Design 3 Midterm Report

Clean Snowmobile Competition
Noise, Vibration and Harshness Team
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The Yamaha Phazer is a sporty sled designed for performance and not for being quiet. It is the job of the NVH team to revamp the sled and make it quieter.
Milestones were developed and are being completed to reduce the noise emission of the sled. Milestones are listed and commented below.

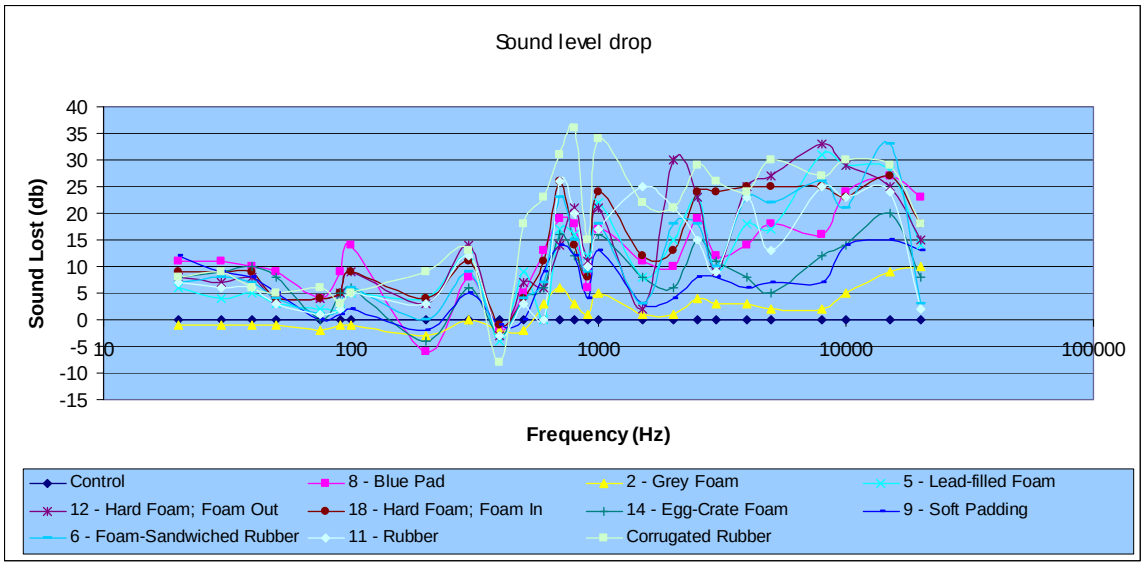
- Obtain SAE J192 Noise Standard
  - A copy of the standard was found in a stack of papers left behind by the previous team. The pamphlet describes the noise test in detail including the type of equipment used and the layout and requirements of the test area. The basic idea of the test is that a microphone will be placed 50 feet from an "acceleration lane" and the snowmobile will accelerate at full throttle in the acceleration lane for 150 feet while the sound level meter attached to the microphone records the sound level. The test is then repeated with the snowmobile traveling in the opposite direction. The highest recorded value from each run is used, and the side of the snowmobile that creates the most noise is the side that will be judged.
  - What this means is that the sled must make minimal noise on approach, on departure, and from both sides. It would not be beneficial to have a loud spot on one side of the sled as that one loud spot would then determine our score on the noise test.

- Design and conduct a repeatable noise level test on the dyno (RPM vs. Time)
  - A repeatable test done indoors will not have reliable results, but when done carefully can help determine major changes or major sources of noise. A test has been designed and partially run to determine major noise issues but the sled has been largely disassembled making further testing inconclusive.
  - One setback is that track noise cannot be accurately determined without actually testing the snowmobile on snow. This is a setback because now that there is snow, the sled is not in an operating condition.

- Determine Mechanical Noise Issues
  - Major noise sources that have been discovered include:
    - Clutch gearing mechanism
      - The clutch for the Phazer is geared to reduce the high engine speed to a speed that is more suitable for the track. These gears have a significant amount of whine that is prominent at low engine speeds because of their square-cut nature.

