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Reduced Air Pollution and Fuel Consumption With Preheated Car Engines

by **Paul G Höglund*** **Anders Ydstedt****

** Traffic and Transport Planning, Royal Institute of Technology, S-100 44 Stockholm, Sweden*
Telephone +46 8 7907936, Telefax +46 8 212899,
Mobile phone +46 10 2757945, phoglund@ce.kth.se
*** ScanTech Development AB, Box 583, S-201 25 Malmö, Sweden, Telephone +46 40 123745, Telefax +46 40 123722, anders@scantechab.se, www.scantechab.se*

Abstract

To reach a sustainable use of the existing road and street infrastructure without the need large of financial resources is a difficult task. We need to find cost efficient methods.

From passenger cars the majority of harmful emissions are generated by cold starts and occur whether or not the car is fitted with a catalytic converter. Cold starts will be reduced by preheating the engine before driving starts or by better travel planning . The shorter trips you make the more you can save with electric heating. Cold start emissions for CO and HC are approximately 80 % of the total emissions during driving.

A suitable future technology for electric engine heaters in cars could give substantial economic and environmental benefits for the society at large as well as for the individual car owner. Power outlets for engine heaters will in the future also be used for electric vehicles which makes them an interesting investment in a sustainable transport system.

1. Introduction

The sustainable use of the existing road and street infrastructure is dependent on successful traffic management methods and flow homogonizations as well as new fuel and engine technology. But traffic signalization and vehicle improvement need large financial resources Such resources are mostly limited and scarce. Therefore we need cost efficient methods and goal achievement with limited additional investments in the existing infrastructure If the amount of cold starts is reduced, or in the extreme eliminated from the traffic flow, there could be such a significant reduction in detrimental exhaust pollution, that considerable flow increases could be accepted without additional environmental harm. This is probably one of the most important remedies for achieving the goal of a sustainable mobility *for* year 2000 and beyond

Until Sweden became full member of the European Union in 1995 the exhaust regulation for passenger cars was totally adapted to the US CARB regulations. The CARB regulations is intended to solve the air quality problems in Californian climate. Sweden has a much colder climate. Since the beginning of 1980ies Scandinavian emission laboratories (1) have produced reports on emission at colder climate. These reports indicated that the emissions are much higher at cold starts. Since 1989 catalytic emission control is mandatory in Sweden. Laboratory emission studies on cars with catalytic emission control also showed higher emission at cold starts and the emission increased with lower ambient temperature. The increase in emission at cold starts, measured according to the US Federal test procedure (FTP-75) as the emission in cold transient phase (Yct), was higher in percentage for cars with catalytic emission control although the total emission was much lower both at Yct and hot transient phase (Yht) and stabilized phase (Ys) (2).

In the new European driving cycle for the year 2000 the start-up phase will be modified. The emissions will be measured imediately after start. This will mean more technological focus on how to reduce the cold start emissions.

2. Many starts are cool and cold starts

Swedish official statistics on travel patterns shows that the median journey with cars in Sweden is about 5 km. This corresponds aprox. to the first

driving cycle used in emission tests (FTP-75). For a large proportion of short car trips, the percentage of emissions from cold starts can be calculated as the results obtained in this driving cycle tests. Skandia Insurance Company has put together information on Swedish travel patterns and emissions at Yct, Yht and Ys.

A cold start can be defined as a start in which the temperature of the engine and catalytic converters are the same as the surroundings.
Cool starts can be defined as at start in which the engine temperature is minimum +20ºC and the catalytic converter has cooled to below the reaction temperature (+350-450ºC).

The total amount of cold and cool or starts per year

Sweden	2700 millions (3)
Finland	2600 millions (4)

The Skandia Study was presented in a report in 1992 (3). This report stated that cold starts was responsible for 90 % of total emissions of hydrocarbons and carbon monoxide and 50-70% of the nitrogen oxides from passenger cars in Sweden.

3. Emissions at cold starts

The Swedish Motor Vehicle Inspection Company (ASB MTC) has been commissioned by the Swedish Environmental Protection Agency to inspect the service life (using what are known as A60 tests) of the catalytic converters on cars approved according to the Swedish A13 regulations. These studies of used cars also showed higher emission at cold starts (5, 6).

Using data from MTC, ScanTech Development AB has calculated emissions from cold starts as a percentage of total emissions in the driving cycle. The calculations were based on Skandia's model for cold starts. The cars in the ScanTech study, which used data from 132 cars from the 1989/1990 model year, had been on the road for around three years and had generally been driven between 30,000 and 60,000 km. The emission

samples were collected in bags for the different phases of the driving cycle. Using data from the individual bags, cold start figures were calculated (in grams). The figures have been weighted according to the market share of each make of car. A sensitivity analysis, using a more precise breakdown in terms of percentage sales per model, yielded much the same results. Cold starts account for a very high proportion of the total emissions. "Ageing" of emission control equipment is largely attributable to the high emission levels in conjunction with cold starts, because the light-up temperature increases if the catalytic converter is exposed to lead, phosphorus and sulphur (7).

Cold start emissions in grams for a single start are calculated as follows:
(YCT[g/km]-YHT[g/km]) x 5.78[km]

Total emissions in grams for YCT are calculated as follows:
YCT[g/km] x 5.78[km]

Finally, the percentage of cold-start emissions in YCT is calculated as:
((YCT[g/km]-YHT[g/km]) x 5.78[km]) /(YCT[g/km] x 5.78[km])

Cold start emission as a percentage of emissions from the total driving cycle, FTP-75 (8)

CO	83 %
HC	84 %
NOx	51%

In 1996 Swedish state authorities started to investigate the possibilty to reduce fuel consumption and cold start emission with electrical engine heaters. A joint project between state authorities resulted in several SAE-reports from the Swedish Motor Vehicle Inspection Company and the Swedish Environmental Protection Agency (6, 9). The first report showed that gasoline cars also emitted small particles, PM-10, at cold starts. The amount of cold small particles from a gasoline car at cold start was in the same range as from a diesel car with warm engine.

