Treadmill Belt Tester

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I. Abstract:

The purpose of this project is to design a test fixture or suit of text fixtures to replicate the real-world stresses that a treadmill belt experiences. This will help our client to evaluate and compare future belt designs faster and without any public exposure. Our optimal design is based on simplicity and efficiently that would meet the requirements that our client sat for us to follow.

II. Introduction

Life fitness had multiple issues with their design that would make it unrealistic thus, unreliable data to make any changes in the belt's material. First of all, feet were constantly to hit the same spot. Feet were also getting dragged by the belt. We used data collected by our client to determine what type of motor we will use with what characteristics.

Running speed (km/h)	Men/women	Age in years	Body mass in kg	Body height in m	BMI in kg/m^2
10	m (n = 246)	33.2 (± 11.5)	78.5 (± 10.1)	1.80 (± 0.07)	24.0 (± 2.40)
	w (n = 171)	30.3 (± 12.2)	63.6 (± 10.2)	1.69 (± 0.08)	22.2 (± 2.95)
12	m (n = 246)	33.2 (± 11.5)	78.5 (± 10.1)	1.80 (± 0.07)	24.0 (± 2.40)
	w (n = 170)	30.2 (± 12.0)	63.6 (± 10.3)	1.69 (± 0.08)	22.2 (± 2.96)
14	m (n = 244)	32.8 (± 10.8)	78.6 (± 10.2)	1.81 (± 0.07)	24.0 (± 2.41)
	w (n = 167)	29.7 (± 11.6)	63.7 (± 10.3)	1.69 (± 0.08)	22.2 (± 2.97)
16	m (n = 243)	32.9 (± 10.8)	78.7 (± 9.86)	1.81 (± 0.07)	24.0 (± 2.37)
	w (n = 152)	28.6 (± 10.5)	63.0 (± 8.54)	1.70 (± 0.08)	21.9 (± 2.21)
18	m (n = 238)	32.6 (± 10.6)	78.6 (± 9.90)	1.81 (± 0.07)	24.0 (± 2.38)
	w (n = 123)	27.9 (± 9.81)	62.9 (± 8.61)	1.70 (± 0.08)	21.7 (± 2.18)
20	m (n = 220)	32.0 (± 9.93)	78.5 (± 9.93)	1.81 (± 0.07)	23.9 (± 2.39)
	w (n = 82)	25.3 (± 8.10)	63.2 (± 8.55)	1.71 (± 0.08)	21.6 (± 2.06)
22	m (n = 186)	30.6 (± 8.88)	78.1 (± 10.1)	1.81 (± 0.08)	23.8 (± 2.43)
	w (n = 50)	24.0 (± 6.55)	62.6 (± 8.23)	1.71 (± 0.08)	21.2 (± 1.73)
24	m (n = 138)	29.1 (± 8.12)	77.9 (± 10.2)	1.81 (± 0.08)	23.8 (± 2.39)
	w (n = 28)	23.9 (± 8.17)	62.6 (± 7.53)	1.72 (± 0.07)	21.1 (± 1.94)

Figure 1: Speed table of runners

According to the speed data collected we have chosen the most suitable motor for this. The motor is 2.5 hp (1.9 kW) 48 volts

Figure 2: Chosen motor

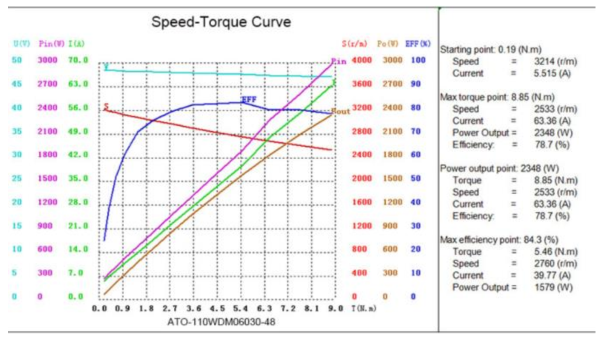

Figure 3: Speed-Torque graph[1]

Model	ATO-110WDM06030 (Click it to see more motor specs)			
Matched Controller Model	ATOTH-G (Click it to see more controller specs)			
Square Flange Size	110 mm			
Phase	3 phase			
Rated Voltage	24V DC	48V DC	72V DC	96V DC
Rated Current	98.2 A	44 A	32.7 A	22 A
Rated Power	2.5 hp (1.9 kW)			
Maximum Power	5.7 kW			
Holding Torque	6 Nm			
Peak Torque	18 Nm			
Rated Speed	3000 rpm			
Maximum Speed	3600 rpm			
Efficiency	85%			
Rotor Inertia	10 kgcm^2			
Electric Potential	6.7 V/K rpm	13.3 V/K rpm	20 V/K rpm	26.7 V/K rpm
Brake Apparatus Voltage	24V DC, (If 24V voltage is not connected, the motor brake)			
Motor Lead Length by Default	30 cm, if buy a kit (motor+controller), extra 1 meter of wire shall be provided.			
Warranty Time	12 months			
Certificate	CE, ROHs, ISO/TS16949			
Insulation Rank	F			
Protection Rank	IP65			
Temperature	-20~55℃			
Humidity	<90%RH (no dewing)			
Motor Weight	6.6 kg			
NOTE: *Tell us your application needs, we can customize the BLDC motor to meet your precise power, speed, voltage and current requirements.*				

Figure 4: Motor Information

III. Mechanical Design

Our design is based on having two motors for each foot; the main idea is to get both feet to walk with the treadmill like a real human in terms of changing speed according to the belt. A coupler is attached to the shaft of the motor to attach an encoder that would provide speed and positioning of both feet. In order to match the speed of the feet with the belt we designed a wheel that would be constantly rolling on the belt with an encoder attached to it that would send signals to the Arduino to change speed of both feet based on data collected. Both feet are going to move using a chain, a threaded bolt is used to tighten up any slake on the chain. A bicycle hub will be used to rotate the chain attached to long slot for any high adjustments as well as having a disc brake to stop both feet.

IV. Safety Precautions

It’s important for us to keep the user and people surrounding the device safe from any danger that a break down could cause. Therefore having acrylic plates is essential to keep everybody safe, the fixture was cover with acrylic plates from the front and both sides in case the chain broke down. We attached optical switches to control how far feet are traveling across the rails and incase one foot is to get through these switches it will send a signal to the disc brake to apply an emergency brake in order to stop the foot from reaching out to either the end or the front of the fixture and cause any damage.

Figure 5: Optical Switch

V. Conclusion

The design is not yet to be perfect and ready to build. But we can say that we have learned a lot through this semester as well as made a lot of progress in terms of getting it to meet with our client’s requirements in terms of replicating some of the real life stresses applied to the belt when using the treadmill.

VI. Reference

[1] SKU: ATO-BLDC 2300R3 (https://www.ato.com/3-hp-2-3-kw-24v-brushless-dc-motor).

[2] Pierrot, F., Reynaud, C., & Fournier, A., "DELTA: a simple and efficient parallel robot." *Robotica* v8(2):105-109,April1990, (https://www.cambridge.org/core/journals/robotica/article/delta-a-simple-and-efficient-parallel-robot/CC452596DC61FFC0F2E8CFF0ACE44994).