A Rat Model for studying Hazards in Industrial Power Tool Operation

Team Names: Carlos Veguilla, Luke Hetue, Mengizam Tizale, Yash Gokhale

Client: Dr. Robert Radwin & Dr. Mary Barbe

Advisor: Dr. Colleen Witzenburg

BME Design

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

Abstract

In collaboration with researchers at Temple University and UW-Madison,our team is developing a device that contains a handle that a rat can be trained to pull which initiates a controlled rapid impulse force in the opposite direction that results in eccentric muscle contractions in the rat's arms, bringing us one step closer to simulating repetitive power hand tool operation. The design includes a linear actuator mounted in line with a miniature load cell. A micro controller controls activation and operation of the device including the pull force and rate of impulse loading. The device aims to transition from a passive pull force system to a dynamic pull force system which is a necessary step in accurately modeling the effects of power hand tools.

Motivation

- Workplace's leading cause of pain is work-related musculoskeletal disorders (MSD's) [1].
- Accounts for 34% of all work days lost; up to $20 billion annually in direct workers' compensation
- In the 2010 National Manufacturing Agenda of the National Institute of Occupational Safety and Health, it was recommended that biomechanical research be put into the cause of MSD's [2].

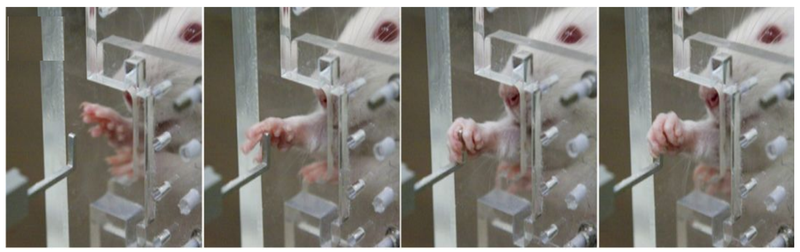

Figure 1. A sequential illustration of a rat reaching out, grasping, and pulling on a handle [3]

Background

- Bone structure can be manipulated by repetitive loading of the tissue [4][5].
- Bones of patients with MSD's were scanned and found to have increased blood flow and blood pooling [4].
- Dr. Mary Barbe currently has a static device at temple University
- Rats are trained to grab a handle and meet a certain force and time threshold to receive a food pellet
- Force generated by rats can be measured and recorded.

Problem Statement

Rats are being used as models to study the repetitive use of power hand tools. Currently a device exists to measure the force a rat produces by pulling on a handle. Our design aims to transition from a static system to a dynamic one that not only measures forces but can react and apply opposing forces to the rat.

Design Criteria

- A device which provides an opposing force to a rat's pull
- Reach duration should be able to be changed by the researcher
- Opposing force should begin immediately once the rat begins to pull on the handle
- Test must not result in a reward unless the test lasts for the entire time frame specified for the test

Final Design

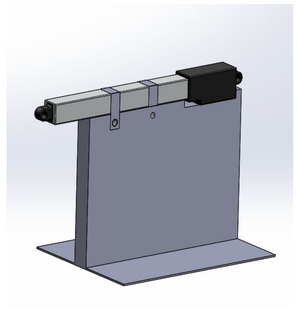

Figure 2. SolidWorks model of the final design

Figure 3. The current static block which we will be replacing

Testing Data & Results

Testing will follow the established testing protocol

1. Calibration with weights
2. Excessive load test
3. Insufficient load test
4. Durability Test

Figure 5. Testing stability of internal components

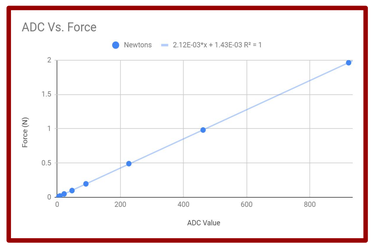

Figure 4. Calibration curve for load cell readout to force conversion

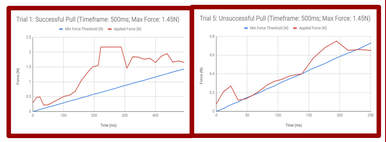

Figure 6. Example of successful and unsuccessful attempt

Testing Setup

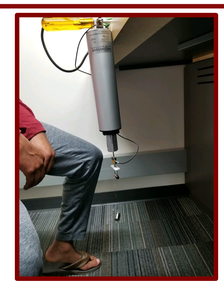

Figure 7. Image of testing setup used for the calibration testing which resulted in the calibration curve shown in figure 4.

