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Emissions of Compressed Natural Gas in a Wankel Rotary Engine Comparison with Gasoline Emissions

Introduction:

The current energy and global warming crises has prompted increased research in the discovery and use of alternate fuels that are less detrimental to the environment. One way to help end these crises is to convert cars to run on Compressed Natural Gas (CNG) as advertised in T Boone Pickens's plan. 84% of natural gas used in the US is produced domestically and the remaining 16% comes from nearby nations which are much more stable than Middle Eastern Nations. Converting cars to run on CNG would greatly help to make the US energy independent and would also help reduce air pollutions as emissions from methane (the gas that makes up natural gas) are much cleaner than those from gasoline. As a further advantage, natural gas costs $1.50 to $2.00 a gasoline-per-gallon-equivalent (GGE). There are, however, certain disadvantages from using CNG in cars. Most notably, CNG tanks require storage space that is not readily available in conventional cars.

This problem can be solved if CNG technology is combined with the underused technology of the Wankel Rotary Engine. The Wankel engine is a piston-less engine that has many advantages when compared to a conventional piston engine. First, a Wankel engine is a lot smaller and has very few moving parts (3) compared to a piston engine (over 40). This increases reliability while providing extra room, which could be used for CNG tanks. Furthermore, a Wankel engine is balanced so it can run smoother and attain higher RPM's (6000-9000) while the constant changes in direction in piston engines cause extreme vibrations. Wankel engines are usually less efficient and pollute more than piston engines, but using CNG could help solve this problem.

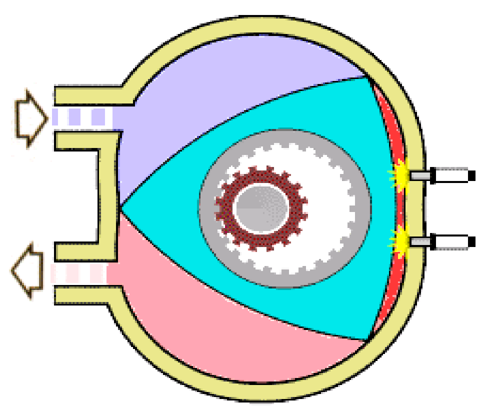

Figure 1: Wankel Concept

Figure 2: Wankel Engine

Combining the synergies of the Wankel engine and CNG technology could create a vehicle that takes advantage of both technology's positive impacts on energy and the environment while minimizing their shortcomings.

Procedure:

1. The engine was set to run on Super Grade Gasoline (93) mixed with 4 oz of engine oil per gallon.
2. Emissions were drawn from the tailpipe of the muffler into a 60cc syringe by use of a 3ft brass tube bent at a 90-degree angle.
3. Emissions were drawn every minute for 5 minutes.
4. Then the gas in the syringe was analyzed using Gas Phase Fourier Transform Infrared Spectroscopy. A gas cell was purged with helium and the background was collected before the gas from the first minute was injected.
5. Then the cell was purged again before injecting the second minute. This was repeated until all five syringes were tested.
6. The peak areas were determined using the Spectrum Software, and the results were graphed and analyzed.
7. This procedure was repeated two more times so that a total of three trials were conducted.
8. A calibration curve for all emission gases including CO, CO_2, Unburned Hydrocarbons, and NO_x is being created in order to create a Peak Area versus Concentration graph for each gas.

Part 2:

1. The engine is presently being re-engineered to run on compressed natural gas.
    a. As the oil was mixed with the gasoline, a method using an oil pump was devised to inject the oil into the natural gas line where it went to a diffuser jet in the carburetor (Figure 3).
2. At engine RPM and oil-injection rates that are consistent with my first experiment with gasoline fuel, emissions will be drawn from the tailpipe in the same way as before and the results will be analyzed to determine the concentration of each emission gas.
3. The tests using natural gas will be conducted three times to help improve accuracy.

Figure 3: Oil Injection

Preliminary Results for Gasoline Fuel Emissions:

