A rat model for studying hazards in industrial power tool operation, Team PT GKG

Product Design Specification (PDS)

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Preparation and Evolution of the PDS: The PDS is a comprehensive document, which contains all the facts relating to the product outcome, and should contain all the realistic constraints to be imposed upon the design by the client.

Items in the PDS should be as quantitative (in SI units) as possible. (e.g., the device must weigh less than 2 kg.; the device must fit in a 3 m x 3 m x 2 m space), and ranked in order of importance.

The PDS is a dynamic document that should evolve as the project scope develops. This is because frequently at the start of a project it is not always clear what is achievable and to what extent certain parameters are essential.

CONTENTS OF PDS

Client requirements (itemize what you have learned from the client about his / her needs): Briefly describe, in bullet form, the client needs and responses to your questions.

- Needs a device which provides a opposing force to the rat's pull
- Forces applied to the rats should be able to be changed by the researcher
- Opposing force should begin immediately once the rat begins to pull on the handle
- The rat must retain it's grasp on the handle for a given amount of time in order to receive it's food (the food should not fall out immediately once the rat pulls on the handle).

Function: Power hand tool operation in factories and service facilities, including threaded fastener tools (i.e. screwdrivers and nut drivers), present hazardous hand loads resulting in repetitive motion injuries. The rapidly rising impulse loads transmitted to the hands while operating tools often produce stressful eccentric muscle contractions, which exceed the operator's capacity to hold the tool stationary and stretch muscle fibers and tendons, resulting in chronic injuries due to repetitive loading. The objective of this research is to conduct animal studies leading to an understanding of the pathophysiology associated with repetitive tool operation.

This project proposes to develop 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, simulating repetitive power hand tool operation. The investigators intend to train rats to repetitively pull on the handle using sufficient force to activate a motor that pulls the rat hand in the opposite direction in order to receive a food pellet. The device will need to fit inside a cage-mounted device of similar dimensions that currently controls passive pull force.

1. Physical and Operational Characteristics

a. **Performance requirements:** The performance demanded or likely to be demanded should be fully defined. Examples of items to be considered include: how often the device will be used; likely loading patterns; etc.

- Data
    - Mean max force = 163gf
    - Threshold = 24.45 gf
    - Mean reach force = 142 gf

b. **Safety:** Understand any safety aspects, safety standards, and legislation covering the product type. This includes the need for labeling, safety warnings, etc. Consider various safety aspects relating to mechanical, chemical, electrical, thermal, etc.

- The design must be free of pinch points and fire hazards
- If the product is damaged, exposed wires could cause electric shock.

c. **Accuracy and Reliability:** Establish limits for precision (repeatability) and accuracy (how close to the "true" value) and the range over which this is true of the device.

- Resolution for force control should be 0.024N

d. **Life in Service:** Establish service requirements, including how short, how long, and against what criteria? (i.e. hours, days of operation, distance traveled, no.of revolutions, no. of cycles, etc.)

- The experiment will be run over 6-12 weeks and the device should last for multiple trials

e. **Shelf Life:**

- The apparatus should be stored at approximately 25 degrees Celsius.
- The apparatus should be able to last at least a few years on the shelf while maintaining functionality

f. **Operating Environment:**

- The materials used will be put under stress by the pull of the rat. This is not a very significant amount of force (about 1.5 Newtons), but it will stress materials over a long amount of time. While the experiment is only being run for 6-12 weeks, preferably the

device will be able to last for longer than that, in case it is needed for further research. The lab could become humid during the summer months.

g. **Ergonomics:**

- The handle must be small enough to be gripped by a rat. It must be strong enough to not become weak or deformed under the force of the rat pulling on it. The handle needs to be located approximately 8.5 cm above the level of the rat (in order to fit the current model), and it must be located about 1.5 cm from the hole that the rat has to reach through.

h. **Size:**

- The product must be able to fit within the rest of the current model. The box that rats are held in is 31.8 cm tall. The handle is 8.5 cm from the bottom of the box.

i. **Weight:**

- Once our product is installed to the rest of the machine, it will not move. That being said, it needs to be light enough to handled by the average person (50 lbs). Apart from that, there are no weight limitations.

j. **Materials:**

- For the handle, we will need to use a material strong enough to endure pressure over time. No materials are off limits, but the current model uses some type of metal, which would probably work well in our case.

k. **Aesthetics, Appearance, and Finish:**

- Because it is being used to research with rats, the functionality is the only concern for our product. Appearance is not important.

2. **Production Characteristics**

a. **Quantity:** number of units needed

- 1 unit required

b. **Target Product Cost:**

- We are still investigating. Once we begin brainstorming ideas and putting together a bill of materials, we will know more.

3. **Miscellaneous**

a. **Standards and Specifications:**

- FDA approval is not required.

b. **Customer:**

- Our customer is working with a professor from Temple. Their main concern is that the new model will be dynamic, not static.

c. **Patient-related concerns:**

- Because the device is being used to test rats, there are no real safety, sanitation, or confidentiality concerns.

d. **Competition:**

- The current model being used is very similar to the model we have been asked to develop. The main difference in the two models is that the current model is static. When the rat pulls on the handle, the force is sensed, and the food is dispensed. Our model will provide a reaction force to the rat when it pulls on the bar.