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AIR CONDITIONING OF VEHICLES USING THE ABSORPTION CYCLE

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ABSTRACT

The aim of this project is to study air conditioning of vehicles using absorption cycle. We discussed briefly the current system used: vapor compression system. Then, we studied the potential of using exhaust gases as a heat input to the absorption machine and if it's sufficient to produce the cooling load demanded. Moreover, an economical study is estimated, the initial cost of the machine, the economy per season and the fuel's price, in different countries, is calculated. As a conclusion, we have drawn a step of this idea and determined how this system is benefiting on environmental and economical sides.

INTRODUCTION

The wide majority of vehicles today are equipped with an air conditioner. This reveals its importance and necessities to study the system in different aspects: thermodynamically, technologically, environmentally and economically. The classical system used today has some disadvantages. According to experts, the temperature of the earth would increase by 2 to 5 degrees till the end of this century caused by pollutants, and 1/4 of this increase is from the transportation section; in addition, the over consummation and the leakage of the refrigerant gas (HCF). So for all these reasons we are interested to study the air conditioning using the lithium bromide absorption machine.

The classical air conditioning system used on vehicles today is the vapor-compression system. It uses the principle of variation in pressure and changing in state (gas/liquid) of a frigorific fluid that can be R12 or R134a. The cycle is formed of: 1. a compressor, 2. a condenser, 3.an expansion valve, 4. an evaporator However, in spite of the advantages of the system, it has constraints mainly on the environment and the economical sides. The refrigerant used, R134a increases the global warming of the earth and R12, whose production is not allowed anymore, has an effect on the ozone layer depletion. In addition, using a compressor in the system increases the consummation of fuel and leads to an increase in pollutants.

The absorption system uses thermal compressing by an absorber and a generator, instead of mechanical compressing of the refrigerant. The refrigerant used is water and the absorbent is lithium bromide (couple: H_2O/LiBr)

The heat input source which is the exhaust gas in our case, provides heat to a diluted solution of lithium bromide pumped from the absorber at 99ºC and high pressure.

ANALYSIS AND RESULTS

Calculations have been made to see whether the exhaust gas is sufficient to produce the cooling load demanded witch depends on exterior temperature and volume of the car. The performance of the system varies with the flow rate and temperature of the exhaust gas, the motor capacity and its type: gasoline or diesel. Taking into consideration that we are limited by the length of the exhaust pipe that is straight, we have studied the system's performance with 1m length of exhaust pipe as a requirement and with a possibility of studying this value from the technological side. The graphs resulted are for each country or region, for gasoline and diesel motors and for motor capacities of 1.2 L and 3L as examples.

