Montana State CSC Design Paper

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Introduction

As a first year team, the Montana State University Clean Snowmobile Challenge set its values on building a snowmobile that was cleaner, quieter and more efficient, but also making it reliable and still retaining or improving the overall performance of the snowmobile. The team learned several lessons it's first competition year and is looking forward to building on the modifications for competition for years to come.

Innovations

A dual catalytic converter system was designed and implemented to help mitigate the pollution from unburnt hydrocarbons and carbon monoxide. These catalytic converters were placed parallel such that the exhaust gases passing through the catalysts would be traveling at a relatively slow space velocity and have plenty of time to complete full combustion.

To comply with the flex-fuel capability requirement, the team decided to implement a Dynojet Power Commander V to adjust the fuel injector duty cycle based on the 0-5V signal from a GM fuel composition sensor in series with the fuel supply line and a wide band oxygen sensor. Using these measured variables, the team created a custom engine map to help maximize engine efficiency.

The stock Polaris snow flap was redesigned to be suitable for competition to ensure minimal clearance with the ground and to not allow for the flap to get stuck under the track while reversing. To accomplish this, a heavy-duty rubber mat was purchased and a frame was manufactured with sheet metal with a design emphasis to avoid tearing. The snow flap was also designed to help mitigate the sound coming off of the track of the snowmobile by positioning it at an angle.

Team Organization and Time Management

The Clean Snowmobile Club at Montana State University MSU was officially created in November of 2017. Aaron Juntunen, the president of the club, ran weekly club meetings and facilitated the operations as well as the vision of the club. Joseph Swenson operated as the team treasurer to manage club finances and expenditures. The project was kept on task by dividing the team into groups that covered various aspects of the snowmobile build. The sub-teams researched their portion of the build for the initial stages. Altogether the team would check in weekly with progress reports and any suggested updates to the timeline, along with any other needs, in order to make the competition deadline. The team set deadlines for projects to be at a certain stage before they would be cut from the project.

The original club's general timeline, included fundraising and project planning from August through October, building from October through December, testing and refining from January until competition, and writing the reports from January through February 18th. Due to an abnormally high amount of project delays, several projects were pushed until next season, building began in mid-January and completed by mid-February, fundraising and planning were accomplished on time.

For the 2019 competition, three separate fundraisers were held. The team worked concessions at the Brick Breeden Fieldhouse on two occasions, the third fundraiser involved hosting the Thunderstruck snowmobiling documentary on MSU's campus.

Team building through group activities was an important part of creating team cohesion. The team met several weeks for dinner at a local restaurant, as well as occasionally playing pond hockey, and hosting a club Thanksgiving dinner.

Build Items of the Snowmobile

- Snow flap - Student designed and manufactured
- Chassis - Polaris, Switchback Assault 144", 2019
- Engine - Polaris, Gasoline, 2015 Cleanfire, 2- stroke, 599cc, 125 HP (Estimated from external specifications [1])
- Track - Polaris, 144" long, 1.35" high lug, Cobra Track
- Muffler - Stock Polaris Muffler
- Catalytic Converter - BASF, Bi-metal
- Skis - Stock
- Dual Expansion Chamber - N/A

Emissions Reduction

MSU CSC decided to use a two-stroke Polaris 600cc Clean Fire engine to take advantage of the two-strokes high power to weight ratio and low-cost of manufacturing. To reduce emissions, the team partnered with BASF to implement a catalytic converter system.

Inherently with the two-strokes low trapped compression ratio, there is little NOx [2] production and a high amount of excess oxygen due to short-circuiting during the intake and exhausting period. As a downfall with the two-stroke engine, there is an excess of HC and CO. With these characteristics in mind, Peter Jensen at BASF [3] recommended the use of their new TEX-2182 coating technology.

This wash is proficient at exchanging oxygen which is suitable for completing oxidation of the excess CO and HC in the two-stroke exhaust stream (Table 1).

Table 1. Specifications of the Catalytic Converters.

Manufacturer	BASF
Wash ID	TEX-2182
Length	3.07 in
Diameter	2.72 in
Loading	36 g/ft^3
Loading Ratios	0/29.25/6.75 (Pt/Pd/Rh)

Careful consideration was taken into the implementation of the dual catalytic converters (Figure 1). First, they were installed in parallel, this also allowed for a slower space velocity due to the larger cross-sectional area available to flow through. Second, to ensure an even loading, a manifold 6 inches long that connected the single expansion chamber outlet pipe to the two catalysts was fabricated to allow adequate distance for the exhaust to spread evenly among them. Third, since the housing of the converters was metal, one side was welded to the fabricated housing, while the other was left unattached so that it would be able to thermally expand. With the dual catalyst system, the individual converters will have an increased lifetime meaning the snowmobiles emissions will be cleaner for longer.

Figure 1. Modified exhaust system with no exhaust wrap.

Results

While the team was unable to gather data before competition to show how the modifications improved the snowmobile, the team was successful in spatially implementing the designs into the snowmobile, and will be ready for data acquisition at the Clean Snowmobile Challenge.

Summary/Conclusions

Though the team faced many setbacks through the first year, positive modifications were made to the snowmobile which helped to build towards goals of the competition and the team. With the base knowledge gathered the team's first year, that will be able to directly apply to next season's design and build.

References

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Definitions/Abbreviations

MSU	Montana State University
CSC	Clean Snowmobile Challenge
CO	Carbon Monoxide
HC	Hydrocarbon

Pt	Platinum
Pd	Palladium
Rh	Rhodium