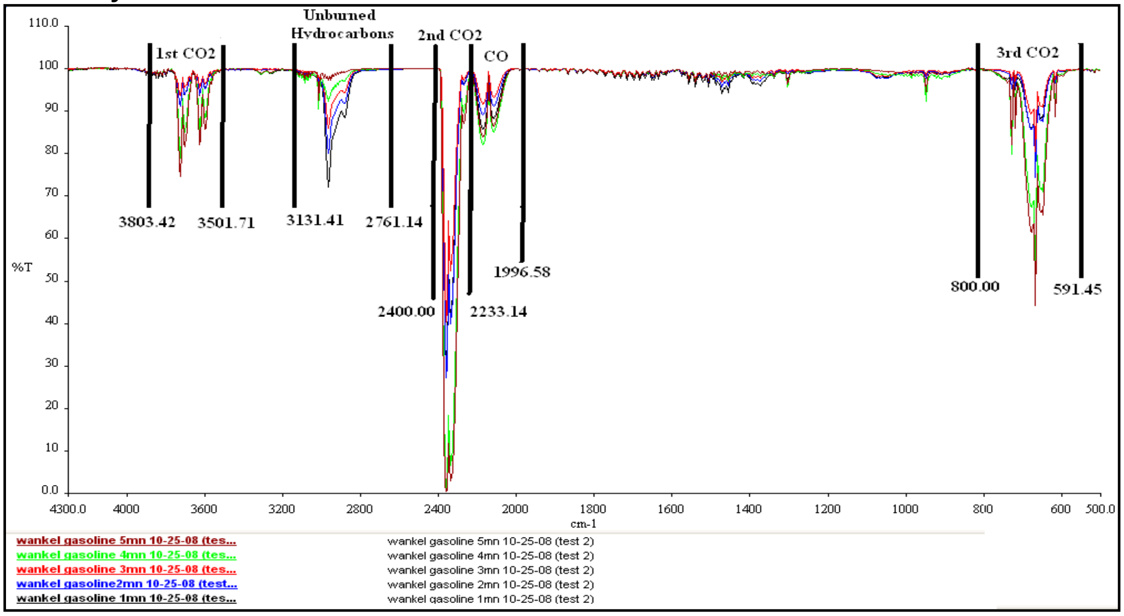

Figure 4: Sample image of the second emissions test in IR Spectrometer on gasoline

Table 1: Data table of average peak areas of three gasoline runs

Average	1st CO2 Peak	Unburned Hydrocarbons	2nd CO2 Peak	CO Peak	3rd CO2 Peak
1 minute	29430.28	33930.77	12836.43	22125.46	19757.79
2 minutes	29254.74	35447.29	11697.36	22690.59	19720.76
3 minutes	28960.32	35915.35	10943.05	22373.27	19307.52
4 minutes	28232.91	36484.22	8915.14	22062.25	18411.36
5 minutes	28272.22	36651.84	8957.97	22446.56	18514.83

Figure 5: Graph of average of average peak areas versus time of three gasoline runs

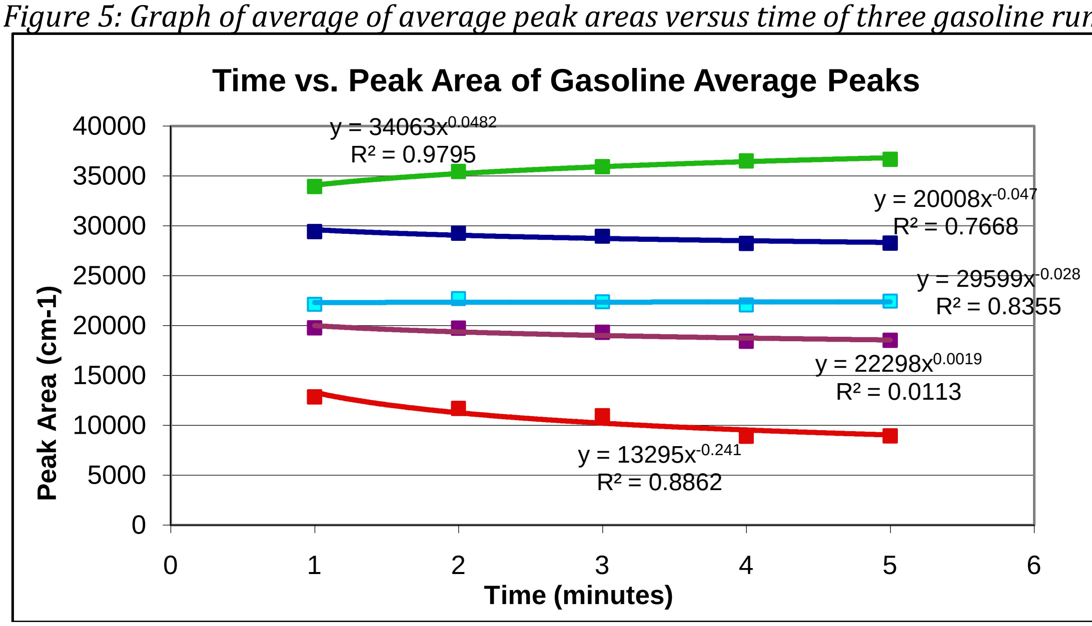

Figure 5 suggests that the concentration of emission gases stayed constant after 4 minutes of uniform running time from a cold start. Therefore, emission gases will be collected after 4 minutes of running time from a cold start since the emission gases remain constant after this period.

Safety:

- As highly flammable, toxic, and irritant liquids such as gasoline were being used, care was taken while handling them and when the gasoline tank was filled, it was done in open ventilation on top of a waste tank. Furthermore, neoprene gloves as well as a neoprene lab coat and goggles were worn when gasoline was handled and no spills occurred.
- As the highly flammable gas methane was used, all tests were conducted outside so that any fumes would disperse and the canister was safely strapped to the cart. When the cart was brought inside for the night, the gas valve on the tank was shut off and the line was emptied before bringing the cart inside.
- Even though engine oil is not extremely flammable, it can cause irritation so gloves, a lab coat, and safety glasses were used. To extract the oil from the bottle, a syringe was used to further minimize exposure.
- Due to the high danger of fire, a class C fire extinguisher was on hand to protect against fire.
- Due to the extreme heat of the engine ($>300^{o}C$) heat gloves were worn as well as a lab coat, safety glasses, and hearing protection whenever the engine was running.
- To prevent against the danger of moving parts, a clutch box was created out of half-inch thick plywood which was reinforced with metal supports.
- To prevent against any possible danger when the engine was put away, the spark plug was disconnected to prevent ignition and the engine was kept in a locked closet after it had cooled down.

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