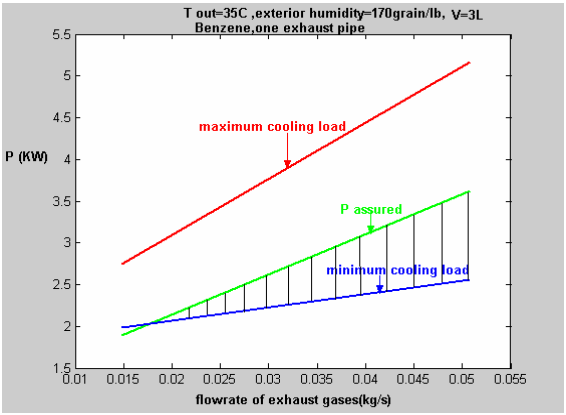

Figure 1: Graph resulted for Lebanon, Gazoline motor, capacity of 3 liters

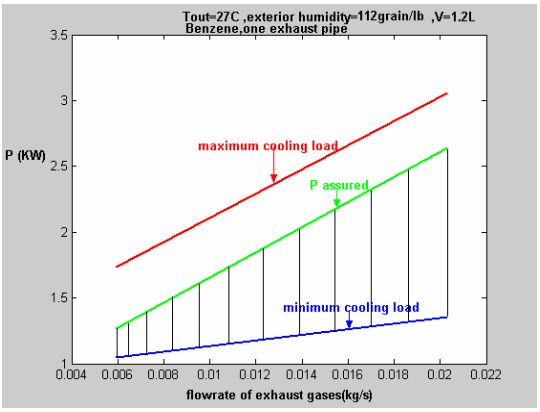

Figure 2: Graph resulted for France, Gasoline motor, capacity of 1.2 liters

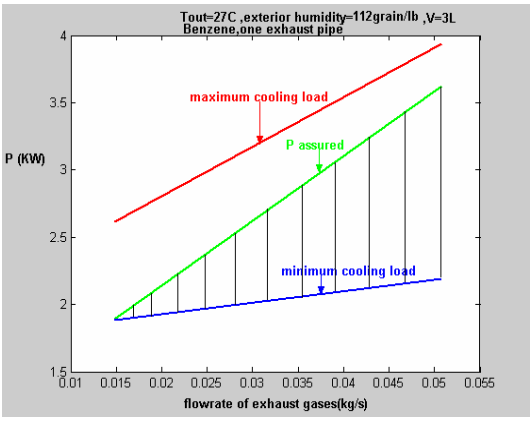

Figure 3: Graph resulted for France, Gasoline motor, capacity of 3 liters

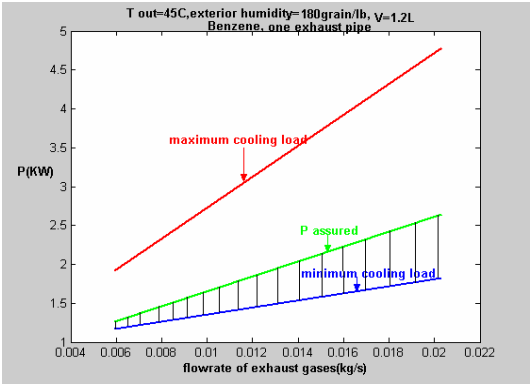

Figure 4: Graph resulted for Lebanon, Gasoline motor, capacity of 1.2 liters

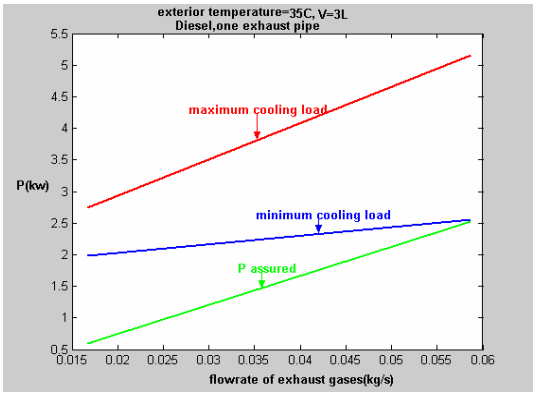

Figure 5: Graph resulted for Lebanon, Diesel motor, capacity of 3 liters

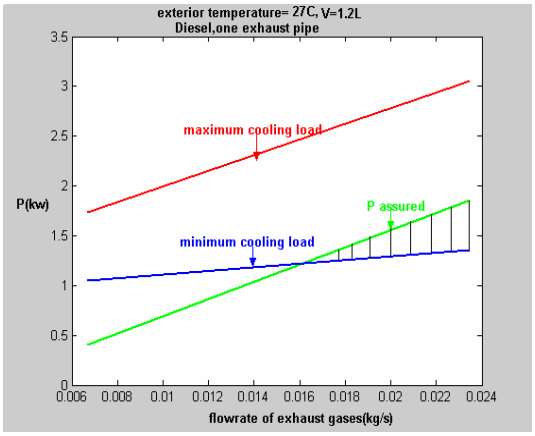

Figure 6: Graph resulted for France, Diesel motor, capacity of 1.2 liters

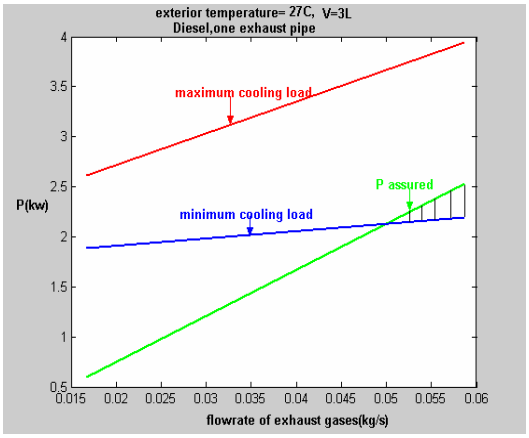

Figure 7: Graph resulted for France, Diesel motor, capacity of 3 liters

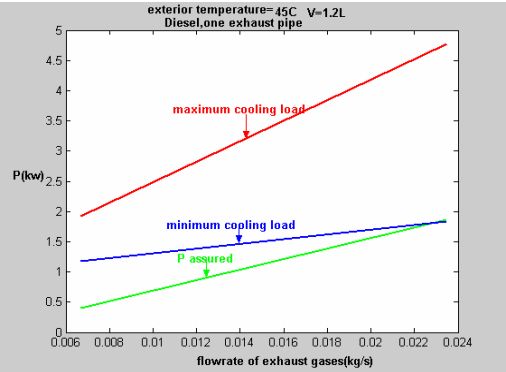

Figure 8: Graph resulted for Lebanon, Diesel motor, capacity of 1.2 liters

Comparing the results obtained for gasoline and diesel motors, we get these charts showing the percentages of the average assured load from the average required.

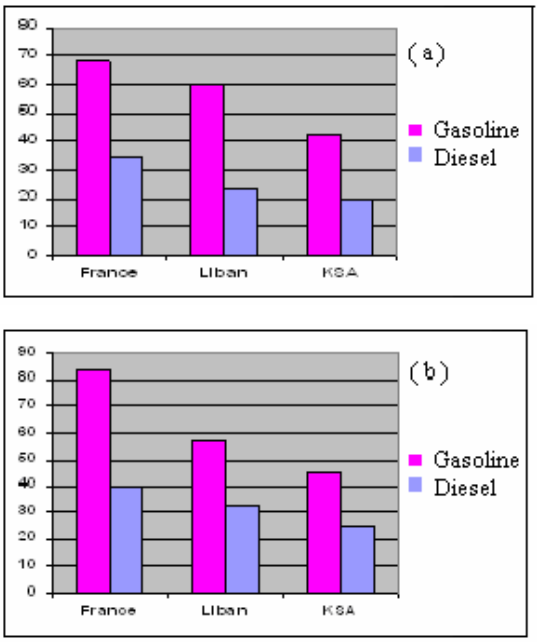

Figure 9: Comparing for gasoline and diesel motors of the percentages of the average assured load from the average required. a: capacity of 1.2 liters, b: capacity of 3 liters. France, Lebanon and Kingdom Saudi Arabia (KSA).

