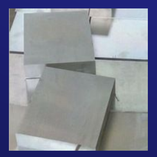
COMMERCIAL OFF-THE-SHELF PRODUCTS

Our idea was inspired by a clothes wringer and toothpaste squeezer because it will work in zero gravity and can be altered for agitation. Our rollers were inspired by muscle rollers because its shape seems like it can agitate clothing well. We created foam rollers with a gear-like pattern to replicate this concept, in a cheaper way, for our prototype.

IDEAL MATERIALS

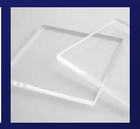
Roller:	Axle:	Container:	Chain/ Sprocket:
Synthetic Rubber	Carbon Fiber	Magnesium Alloy	Stainless Steel



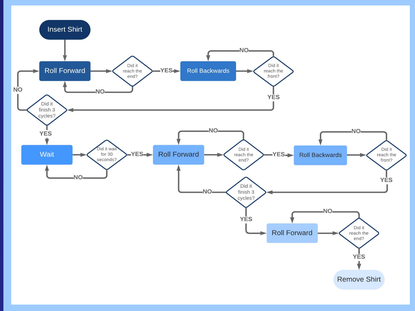


MATERIALS USED

The box is made of clear acrylic glass. Four rollers are made of wood and rubber carpet padding. The rest are made of wood and pipe insulators. VEX parts such as chains, sprockets, gears, and shafts are made of plastic and metal.



FLOWCHART



To make this completely automated, servo motors will replace the manual cranks and be used to turn rollers following this flowchart.

TESTING DATA

TEST #1: ROTATING THE ROLLERS	
TRIAL	SUCCESS OR FAIL?
1	FAIL: The axles did not move. SOLUTION: Sand the axles. Try to implement the idea of idler gears in our next test.
2	FAIL: The axles still did not move. Regardless of the idler gears, this system would not work with our prototype because the chain system required too much force and the chain itself is too weak. SOLUTION: Use the other chain design brainstormed from before. This chain design uses two separate chains (one for the top and one for the bottom) and two gears at the end, connecting the two chain systems.
3	FAIL: The new chain system rotates most of the axle but skips over some axles that are stuck, which do not rotate. Also, there are times were the gears did not connect properly to turn all of the axles. SOLUTION: Sand the axles more. Use a lubricant (beeswax). Move the position of the gears to the opposite side, where the dimensions are a little different, to see if they will match up better.
4	ALMOST SUCCESS: This new chain system rotates correctly. The beeswax helped the rollers rotate smoothly. However, a few errors can come up when the hand crank rotates because its vertical cranking motion can misalign the gears that allow both top and bottom rollers to move with one crank. Also, the space between both of the chain systems is very small and can cause friction. SOLUTION: Replace the hand crank with a wheel so that the force is evenly spread out when turning to have minimum vertical movement. This might prevent the gears from misaligning while turning the wheel. (This detail is for demonstration purposes because the real product is theorized to be automated.) To reduce the friction between the two chains, off-set the bottom chain system so that they are no longer in contact.
5	SUCCESS: This chain system is now rotating perfectly and will be tested with a shirt. Replacing the hand crank with a wheel was an efficient idea that makes manual demonstration more reliable.
CONCLUSION: After many trial and errors, we were able to come up with a working solution with the materials that we have.	

TEST #2: INCORPORATING A SHIRT: MEDIUM POLO	
TRIAL	SUCCESS OR FAIL?
1	FAIL: The chain and sprocket system was slipping because the metal shafts became loose from the wooden axles and the chain was not tight enough SOLUTION: Tighten the chain. Hot glue the metal shaft in the wooden axles again.
2	FAIL: We tightened the chain as tight as we could. It was a little tighter than we needed, but any more loose would be too loose. The tightness of the chain was also an issue because it bent and loosened the metal shafts on either end. One metal shaft on the end with the wheel crank on it fell off while trying to rotate the axles because of the tight chain and amount of pressure from the crank. SOLUTION: Try Krazy Glue for the metal shaft.
3	FAIL: The metal shaft on that one roller fell off even after the Krazy Glue. SOLUTION: Screw the sprocket into the wood, without the shaft, and relocated the position of the crank to the other end.
4	FAIL: The sprockets were now all secured in place. The shirt got stuck/bunched up halfway and became too hard to crank. This was due to the amount of force originally needed to rotate all of the axles, along with the addition of a bunched up shirt, making the required applied force very large. SOLUTION: Move the crank to the shaft with the smaller gear. This will make it easier to turn from our knowledge of gear ratios: the smaller gear driving the larger gear will use less force, even though it will turn slower.
CONCLUSION: There are many possible errors regarding this prototype due to our limited materials. (lack of high quality and perfectly sized chain and specifically sized sprockets/gears). It took a lot of searching to obtain parts that were close enough to fit exactly in specific areas. We worked with what we had and worked on refining the prototype some more.	

TEST #3: INCORPORATING A SHIRT: SMALL T-SHIRT	
TRIAL	SUCCESS OR FAIL?
1	SUCCESS: The small T-shirt was able to go in more smoothly because it was thinner (compared to the polo), so the gears also did not require as much force. The ideas from the previous tests were all implemented and are successful.
2	SUCCESS: The shirt repeated the process again with no issues.
3	SUCCESS: The shirt repeated the process a third time with no issues.
CONCLUSION: For our prototype, a thinner, smaller t-shirt was able to work better and complete the steps because it was thinner than the medium polo, which made it less likely to get stuck. It would be more efficient with better/ideal materials. After the improvements from the previous tests, we were able to complete the prototype and make it work as we want.	

CAD FILES