        - Exhaust noise
            - The Phazer's exhaust has been designed from the factory to have a loud, sporty tone in order to sound powerful. While this is pleasing to listen to, it is not desirable for the Clean Snowmobile Challenge and must be addressed. (see below)
        - Engine Intake noise
            - The two cylinder engine in the Phazer breathes through a large airbox positioned at the front of the sled. The inlet of the airbox is underneath the box and is in what can be loosely referred to as the engine compartment. This noise source will be addressed with the new cowling.
        - General engine mechanical noise
            - Reciprocating engines create noise by their nature and the one in the Phazer is no exception. The engine in this sled is located beneath a considerable amount of other bits and pieces which will all help isolate the noise, but the new cowling will be the biggest help to the problem.
    - Track noise has not been determined yet but in comparison to the other noises, is not expected to be a large contributor until after the other sources have been addressed.

- Test Sound-barrier Materials
    - A selection of sound isolating materials was tested using a pre-existing apparatus and a sine-wave generator. Results are in the appendix.
    - The design of the apparatus caused peaks and valleys at certain



frequencies due to the length of the apparatus. These peaks and valleys have not been addressed yet but the data shows comparative results between the different materials.

- Kevlar-Covered Aluminum Clutch Cover

- Competition rules state that the clutch cover must extend at least to the centerline of each clutch pulley, be made of aluminum at least 0.09in. thick, and be covered in Kevlar belting. The stock clutch cover did not satisfy any of these requirements so a new one is being fabricated.
- The new clutch cover started as a very rough cardboard mock-up made by eye. It was then sketched and designed to use the smallest sheet of aluminum possible. Once it was sketched, another cardboard mockup was constructed to check measurements and spaces. This mockup was improved and altered, and the sketches were updated to match. The new sketches were used to construct a third mockup, which was then fine-tuned to fit the existing mounting points of the old cover. Once the sketches were updated, the cover was cut out of the aluminum and welded together.
- The old plastic side-panel will not fit over the new clutch cover so a new side-panel will have to be constructed with the new cowling.

- Completed Exhaust System
  - The existing exhaust system on the Phazer had been modified by the previous year's team to include a catalytic converter. The welding done by the team leaked and the muffler was original equipment from the factory.
  - The exhaust system was removed and disassembled and the muffler was opened.
  - The muffler turned out to be completely void of any sound-absorption material on the side case. There was some fiberglass packing on the end plates, however much of it was enclosed by solid sheet steel, rendering that part useless. The end plates were modified to expose more packing, and packing was added to the side casing. This modification should quiet the exhaust noise, especially the peaks, while retaining the desirable sporty tone.

  - The welds done by last year's team were cut, ground, and re-welded during the construction of the exhaust system to fix the leaks and obstructions.
  - Heat wrap has been purchased to insulate the entire exhaust until the muffler entrance. This will keep the catalytic converter in the operating temperature range. A side effect with the hotter exhaust gasses is a lower viscosity, reducing the back pressure, and thus increasing performance.

- Obtain SAE J192 Test Equipment
  - The equipment specified in the J192 standard is very specific and include specifications on:

        - Sound Level Meter
            - Has been borrowed from Karen Horton of the Mechanical Engineering Technology department.
        - Microphone Windscreen
        - Sound Level Calibrator
            - The sound level meter has been calibrated prior to its acquisition, so the calibrator is unnecessary.
        - Tachometer
            - The engine management team will be fitting the snowmobile with a tachometer that meets these requirements.
    - The following items are listed as necessary, but no specifications are given:
        - Barometer
        - Thermometer
        - Sling Psychrometer
        - Wind vane
        - Anemometer

- Partial Cowl fitted to sled
    - The original cowling for the Phazer did not meet the requirements set by the Clean Snowmobile Challenge, nor did it leave room to add sound insulation. A new cowl is being designed that will meet both of these requirements. The starting point is a frame, top and side pieces from the shroud of a Yamaha Venture Lite, which is the touring model of the Phazer.
    - The new cowl will have no more than 3 panels and must be able to be sealed with the use of two zip ties. There will need to be custom fabrication to meet these requirements, but we have a starting point.