We note that:

-The assured load for the gasoline motors are more than that for the diesel motors where the temperature of the exhaust gas is higher in the gasoline motors.

-The assured load for *V=3L* is higher than it is for *V= 1.2L* because the flow rate of the exhaust gas is higher

-The graphs show a region of insufficiency of the heat input especially for low RPM where there is insufficient exhaust flow rate and so an auxiliary system is needed to cover this requirement. This system can be a small compressor for gasoline engines and for required high cooling load.

-Using the absorption machine of double effect increases these percentages in an order of *10%* but the volume of this machine leads to a problem for its installation in the car.

NEW PROPOSITION AND RESULTS

The maximum load of cooling cannot be reached since we are limited by the length of the exhaust pipe. One of the solutions consists in proposing a new technology of construction of the exhaust pipe. We have studied the case of making *4* exhaust pipes of *1m* length but of smaller diameter, *3/4* of the actual diameter, so that the surface of heat exchange is bigger.

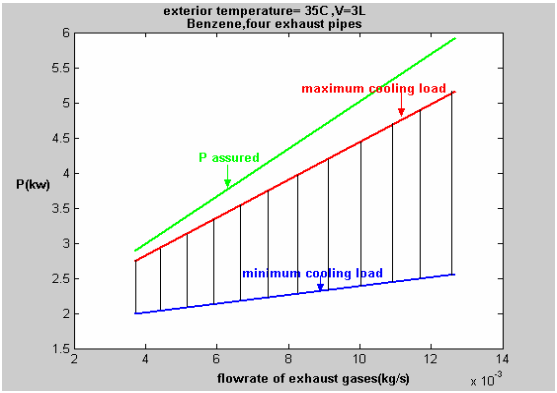

Figure 10: Graph resulted for Lebanon with new proposition, Gasoline motor, capacity of 3 liters