Material Costs

Item	Descrip	Manu	Part Number	Date	QTY	Cost Each	Total
Acuator							
100 mm Stroke 4 lb Thrust Light Duty Linear Servo	Regardi	Acuon	L12-R-100-50-6	2/13/2019	1	69.99	$69.99
Load Cell							
FUTEK LSB200	Jr. Mini	Futek	FSH02602	2/24/19	1	500	$500.00
SD cards/reader							
SenMod 5PCS Micro SD Card Micro SDHC Mini TF	Used to	SenM	2126efef26m206	3/31/2019	1	8.29	$8.29
Amplifier							
Analog Amplifier with Voltage Output	Used to	Futek	FSH03863	3/31/19	1	425	$425.00
H-Bridges							
DC Brush Motor Controller	DROK 1	DROK	2001712008	2/24/19	1	18.99	$18.99
Fuses							
10pcs 5x20mm Fuse Holder Inline Screw Type With	Will red	Lime :	B07F8RLMPB	4/4/19	1	11.99	$11.99
Rocker Switch	To turn t	Karlss	COM-11138	4/4/19	1	0.5	$0.50
Circuit Box (houses the circuit making it look nicer as well as minimizing damage that could occur while storing or trans							
JBH-4955-KO	used to	Bub ir	**JBH-4955-KO**	4/5/19	1	15.3	$15.30
Perf boards (used to construct circuit on to minimize wiring)							
FTCBlock 32 Pcs Double Sided PCB Board Prototyp	used to	FTCB	B07FYD8ZFS	4/4/19	1	8.45	$8.45
Wall Plug (to power system)							
VSEER 6ft 18 Gauge 3 Prong Heavy Duty Universal	Used to	VSEE	B07KN7MN9C	4/5/19	1	7.99	$7.99
VTX-214-001-318 -	used to	Virgor	VTX-214-001-318	4/7/19	1	27.53	$27.53
Mount material							
Aluminum plate	6" x 6"	Grain	Alloy 6061	4/7/19	1	33.3	$33.30
7-segment LED display							
uxcell 5 Pcs Common Cathode 12 Terminals 4 Bit 7	**Used to**	uxcel	**3461AH**	4/7/19	1	3.82	$3.82
Total							$1131.15

Future Work

- Implement L12
- Revise device to pass all tests
- Send device to Dr. Barbe for on site testing with rat
- Take feedback to revise device
- Implement vibrational loading 77

Acknowledgements

Dr. Robert Radwin, Dr. Mary Barbe, Dr. Colleen Witzenburg, John Puccinelli

References

[1] United States Department of Labor, "PREVENTION OF WORK-RELATED MUSCULOSKELETAL DISORDERS," 2014. [Online]. Available: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=4481&p_table=UNIFIED_AGENDA. [Accessed: 26-Feb-2019].

[2] L. Foss et al., "The Impact of Workplace Risk Factors on Long-term Musculoskeletal Sickness Absence," J. Occup. Environ. Med., vol. 53, no. 12, pp. 1478–1482, Dec. 2011.

[3] S. A. Hays et al., "The isometric pull task: A novel automated method for quantifying forelimb force generation in rats," J. Neurosci. Methods, vol. 212, pp. 329–337, 2013.

[4] V. S. Massicotte et al., "Prolonged performance of a high repetition low force task induces bone adaptation in young adult rats, but loss in mature rats," 2015.

[5] J. O. Green, S. Nagaraja, T. Diab, B. Vidakovic, and R. E. Guldberg, "Age-related changes in human trabecular bone: Relationship between microstructural stress and strain and damage morphology," 2011.