Appendix

Freq (Hz)	Control	8 Blue Pad	2 Grey Foam	5 Lead-filled Foam	12 Hard Foam Foam Out	18 Hard Foam Foam In	14 Egg-Crate Foam	9 Soft Padding	6 Foam-Sandwiched Rubber	11 Rubber	Corrugated Rubber
20	72	61	73	66	64	63	64	60	65	65	64
30	84	73	85	80	77	75	75	75	76	78	75
40	85	75	86	80	77	76	75	77	78	79	79
50	85	76	86	82	81	81	77	80	81	82	80
75	84	80	86	82	80	80	84	84	83	83	78
90	90	81	91	88	85	85	85	89	88	88	87
100	92	78	93	87	83	83	86	90	86	87	87
200	80	86	83	76	77	76	84	82	80	77	71
300	88	80	88	76	74	77	82	83	79	76	75
400	89	91	91	93	92	90	92	90	92	92	97
500	86	81	88	77	79	82	82	86	82	83	68
600	95	82	92	95	89	84	89	86	88	95	72
700	96	77	90	79	82	70	80	82	73	70	65
800	96	78	93	80	75	82	84	84	81	76	60
900	87	81	86	75	76	79	78	83	78	77	72
1000	94	77	89	72	73	70	78	81	76	77	60
1500	93	82	92	85	91	81	85	90	90	68	71
2000	91	81	90	76	61	78	85	87	73	70	70
2500	89	70	85	66	66	65	74	81	71	74	60
3000	90	78	87	81	81	66	79	82	80	81	64
4000	91	77	88	73	66	66	83	85	68	68	67
5000	90	72	88	73	63	65	85	83	68	77	60
8000	95	79	93	64	62	70	83	88	69	70	68
10000	93	69	88	64	64	70	79	79	72	70	63
15000	82	55	73	54	57	55	62	67	49	58	53
20000	68	45	58	54	53	50	60	55	65	66	50

All measurements are in Decibels

Sound Level Difference

20	0	11	-1	6	8	9	8	12	7	7	8
30	0	11	-1	4	7	9	9	9	8	6	9
40	0	10	-1	5	8	9	10	8	7	6	6
50	0	9	-1	3	4	4	8	5	4	3	5
75	0	4	-2	2	4	4	0	0	1	1	6
90	0	9	-1	2	5	5	5	1	2	2	3
100	0	14	-1	5	9	9	6	2	6	5	5
200	0	-6	-3	4	3	4	-4	-2	0	3	9
300	0	8	0	12	14	11	6	5	9	12	13
400	0	-2	-2	-4	-3	-1	-3	-1	-3	-3	-8
500	0	5	-2	9	7	4	4	0	4	3	18
600	0	13	3	0	6	11	6	9	7	0	23
700	0	19	6	17	14	26	16	14	23	26	31
800	0	18	3	16	21	14	12	12	15	20	36
900	0	6	1	12	11	8	9	4	9	10	15
1000	0	17	5	22	21	24	16	13	18	17	34
1500	0	11	1	8	2	12	8	3	3	25	22
2000	0	10	1	15	30	13	6	4	18	21	21
2500	0	19	4	23	23	24	15	8	18	15	29
3000	0	12	3	9	9	24	11	8	10	9	26
4000	0	14	3	18	25	25	8	6	23	23	24
5000	0	18	2	17	27	25	5	7	22	13	30
8000	0	16	2	31	33	25	12	7	26	25	27
10000	0	24	5	29	29	23	14	14	21	23	30
15000	0	27	9	28	25	27	20	15	33	24	29
20000	0	23	10	14	15	18	8	13	3	2	18

All measurements are in Decibels