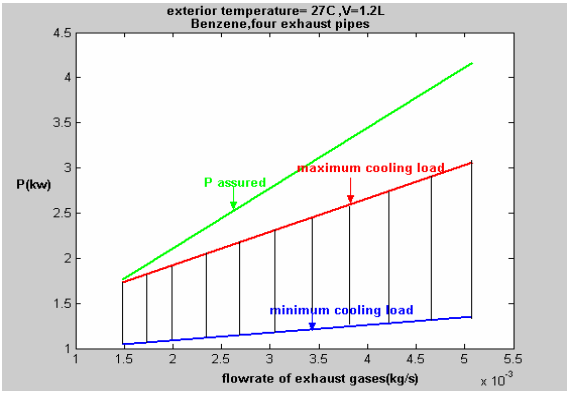

Figure 11: Graph resulted for France with new proposition, Gasoline motor, capacity of 1.2 liters

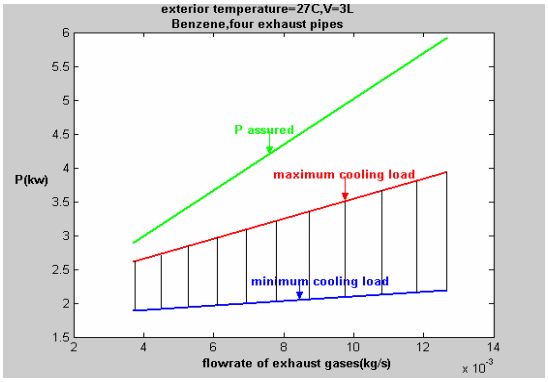

Figure 12: Graph resulted for France with new proposition, Gasoline motor, capacity of 3 liters

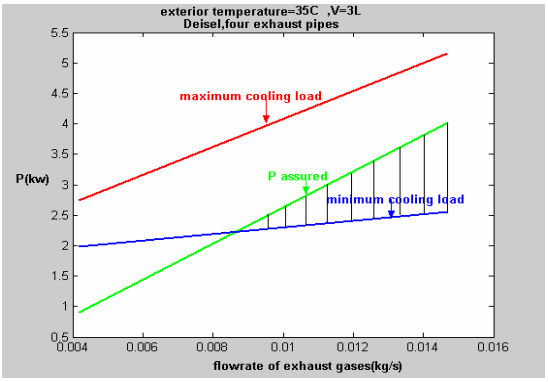

Figure 15: Graph resulted for France with new proposition, Diesel motor, capacity of 3 liters

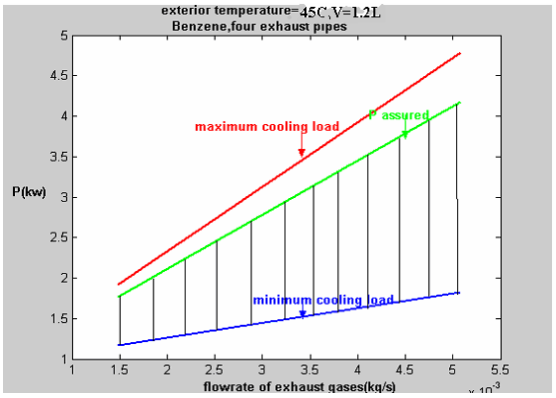

Figure 13: Graph resulted for Kingdom Saudi Arabia (KSA) with new proposition, Gasoline motor, capacity of 1.2 liters

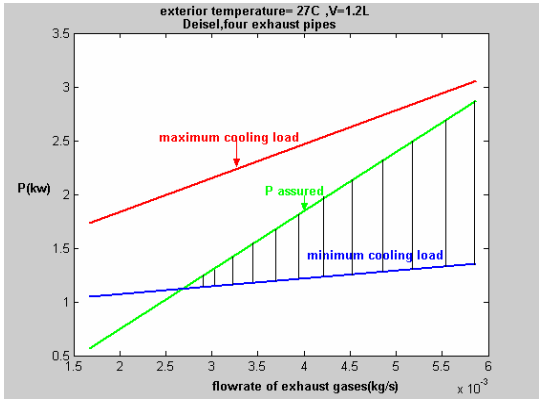

Figure 16: Graph resulted for France with new proposition, Diesel motor, capacity of 1.2 liters

