GE Project

Kinetic Energy Generating Wheels
Stator Magnets

Engineering Design 100
SECTION 025 Dr. Ritter
December 14, 2015

TEAM WON
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Abstract

GE is now looking for an effective system to bump their tier 2 locomotives into EPA standard tier 3 or better. In order to reduce the amount of harmful smog emissions in Pittsadelphia and to meet tier 3 standards we decided to implement a kinetic energy system into all of the wheels of the locomotives and rail cars.

With our system we will surpass tier 3 standards but fall short of tier 4 standards. Our system will consist of 336 stator magnets. The coal trains will share 168 stator magnets with each wheel will holding two magnets. Since the freight trains have less weight and cars then the coal trains the freight trains will have three stator magnets on each wheel. The freight cars will also share 168 stator magnets. With our proposed system we plan to cut the amount of diesel fuel by 61% therefore we will cut emissions by 61% also.

Introduction and Problem Statement

Approximately 165,000 tons of freight or minerals per day travel by fifty locomotives from Indianapolis to the city of Pittsadephia located 500 miles away from Indianapolis. The amount of freight carried by locomotives is significant and extremely beneficial to the city and its residents, however the smog from the locomotives causes environmental problems including air pollution. During the combustion of the fuel, one of the pollutants produced is NOx. “Nitrogen Oxides (mainly NO and NO2), or NOx, is the generic term for a group of highly reactive gases, which contain nitrogen and oxygen in various amounts and chemical configurations. Most of the nitrogen oxides are colorless and odorless. However, one very common pollutant, nitrogen dioxide (NO2) along with other particles in the air can often be seen as a reddish-brown layer of smog over many cities or heavily populated areas (Einstrument.com).” Therefore smog from locomotive emissions is the biggest complaint from city residents. Based on the background
research, we created a problem statement for the better understanding of the objective of the project which is located below.

The smog from the emission of the transportations releases substances like NOx that are harmful to people in cities and the environment itself. We are currently in tier 2 of the eco requirements and we have to get to tier 3 or better with the new system. We must reduce the smog for the people by creating or manipulating the ways of transportation system such as fleet upgrades or alternate shipping methods.
**Customer Needs**

The following table explains the customer needs and the goals of the project according to the needs. We separated the goals into two parts acceptable and ideal.

**Table 1. Customer needs**

<table>
<thead>
<tr>
<th>Need</th>
<th>Acceptable specifications</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce smog</td>
<td>Tier 3</td>
<td>Tier 4</td>
</tr>
<tr>
<td>Affordable</td>
<td>6 year return investment</td>
<td>less than 2 years</td>
</tr>
<tr>
<td>Efficient</td>
<td>a. maintaining 165,000-tons of freight or minerals (coal, etc) per day travel</td>
<td>a. greater than 165,000 tons of freight or minerals</td>
</tr>
<tr>
<td></td>
<td>b. at most 2 hours delay of delivery schedule</td>
<td>b. on time or early delivery</td>
</tr>
<tr>
<td>Practical</td>
<td>easy to maintain and implement in less than 2 months. If infrastructural change is required, then 5 months should be acceptable.</td>
<td>1 month or less. But if it requires infrastructural change, then ideally it is going to be 4 months or less.</td>
</tr>
<tr>
<td>Durable</td>
<td>lasts (being able to withstand harsh weather conditions and being able to hold still in near perfect condition without requiring much frequent maintenance) for at least 20 years over 500 miles at 50 miles per hour</td>
<td>lasts (being able to withstand harsh weather conditions and being able to hold still in near perfect condition without requiring much frequent maintenance) for at least 30 years over 500 miles at 50 miles per hour</td>
</tr>
<tr>
<td>Public opinion</td>
<td>minimal noise pollution appearance (% of people surveyed are appealed)</td>
<td>zero noise pollution appearance (100% of people surveyed are appealed)</td>
</tr>
<tr>
<td>Safety</td>
<td>pass modern safety test</td>
<td>exceed modern safety test</td>
</tr>
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</table>
Concept Generations

Idea 1: Catalytic Converter

Our first idea was to use a catalytic converter in all of the tier 2 locomotives to lessen the emissions of NOx and PM which would convert the tier 2 locomotives into tier 3.

