L36 _ 05

Megan Antczak, Clare Kowalczyk, Grayson Lentner, Noah Walters

PD5 - FMEA Memo

Executive Statement/Introduction

In this memo, we discuss the implication of FMEA, or Failure Modes and Effects Analysis, in our current project, an autonomous snowmaker. This analysis will allow us to effectively detect errors and failures in our design, and minimize them to the fullest extent possible without reducing the effectiveness or functionality of the device. This stage of development is essential for the customer, as major safety hazards and defects to the user are caught. New changes to the existing design are then made to eliminate these failures to the best of the designer's ability.

Background

Our product is an autonomous snowmaker. The objective of our product is to improve skiing conditions for the large population of skiers, specifically in the Midwest region. Our product will autonomously detect ideal snowmaking conditions using temperature and humidity sensors and the necessity to make new snow. If a need for more snow is detected, our product will create new snow through a device with a pressurized pump with a mist nozzle. This design will evenly distribute uniform snow in hazardous areas. This innovation will greatly improve the consistency of slopes. Therefore, skiers' safety, enjoyment, and overall experience will be substantially enhanced.

This product will bring attention to the importance of maintaining ski hills for recreation and sport. In the upper peninsula last year several popular ski hills had to close very early due to the abnormal winter. With this product, the resorts could extend their season bringing more tourism and innovation to the area.

Methodology

Our procedure for the FMEA analysis is as follows:

1. **Description of parts and their modes of failure** - Every significant component of our system, including but not limited to the pump, nozzle, and fan is identified. Most failure modes are identified and connected to their corresponding parts.
2. **Symptoms, Effects, and Significance Rating** - The symptoms of failures are identified along with the possible effects and damages they may have on the customer. The symptoms and effects are then used to conjure a Significance Rating from 1 to 10 based on how severe the failure may be to the customer, with 10 being the most severe.
3. **Probability of Occurrence Rating -** Notes are produced to determine how likely the failure mode is to occur, and then a probability rating from 1 to 10, with 10 being the most likely, is determined based on these notes.
4. **Detectability Rating -** Notes about how a failure mode may be detected before it occurs are taken, and then are used to determine a detectability rating from 1 to 10, 10 being the least detectable.
5. **Risk Priority Value -** Risk priority values are calculated by multiplying the significance rating, probability rating, and detectability rating together. The risk priority value is then used to determine which failure modes require the most attention.

Results and Discussion

Through our discussion of each hazard and the completion of the FMEA analysis, we identified 8 different components of our design to revise. These include the water pump, mist nozzle, tubing, DC motor/fan, servo, servo value, wiring, and temperature and humidity sensor. We went over multiple different fail mechanisms for each of the components through research into common problems as well as thinking through environmental conditions or basic human errors that might occur.

Parts, Concerns, & Solutions

1. **Water Pump:** (clogged, internal friction, not enough power/pressure supplied)
   Solutions: Create a protective structure over the inlet, apply lubricant to areas of friction, and modify the stepper motor to supply greater torque.

   – Average Risk Priority Number: 58.7

2. **Mist Nozzle:** (uneven water distribution, unsuitable mist power, clogged, freezes over, breaks from failure)
   Solutions: use references for nozzle design, test design with the right pressure and environmental conditions, calibrate to apply the right amount of pressure, and use durable material and design aspects.

   – Average Risk Priority Number: 162.5

3. **Tubing:** (leaks, freezes over)
   Solutions: use extra adhesive or connective material (tape), and heat/insulate the water supply to keep it from freezing

   – Average Risk Priority Number: 224

4. **DC Motor / Fan:** (not enough air current to propel mist)
   Solutions: determine the right current and proper mist size before in a test environment

   – Average Risk Priority Number: 60

5. **Servo:** (motor fails)
   Solutions: intentional placement to minimize failure of moving marts

   – Average Risk Priority Number: 8

6. **Servo Value:** (seal is not sufficient)
   Solutions: rubber material to create a seal

   – Average Risk Priority Number: 80

7. **Wiring:** (not secured/comes loose, short circuits)
   Solutions: if they come undone they will be detected through electronics not operating, and can be fixed manually after that, prevention includes checking all connections before the final assembly

   – Average Risk Priority Number: 18

8. **Temperature & Humidity:** (correct conditions are not detected, doesn't work)
   Solutions: testing before implementation into the device.
   – Average Risk Priority Number: 36

Many of the hazards resulted in unsafe conditions for users of the ski hills, thus our rating for failure severity was based on how dangerous it was to the public. In cases where the water was distributed in heavy amounts, the snow would not form in the process of the device. This would create more ice patches on the ski hills and make the slope very dangerous for any of the people using it that day. Best case scenario, the ski hill would have to close down for the day and lose profit. Other hazards resulted in the device failing to work, so those were rated less severe due to no possibility of human casualty.

We chose the mist nozzle and the tubing as our top hazards because almost all of their failure symptoms had consequences involving injury. Both also had a high chance of happening based on how likely it was that they could freeze or break under temperature-induced brittleness. For the mist nozzle we decided to test our 3D printed nozzle before implementation into the design as well as testing it in cold conditions to test whether it would freeze over or fracture. For the tubing, we discussed implementing an insulation system or water heater to keep the water supply from freezing. We also discussed adding extra reinforcement to the joints of the tubing to reduce fractures and leaks.

These changes will reduce the occurrences of such failures and keep extra water from being distributed over the hill. This will result in safer ski hill conditions overall and reduce the impact of such failures on the community.

Conclusion

We have considered many failure modes in our device including frozen water in tubing to reduce hazards that may be brought about by the device. These failure modes were detected via FMEA and included but were not limited to the uneven distribution of water, and torque failures within the motors of the device. Several precautions have been taken to minimize these failures as well as their effects, ensuring the customer will be satisfied with their use of the device. These Precautions include installing insulation within certain parts of the device to prevent freezing, as well as modifying some motors to withstand a higher amount of torque. In total, significant errors and failures of the device are being taken into account and will be minimized in the interest of the user.