The second study indicated that the amount of unregulated pollutants such as Polycyclic Aromatic Hydrocarbons (PAH) emitted from vehicles in general increased at cold starts. Some compounds in the group of PAH are

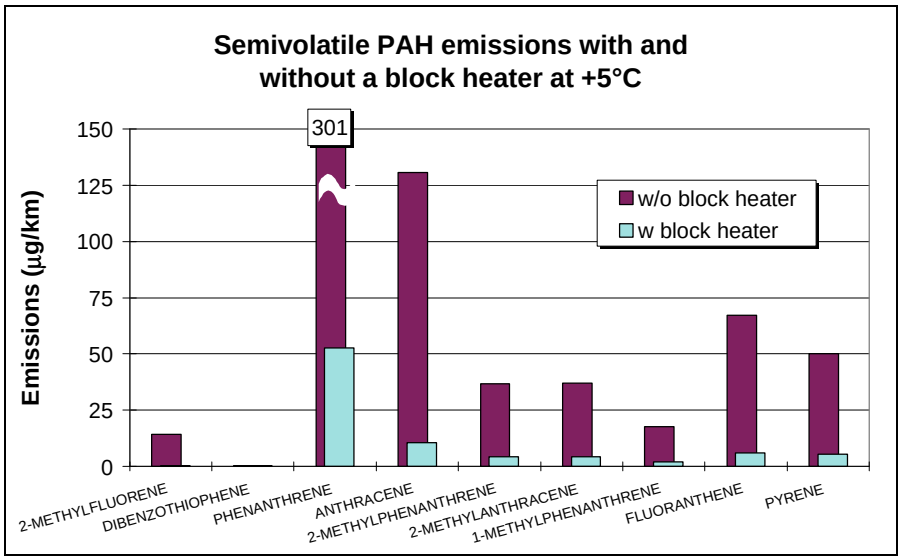
shown to be mutagenic in the Ames test. Some PAH cause cancer in animals after skin painting experiments.

4. How to reduce Emissions and fuel consumption at cold starts

Engine Heaters

In Scandinavia the use of electric engine block heaters is common. About 50% of all passengers cars are equipped with engine heaters in Sweden. The increased engine temperature reduces the amount of emissions and the fuel consumption at cold starts. Block heaters are also suitable for aftermarket installation which makes them an effective mean to reduce emission from in-use-cars. The engine block heater uses electricity (230V) from the electric grid. Power outlets for engine heaters will in the future be used for electric vehicles which makes them an interesting investment in a sustainable transport system.

Emission tests with block heaters from the Swedish Motor Vehicle Inspection Company shows that reduction of carbonmonoxide (CO) and hydrocarbon (HC) in the FTP-75 driving cycle can be more than 80% (6).
Recent tests shows a reduction in the emission of hazardous small particles, PM-10. A test with six cars showed that the particulate emission was four times lower with engine heater than without (6).
A special report on mutagenic emissions shows dramatic reductions with engine heaters (9).



Semivolatile PAH emissions with and without engine block heater at +5ºC (9).

The above tests also showed reductions in fuel consumption. For a modern car the reduction is slightly more than 0.1 liters per cold start. For older cars the fuel savings is higher, 0.1-0.2 0.1 liters per cold start.

An estimation of the financial benefit from reduced air pollution is difficult, but an example could be given. A calculation done in Sweden gives a reduction of approximately 0.l-0.2 1 per engine start. If you assume the cost of fuel *8.50* SEK, the cost of electrical energy 0.70 SEK/kWh and a heating time of 0.5 h with 500 W, you will have a cost for heating of 0.26 SEK. 0.1. If fuel costs *0.85* SEK, thus ~ saving of *0.85*-0.26=0.59 SEK for one start.

New emission regulations

The new emission regulations for Europe will be an improvement for lower emissions at cold starts. The technologies used to reach the goals will be new materials in the catalytic converters, better engine management, improved fuel injection systems and better fuel quality.

Better travel planning

Increased awareness of the higher emissions from cold starts together with more environmental concern could help to transform the behaviour of car

drivers. Better planning of journeys could reduce the amounts of cool and cold starts. Many cold starts can be reduced if short trips are replaced with longer trips with shorter stops.

New technological development

Chemical heat storage from engine can give the same advantages as engine heaters for those who travel 30 km or more in every trip. Heat storage does not need connection from the grid and is therefore a flexible solution. The cost of a heat storage is today approx. 4-6 times higher than for a engine heater. In the future we will probably se combinations of heat storage system and engine heaters.

Chemical heat storage systems is now available for BMW cars (Manufacturer: Modine Co).

5. Summary and conclusions

The majority of harmful emissions from passenger cars tare are generated by cold starts and occur whether or not the car is fitted with a catalytic converter. Fuel consumption and emissions of hydrocarbons (HC), carbonmonoxide (CO), small particles (PM10) and polycyclic aromatic hydrocarbons (PAH) from vehicles in general increase at cold starts.

Cold starts can be reduced by preheating the engine before driving starts or by better travel planning . A suitable future technology for electric engine heaters in cars could give substantial economic and environmental benefits for the society at large as well as for the individual car owner. Power outlets for engine heaters will in the future also be used for electric vehicles which makes them an interesting investment in a sustainable transport system.

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