Idea 2: Kinetic Energy Wheels

For our second idea we came up with the concept of wheels that as the train moves, as the wheels turn, kinetic energy will start to generate. Diesel fuel would be used to first propel the locomotive and after a couple of miles the locomotive would start to run on stored kinetic energy. This energy will be stored in a battery and after time the locomotive will become self sustainable.
Idea 3: Wind for Fuel

Our third idea was very similar to our second idea but instead of using kinetic energy we would use the energy generated from wind turbines. Our rationale for this idea was to hollow out the inside of the tier 2 locomotives and put a row of wind turbines inside. For wind to reach the turbines we would leave an openings in the back and front of the locomotive.

TASC

For better understanding of the ideas we used a program called TASC. We uploaded the pictures of our ideas and we chose the words from the supplied list of descriptive words for each picture. Examples of these words included innovative, clean and complex. Each of the words carried some sort of weight with it that focused on different aspects such as creativity and effectiveness. By choosing whichever words came to mind about the design, the TASC program was able to rank our ideas. The results are listed below with the bigger words being the ones
that were picked the most. Using the TASC program helped us to understand the pros and cons of each concept and decide on our final design.

**Figure 1. TASC result for Wind 4 Fuel**

**Figure 2. TASC result for Catalytic Converter**
Figure 3. TASC result for KE
Concept Development, Cost - Benefit Analysis, and Selection

We came up with 3 different ideas for our project. Using concept generation, we ranked the 3 ideas in order of their feasibility and creativity.

Table 2. Concept development analysis

<table>
<thead>
<tr>
<th></th>
<th>Economic/Technical feasibility</th>
<th>Meeting Customer Needs</th>
<th>Cost-Benefit Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalytic converter</td>
<td>Most feasible fairly cheap, does require a decent amount of upkeep and replacement</td>
<td>Equivalent to the amount of emissions needed to meet tier 3 requirement.</td>
<td>usually last 100,000 miles for a car and a truck if you say it travels 500 miles a day you would have to replace it close to twice year(every 200 trips)</td>
</tr>
<tr>
<td>KE</td>
<td>This is the least expensive option if it works. Not sure if the technology is feasible yet though.</td>
<td>Fits better (less emission)</td>
<td>If it creates energy less amount of fuel will be needed. Energy that is created can also be saved and that can be used for the next trip. Will save a ton of money strictly on fuel usage since trins spends almost $20,000 on each trip into Pittsadelphia.</td>
</tr>
<tr>
<td>Wind 4 Fuel</td>
<td>least feasible due to industrial cost constraints such as remodelling the rail system. Very expensive</td>
<td>Fits better (less emission)</td>
<td>Same scenario as the kinetic energy concept but this idea would require a lot of costs on industrial changes for the infrastructure of the rail system itself such as the tracks and tunnels.</td>
</tr>
</tbody>
</table>
Design Review

According to groups two and five, our design requirements are sensible. The additional requirements needed to complete for our design would be generators and an attachment system. We found that our product would meet customer needs by cutting fuel usage by at least half resulting in lower emissions. The idea of using generators for this purpose is a reasonable way to solve the problem. Once our idea is developed further we may even be able to have the locomotive be self propelled. Our design is effective in representing the product and also emphasizing its benefits.

We found that some improvements can be made on the design with the help of some other students. The reviewers suggested to calculate the return on investment because the stakeholder might be affected by the calculation. Also they recommend to consider how much money we would save on fuel since this should be enough to return the initial investment of the Stator Magnet system in a reasonable amount of time. Also, once the return investment is reached we would be able to implement more money and resources into improving the system to becoming even more efficient and therefore create less emissions. Once we figure out these calculations we need to make sure we are making enough of a fuel difference that the EPA requirements are being met and the investment will pay back to our stakeholders in a reasonable amount of time.

Based on the feedback given by our peers, the product we are creating seemed to be feasible. This is a good sign because it means we can move on with the later part of our design process. It is reported that we can still improve on our system diagram for
our product because it is lacking description. We will fix that immediately by adding more pictorial descriptions to clearly support the idea of our product. Also, our product can also function in a larger system which means our product is efficient. Finally, we should be considering to use the electrified tracks instead. And we are told that our product is creative and we are going to improvise more on the different aspects of our design to further enhance our product’s usage and capability.