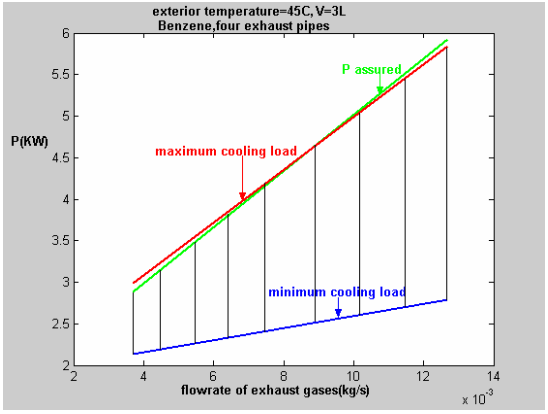

Figure 14: Graph resulted for France with new proposition, Gasoline motor, capacity of 3 liters

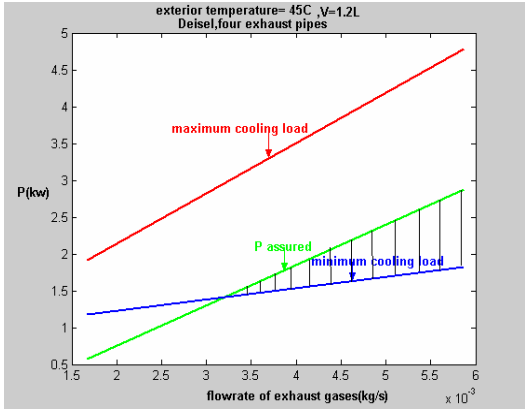

Figure 17: Graph resulted for Kingdom Saudi Arabia (KSA) with new proposition, Diesel motor, capacity of 1.2 liters

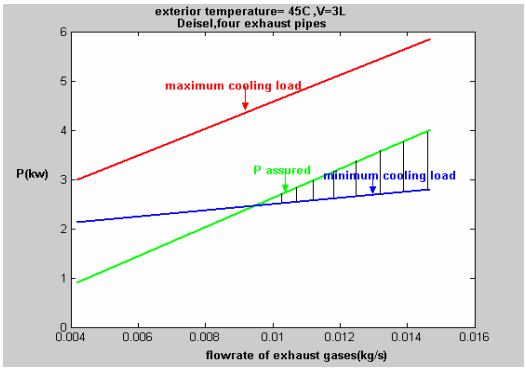

Figure 18: Graph resulted for Kingdom Saudi Arabia (KSA) with new proposition, Diesel motor, capacity of 3 liters

The same charts for comparison of the results are shown here.

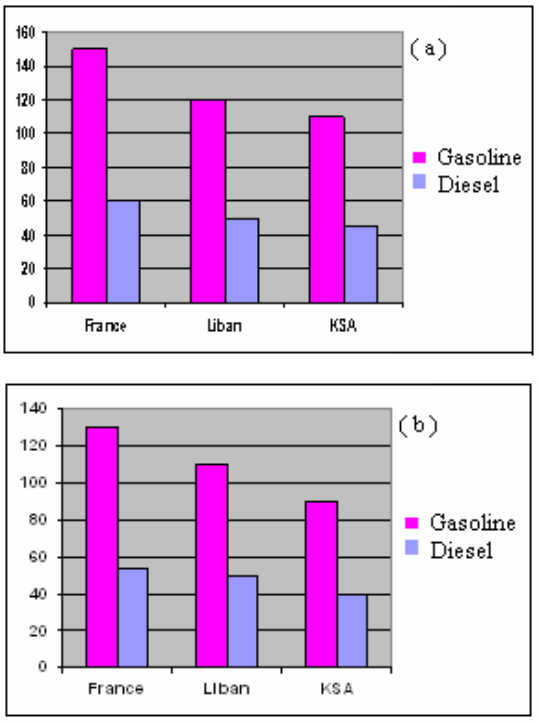

Figure 19: Comparing for gasoline and diesel motors (capacity of 3 liters, new proposition) of the percentages of the average assured load from the average required. a: capacity of 1.2 liters, b: capacity of 3 liters. France, Lebanon and Kingdom Saudi Arabia (KSA).

One can remark that:

- The assured load for the gasoline motors is more than *90%* of the demanded one.

- For diesel motors, it varies from *40* to *60%*.

In fact, the temperature of the exhaust gas after one meter decreases but the difference between the inlet and the exit temperatures increases and leads to an increase in the recovered heat.

ECONOMICS ANALYSIS

A successful achievement of a project requires an estimation of his total cost considering different aspects and references, economical, environmental and technological.

The cost in the market is affected not only by the cost of production but also by the supply and demand competence and regulation.

In this project, we made an estimation of the cost and the economy for an initial feasibility analysis.

