VEHICLE NOISE AND INFLUENCE OF THE COOLING FAN

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Abstract - The combustion engine is only one of many vehicle noise sources. Every combustion engine has inner and external noise sources. The cooling fans can be important noise sources. They are installed to cool the engine, encasement and the inside of the car. The influence of fans are great in case of high ambient temperature, low travelling speed and frequent stoppages.

1 - INTRODUCTION

Various types of vehicles are the most important noise sources in the dwelling surroundings and traffic. The passenger cars prevailing in the road traffic and also utility vehicles. Such utility vehicles include for instance, the load-carrying and terrain vehicles and buses for passenger transportation. In all vehicles, two types of noise occur, i.e., the internal and external noise. All persons in the close vicinity of the road are exposed to the vehicle external noise. The driver and the passengers are exposed to the internal noise.

The influence of the vehicles on the noise level in the dwelling surroundings was realized in the seventies when the existing legal prescriptions were made more severe. During that period, new and considerably lower limit values were introduced. Until 1980/1982 the limit values for external noise level of motor vehicles were very high. Whereas limiting values ≤ 90 dB(A) were allowed till 1980/1982, values about 75-80 dB(A) already expected for the future.

2 - NOISE SOURCES OF VEHICLES

The most important noise sources of vehicles are:
- transmission,
- the rolling noise of tyres connected with the quality of pavement and the road surroundings,
- the driving unit,
- noise resulting from streamings of air on the surface of the vehicle and in the channels,
- vibrations,
- the vehicle body etc.

For a long time the internal combustion engines as driving units had been regarded as the most important noise sources of vehicles. Undoubtedly in case of the limit values until 1980/1982, the combustion engine and their exhaust gas conduct were greatest noise sources on the utility vehicles. On the vehicles for which the external noise level is reduced, other noise
sources become outstanding, particularly the transmission and rolling noise of tyres. This is very obvious in Figure 1 which give the external noise le-

![Diagram](image)

Fig. 1 - External noise of the terrain-vehicle T7 in motion

vel of terrain vehicle T7 with and without engine driving and the depedence of the noise level of the engine on the travelling speed respectively the number of revolutions. The noise of the vehicle with the engine driving refers the state before the noise reduction and the noise of the engine to the state after noise reduction.

3 - NOISE SOURCES OF INTERNAL COMBUSTION ENGINES

The noise level of all internal combustion engines is determined by performance and the speed of engine. Every combustion engine has inner and external noise sources. The most important inner noise sources are: the combustion, strokes of piston, the motor control, the driving wheels etc. The external noise sources are: the suction system, the exhaust gas conduct, the cooling fan, the motor surface etc. Although a number of noise sources are mentioned, their influence on the noise level of the vehicles will differ. One or another noise source can be more prominent.

4 - THE COOLING FAN

The cooling fan is installed to cool the engine and capsule. It may become an important noise source, especially if little attention in its design has been paid to the stream conditions in it or in the inlet and outlet. Such a situation can arise, if the layout speed of the fan proves inadequate and has to be increased by a new gear ratio. Every increase of the numbers of revolutions simultaneously means and increase of the circumferential speed of the fan blades. The stream conditions in the inlet and the outlet and those in the fan change. By an alteration of these conditions the noise of the fan increases too. The noise or the frequency spectrum can be influenced, besides by construction alterations of the fan and the blades, by altering the number of blades or their arrangement.

5 - PERFORMANCE OF COOLING FAN

The capsule and combustion engine arestation is urgently because a part of the resulting heat energy in the engine remain in the capsule. In order to certain normal working conditions in the combustion engine and capsule it is necessary to remove that heat outside the capsule. The quantity of heat to be removed from the capsule will depend on the engine type (water or air cooled), engine output, annual season, duration of working, type of engine loading etc. That heat is removed by air and at a low air temperature and with the same quantity of heat a smaller quantity of air will be necessary than at a higher temperature. That can be seen from the equation for heat discharge
(1)
\[ m = \frac{Q}{c \Delta T} \]  
\[ (kg) \]  
and
\[ V = \frac{Q}{f c \Delta T} \]  
\[ (m^3) \]  
where
\( c \) - specific air heat \( (kJ/kg K) \)
\( f \) - specific gravity \( (kg/m^3) \)
\( m \) - mass of air \( (kg) \)
\( \Delta T = T_2 - T_1 \)
\( T_1 \) - air temperature at the entrance into the capsule \( (K) \)
\( T_2 \) - air temperature at the exit from the capsule \( (K) \)

In case of constant heat discharge with \( T_2 = 363 \) K, \( m = 1 \) kg, \( c = \text{const.} \) (between 273 - 313 K is \( c = 1,005 \) kJ/kg K) and by different outside temperatures \( T_1 \) it is necessary air volume \( V \), Figure 2a.

The power of the cooling fan depend on the air volume and the pressure loss. This can be seen in the equation for calculating the performance \( P \) of a cooling fan (3) and Figure 2b:
\[ P = \frac{V \Delta P}{\gamma 102} \]  
\[ (kw) \]  
where
\( V \) - air volume \( (m^3/g) \)
\( \Delta P \) - pressure loss \( (N/m^2) \)
\( \gamma \) - degree effect of fan.

As the internal combustion engine must be good order throughout the whole year the engine aeration system will be designed for the most unfavourable operating conditions, i.e., for the highest outside temperature. The air supply and discharge openings and channels will be proportioned accordingly. As the channel openings end on the outer side of capsule, the noise will penetrate outwards also through them.

6 - POSSIBILITIES OF NOISE REDUCTION
A noise reduction on a vehicle and a combustion engine can be achieved by a reduction of the influences of different noise sources without or with an encasement of the aggregates.

An encasement of aggregates is not a technical solution because it causes many other problems which must be solved with hardly a smaller expense. Especially disadvantageous is the fact that only the influence of some noise sources is reduced and work on other noise sources must still be done. An encasement can only reduce the influence of the inner noise sources and surface of the engine. It does not affect the external noise sources, the suction and exhaust system, cooling of combustion engine and encasement, etc., remain as they were and must be worked on additionally. The external noise of the vehicle, particularly, if its engine is encased should be measured at an ambient temperature of 303-308 K and not perhaps at a temperature of -273 K and with the engine slightly heated.

7 - INFLUENCE OF FAN IN PASSENGER CAR

Usually, the driving combustion engine of the passenger cars is located at the front side. Temperature of the engine and of the space in which the engine is installed is higher, if the engine is encased, than if it is not encased. The situation is most critical, when the vehicle moves in a column at a low speed and with frequent stoppages and it is still aggravated if the ambient temperature is high. In this way, not only the fuel consumption is increased, but also the quantity of harmful substances in the exhaust gases. This can be seen in Figure 3 showing fuel consumption of petrol engines for different engine work cycles.

Fig. 3 - Consumption of fuel by passenger cars

Fig. 4 - Noise of cooling fans in passenger cars A,B,C,D,E

Fig. 5 - Noise of cooling fans in three passenger cars

Fig. 6 - Noise of cooling fan and combustion engine in a car

All the passenger cars are equipped with multiple-speed fans, whose noise level in most cases is very high so that it is necessary to disconnect it. The fan noise level exceeds the noise level of the driving engine and other vehicle noise sources. Figure 4 gives noise level of the cooling fan with three and four speeds in the inside of four passenger cars. Figures 5 and 6 give the frequency analysis of three fans for cooling the interior of three passenger cars. For comparison, the noise level of the combustion engine at idling is given, Figure 6.