Description of Final Design

336 Stator magnets will be implemented in wheels that are attached to the traction motors. With our new system approximately 61% less fuel will be needed to run the trains. Our kinetic energy system will provide the coal trains with 62% of the energy needed. And for the freight trains our system will similarly provide 60% of needed energy.

We created a system where the wheels of the locomotive will store and produce kinetic energy to make the locomotive self sustainable after the wheels garnered enough kinetic energy to power the locomotive forward. This way, we lessen the amount of fuel used by 61%. And in turn, we are able to reduce the amount of NOx emissions which are harmful to the environment and to the human beings by 61%, which is the primary objective of this project.

Calculations for Final Design

In order to see if our design was plausible we had to use a medium of measurement to compare diesel fuel to kinetic energy, we uses kiloWatt hours. We found out that one gallon of diesel fuel was approximately 33 kiloWatt hours. And when you take in account the weight and velocity of the trains you can figure out the kWh produced by our systems.
Table 3. Calculations for final design

<table>
<thead>
<tr>
<th>Weight (Tons) (cargo + railcars + locomotives)</th>
<th>Velocity (Meters per Second)</th>
<th>Energy Generated by 1 system (\frac{1}{2}(weight)(velocity)^2)</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coal trains carrying 12,000 tons of coal</strong></td>
<td>12,000+240+630 =12,780 tons =11,675,468 kg</td>
<td>33.528m/s</td>
<td>=6,562,353,147J =1,822.876 kWh</td>
</tr>
</tbody>
</table>
| - 1 system saves 44.8 gallons of fuel  
- With 2 systems on each wheel (168 systems) 7,524 gallons of diesel fuel will be saved out of 12,766 |

| Coal trains carrying 1,000 tons of coal        | 1,000+630+240 =1,870 tons =1,696,435 kg | 33.528m/s | =953,504,010.4J =264.862 kWh |
| - 1 system saves 6.5 gallons of fuel  
- With 2 systems on each wheel (168 systems) 1,092 gallons of diesel fuel will be saved out of 1,064 |

| Freight trains carrying 7,000 tons of coal     | 7,000+210+160 =7,370 tons =6,685,952 kg | 33.528m/s | =3,757,928,860J =1,043.861 kWh |
| - 1 system saves 25.6 gallons of fuel  
- With 3 systems on each wheel (168 systems) 4,308 gallons of diesel fuel will be saved out of 7,448 |

| Freight trains carrying 500 tons of coal       | 500+210+160 =870 tons =78,925kg | 33.528m/s | =443,609,094.2J =123.225 kWh |
| - 1 system saves 3.03 gallons of fuel  
- With 3 systems on each wheel (168 systems) 503 gallons of diesel fuel will be saved out of 532 |
Systems Diagram

Stator Magnets ($56,784 one time cost)

Indianapolis $13,035 Cargo + fuel Engine Locomotive Cargo KE Emissions Pittsadelphia

There is a one time cost of $56,784 dollars to implement the Stator Magnet system on the locomotive. Does not include maintenance.

Concept of Operations

Team won

Conops:

Kindic Energy
Conclusions

The objective of the project was to reduce smog from GE locomotives to meet the EPA requirements while maintaining or increasing the capacity of freight into and out of the port city, Pittsadelphia. Considering the objective of the project, we did reach our goal to reduce smog emissions to meet the EPA requirement which is Tier 3. Our Hot Wheel System will decrease the amount of the fuel needed as well as the amount of the emissions by 61% . The new system is economically feasible because it only requires attaching the stator magnets to the traction motors on the back of the wheel. Implementing the system will only cost $56,784 making our return of investment about 25 trips while still maintaining the same amount of trips per day.

References

7) "Wheel Hub Motor Concept Drives Hybrid Progress at MTSU." Wheel Hub Motor Concept Drives Hybrid Progress at MTSU. N.p., n.d. Web.
9) "Understanding the current system calculations." Ritter, Sarah