Treadmill Actuation System
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Abstract—Along with staff from the engineering team at Life Fitness, an alternative treadmill actuation system has been developed to add to the available methods to incline a treadmill. Under various project requirements for compatibility, the design will act no different than the current actuation methods to the end user. The benefit is gained by adding greater flexibility to the design of products. In order to keep costs low and not impact the price of the final product, known materials were used along with current components. No additional operations will be needed compared to the original design, which will help maintain production and assembly times.

I. INTRODUCTION

A treadmill is made up of several key components, including the deck, belt, motor, actuator, arms, and the control panel. The belt is powered by the motor which propels it around two rollers on either end of the deck. The speed of the belt as well as the inclination is controlled by the user on the control panel. The belt is a consumable part that will need to be replaced during standard intervals of maintenance. An important requirement for a viable actuator system is easy replacement of the belt.

Life Fitness’ signature treadmill product line consists of a front housing which includes the motor. The housing contains approximately 168in² (1084cm²) in area. Their primary commercial customers are a wide range of fitness clubs and gyms. An interesting trend in this industry is to utilize smaller facilities to minimize expenses, while providing more equipment for members to use. The Client (Life Fitness there forth) has acknowledged that the extra space in the front housing is too large for an increasing amount of customer’s who are trying to maximize space. These customers, known as HVLP (High Value-Low Price) gyms, are taking an increasing portion of the market’s membership share, with Planet Fitness seeing a 25% YOY member growth since 2010 [1]. In order to be more attractive to this type of market, they have brought their challenge to Northern Illinois University to develop the actuation system.

II. MATERIALS AND METHODS

The primary material used was A500 steel because of its mechanical properties. It provides a large yield strength to withstand the force that will be exerted against it.

There are similar functioning products for compact treadmills on the market but are made for different applications. One of these iterations are concave styled running decks, which are usually non-motorized with no ability to incline. These treadmills are made specifically for running to keep the momentum of the belt moving under the force of the user’s last push off. Because they are specialized machines, they are expensive and therefore not realistic in mass purchase for commercial use. Utilizing a compact form-factor without additional costs to the consumer will be an attractive package.

An important feature to maintain is an accessible way for a technician to change the belt on the treadmill. In order to fulfill this requirement as shown in Figure 2, a pair of supports are included to remove the actuator assembly. The supports are held together with two bolts on either side and will assist with the force dissipation across the system. The highlighted brackets will be welded to the frame of the treadmill and legs of the lift. The supports are fastened in place with those brackets and can be removed while the machine is in a stationary position. This will help in the event the work environment is tight and the machine cannot be moved. The yellow supports on either side of the lift will be welded to the underside of the treadmill frame and will act as the pivot point the actuator will exert a force around.

Fig. 1: A 3D Model of the actuation system located within the treadmill prototype. The front of the frame is on the right and is subject to final revisions.

Fig. 2: A close-up view of the proposed actuation system.
III. RESULTS AND DISCUSSION

The total weight of the design is 60 lbs (27 kg). A goal of production cost per unit was to be less than $100, with the prototype costing $140. This is still within an ideal range as buying in larger quantities will greatly reduce the cost at time of production.

Complex geometry was used to determine the optimal angles needed to achieve the required inclination of 15%. The Client provided that an angle of $8.5^\circ$ must be made between its resting position and the lift frame wheel to attain 15%.

![ANSYS simulation highlighting the physical deformation the system will experience under a maximum intended load.](image1)

Because we are using A500 steel, we realize a very low level of material deformation (.004in) from the force of the actuator. The force is concentrated at the bracket that holds the actuator and is distributed across the top support. The data shown is for a male in the 90th percentile weight exerting three times their mass (968 lbs. combined with the mass of the treadmill) during physical activity. This is the largest force the system will experience during normal user operation and the simulation is visually exaggerated to highlight these findings.

![ANSYS simulation to determine the system’s factor of safety to predict reliability.](image2)

Having a high factor of safety provides peace of mind and communicates a high quality and well-engineered product. The data shows a minimum factor of safety of 8.4. This value is seen near the welding of the upper arms and lower rack. Much of the system sees a factor of safety of nearly 14.

Another test was conducted for a case of misuse with 2000 lbs (907 kg) of acting force. The factor of safety remained at least 1.9 throughout the system and experienced $.01\text{ in} (0.25 \text{ mm})$ of deformation.

IV. CONCLUSIONS

Life Fitness shows ambition in the development of the project to diversify their product line and respond to new customer expectations. As the fitness and gym industries continue to evolve their business models, such as with HVLP gyms, it is important to adapt to the needs of the customer. As the leader in commercial fitness equipment worldwide, the envisioned product will help Life Fitness to offer a machine with a smaller footprint and the same excellent reliability as previous models. Offering compact equipment with an attention to quality will protect the existing clientele and retain them from the competition. It may also attract other customers that have overlooked their brand in the past because they did not offer a product that had fit their needs. The design outlined will address the lift system’s compatibility with the project, allowing Life Fitness to progress in development.

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REFERENCES
