Snowmobiles impact the environment negatively because fuel does not combust as completely in cold weather and the air is denser. As a result, the amount of unprocessed emissions released is higher and lingers in the air much longer than in other seasons. The toxic effects also linger because highly persistent polycyclic hydrocarbons from snowmobile emissions are retained in the snow and are released into waterways when the snow melts in spring.

The Society of Automotive Engineers (SAE) created the Clean Snowmobile Challenge (CSC) for university students. A team at Kettering University, in Flint, Michigan, USA, achieved second place in the 2007 CSC competition.

Snowmobiles were initially created as reliable winter transportation for rural areas. And by the late 1950s, snowmobiling had become a recreational sport in the United States. In the 1970s, snowmobiles came under scrutiny for their negative impact on the environment. Since then, new regulations continue to be implemented, and by 2012, current snowmobile emissions must be reduced by 70 percent. In 2002, the Society of Automotive Engineers (SAE) created the Clean Snowmobile Challenge (CSC) for university students. A team at Kettering University, in Flint, Michigan, USA, achieved second place in the 2007 CSC competition.

Kettering’s tasks for the competition
Under the mentorship of Dr. Greg Davis, Professor of Mechanical Engineering at Kettering, the team took up the challenge of building a cleaner, quieter snowmobile using cost-effective technologies and innovative methods applicable in the real world. The team chose to convert a Polaris FST model to a “clean” snowmobile. The Polaris FST features a 749 cc, four-stroke, turbocharged two-cylinder engine.

Kettering's team decided to focus on reducing emissions, noise, and weight, while maintaining the performance and durability of the snowmobile. Responding to the recent instability of gasoline prices in the U.S., the team decided to adapt the Polaris snowmobile's engine so that it would run on 85 percent ethanol blended fuels (E85).

The Kettering team wanted their clean snowmobile to meet the Environmental Protection Agency’s (EPA) regulations for model year 2012, without sacrificing performance. The regulation stipulates that small motor emissions must be reduced by 70 percent compared to current emission numbers.

SAE Challenges Universities to Develop Clean Snowmobiles

ETAS tools help students at Kettering University win second place

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Switching from gasoline to E85 Ethanol

E85 is blended using ethanol from renewable resources – such as sugar cane or corn – and gasoline. Modern engines can and do burn blended fuels with a low percent of ethanol, but they have to be modified to run with a blend such as E85 because of its much higher ethanol content. Since the stoichiometric air to fuel ratio is about 10 to 1, compared to 14.7 to 1 for gasoline, more fuel must be delivered to the combustion chamber to produce a proper airfuel mixture and thus efficient combustion.
Further, ethanol is more corrosive than gasoline. For these reasons, the team modified the standard fuel system with E85 compatible components (e.g., E85 compatible external fuel pump, 35 micron sintered bronze fuel filter, adjustable fuel pressure regulator, synthetic rubber fuel hose with full coverage, interior braided fabric, larger fuel injectors (453 g/min., 60 lb/hr), larger capacity fuel tank). The team conducted long-term tests to ensure that the remaining original components of the fuel system were compatible with the use of E85. To get the best possible emission results, power output, and efficiency, the team spent a lot of time optimizing engine control on a dynamometer. The standard catalytic converter was replaced by a custom model to further optimize emission results.

**InCA and ETAS hardware: Great tools for engine control optimization**

The snowmobile had a production Bosch ME7.4.4 engine controller (ECU) with closed-loop wide band oxygen sensor feedback. For their optimization work, the team connected a parallel ETK to the ECU and used an EMISS interface module. They did their calibration and measuring tasks on a laptop PC with INCA v5.4 software. They created an INCA experiment environment that met their needs perfectly (Figure 2). Using a dynamometer, the Kettering team tested a variety of air/fuel mixtures and spark timing calibrations to find the optimal operating points for best brake specific fuel consumption, optimize emissions, and reach reasonable exhaust gas temperatures. To compensate for the higher octane rating of E85 (100 versus 87 for regular gasoline), the engine’s spark timing had to be advanced while avoiding engine knock. The team also adjusted the ECU’s speed and load conditions, avoiding rich mixtures that would increase emissions and fuel consumption. To calculate appropriate spark timing and fuel injector pulse-width, the ECU reads manifold absolute pressure (MAP), rather than throttle position versus engine speed.

INCA and ETAS hardware (Figure 3) allow the team to accurately read and adjust MAP to match actual intake manifold conditions. During the standardized 5-mode emissions tests, the team used INCA’s Measure Data Analyzer to accurately monitor engine variables. The results formed the basis for further optimization.

The emissions results for the engine running on E85 were very good compared to the same engine running on regular 87 octane gasoline (see Figure 3). The team is confident that these results could be improved even more in the future. ETAS hardware and software saved the team valuable time and helped them get ready for the competition.

**Great results:** Kettering’s snowmobile wins second place!

The competition was held in March 2007 at Michigan Technological University in Houghton, with 13 university teams participating. The Kettering team achieved second place overall, having done well in many of the individual events during the week of the competition. Dr. Greg Davis, the team’s advisor, praised the work of his students: “I believe the team did really well in spite of the number of setbacks that we encountered this year. I know that they are really looking forward to being on top in the competition again next year.” Dr. Davis also emphasized the value of engaging engineering students in practical projects: “Thanks to the support of sponsors such as ETAS, we’ve been able to research the use of ethanol-blended fuels in recreational vehicles such as snowmobiles. We have as many as 20 students working on this project year-round, and it gets them excited to be able to work on real-world problems and find solutions that can really make a difference.”

In order to enable, besides OBII also the testing of EOBD requirements, a new software architecture was designed for the April 2007 release of OCT4.0. As a result, it is now possible to configure both entire tests and individual test steps. Users can also add test steps of their own design to a given test sequence.

**OCT4.0 features**

OCT4.0 continues to use the familiar Windows®-based GUI of previous versions. Dedicated fault identification, involving the selection of individual test steps and groups of tests, was very common, as was the detailed visualization of the message stream through the use of time stamps, as well as the generation of comprehensive test reports in HTML format. An important new feature of OCT4.0 is the option for starting the certification run with SAE’s open source software directly from within the application. New versions of this software are continuously added to OCT 4.0. Users can specify the open source program version with which to test OBII conformance. All versions between 12.9 and 13.3 are available. OCT4.0 also offers the following key features:

- **Automated test sequences**
- **Configuration of test sequences**
- **Protected**, or “sealed”, test configurations

**Automated test sequences**

In many cases, ECU tests on Hardware-in-the-Loop systems tend to be quite extensive and thus time consuming. The tests are therefore frequently run overnight. To do this, the automated processing of specified test steps is a mandatory requirement.

In contrast to the SAE’s Open Source software, OCT4.0 features a well-documented automation interface for connecting to an HIL system (such as the ETAS tool LABCAR). A suitable tool adapter is part of the ETAS product line.

**Configured test sequences**

OCT4.0 is configurable. The diagnostics knowledge – i.e., in the form of a specification such as J1699/3 – is now separate from the actual testing program and stored in the form of XML files. As a group, these files form a library from which the user can select a given specification as needed, for execution by OCT4.0.