According to some reference books, an estimation of the initial cost of production is *190$/kW* which is *2.5* times the cost of the classical system.

The economy of the system is the quantity of the fuel reserved by canceling the compressor. However, one should not forget to take into account the price of fuel witch is variable and differs from country to another as can be shown in table 1 for three countries: France, Lebanon and K.S.A. Our economical study is done on these countries:

Country	**Gasoline**	**Diesel**
Lebanon	15$	10$
France	22$	15$
K.S.A	5$	3$

Table 1: Price of fuel

Also the usage time of the air conditioning varies from region to another.

Country	**Lebanon**	**France**	**K.S.A**
Time (month)	4	2	6

Table 2: Operating time of the air conditioning.

The economy also depends on the type of motor, the over consummation of the compressor that is function of the type of urban as seen below:

Motor type	Urban	Urban mixte
Gazoline	3.1	2
Diesel	4	2.5

Table 3: Consummation of fuel of the compressor

Calculations are made considering all these factors. In addition, if an auxiliary system is needed, the economy will decrease. This is also taken into consideration in our simulations.

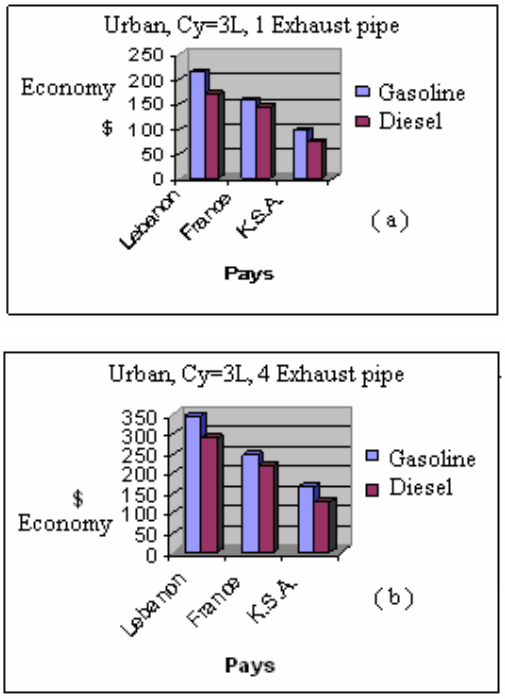

Figure 20: Economical study for 3 pays: France, Lebanon and Kingdom Saudi Arabia (KSA). a: Classical system, b: New proposition

For the new proposition: As an indicator for the economy and for the case of the new proposition of 4 pipes, we have an economy of *0.2L/hr* in an urban medium.

Note that, the over consummation of fuel for a compressor is *1.2L/hr* in an urban medium. Therefore, we have an economy in the over consummation of *16%*

CONCLUSIONS AND PERSPECTIVES

As a conclusion, we see that the absorption machine is not efficient for the diesel motors while for the gasoline types, the heat of the exhaust pipe is sufficient to produce more than *90%* of the cooling load demanded in the new proposition of separated exhaust pipes. In this technology we have canceled the environmental problems and the economy have reached to *0.2L/hr* as mentioned above.

For one pipe, the part not assured is for low exhaust gas flow rate for example, for a sloping road and for low RPM. The assured load reached to *60%* of the demanded one. This needs an auxiliary system which can be an electrical resistance or as we suggested to be a small compressor and for which the economy is studied.

As a perspective, we focused our work on the potential of using the exhaust heat to assure the cooling load. An estimate of the cost and profit from an economic point of view are proposed for the system. Still the barriers that appeared to be studied thoroughly for this project are executed and commercially applied for the cars. These can be summarized in the following ideas:

- The volume of the absorption machine is bigger than that of the current system. It consists of two shells; the first contains the generator and the condenser with the same high pressure of functioning and the second is formed by the evaporator. The placing of the machine in the compartment is still to be studied especially the generator that follows the place of the exhaust pipe.

- A technological study must be done to see whether the length of the exhaust pipe taken as *1 m* can be benefited of or not, and also to see whether the new proposition on the separated pipes can be realized or not.

- The auxiliary system must be determined. It can be a small compressor as we mentioned and it can be another system providing heat.

- One advantage of the system can be in the winter where the system of air conditioning is not needed. As the absorption machine is already installed, one can profit to use it to cool the engine of the vehicle with chilled water.

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