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"Study of Thermal Management inside Acoustic Enclosure in Mobile Power Generation System"

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Abstract: ***In light of the rapid development in the field of advanced technologies, it is very much possible to develop advanced & compact mobile power generation systems, to synchronize with the real-time mission critical system. But in spite of this advancement, Systems designers and systems integrators are faced with the challenge of heat management because of size, weight, and power constraints in defense sector. Power and thermal management considerations move to the forefront in the design, development, system engineering and integration of aerospace and defense systems. In mobile power generation system lot of mechanical, electrical & electronics subsystems are present. Heat generated by these sub-systems is required to be handled very carefully in order to improve efficiency & reliability to prevent premature failure. It is expected that good result will be found by further improvement in thermal engineering in acoustic container.***
Keywords: Power and thermal management, DG set

I. INTRODUCTION

In mobile power generation system lot of mechanical, electrical & electronics subsystems are present. Heat generated by these subsystems is required to be handled very carefully in order to improve efficiency & reliability to prevent premature failure. In order handle the heat radiated by these subsystems lot of conventional as well as advanced technologies are available. Heat dissipation can include exhaust fans, ducts, blowers, louvers heat sinks for electronics and air intake cooling fans for air cooling, and other forms of computer cooling such as liquid cooling, heat pipes etc. In cases of extreme low environmental temperatures, it may actually be necessary to heat the electronic components to achieve satisfactory operation. Reliable and efficient systems are indispensable for successful battle field operations. Mobile or transportable type captive power generation systems are used as the main or standby power supply in the units of military forces at forward areas. A great variety of vehicle or trailer mounted sets are available with military forces, ranging in power output from 1 kW to about 125 kW. The majority employs medium speed diesel engines running at 1500 rpm of both the air-cooled and the water-cooled type. In the absence of utility power supply in remote areas, army units at field are wholly dependent on captive gensets.

II. LITERATURE REVIEW

The primary aspects of a properly designed engine room ventilation system are cooling air and combustion air. Cooling air refers to the flow of air that removes radiant heat from the engine, generator, other driven equipment and other engine room components.

From the literature review it is understood that, following important aspect shall be considered -

Sizing Considerations	Ventilation Fans	Routing Considerations	Additional Considerations
Cooling Air Combustion Air Ventilation Airflow Calculating Required Ventilation Airflow Engine Room Temperature Atmospheric Heat Rejection Correction Factor Radiant Heat	Fan Types Fan Location Exhaust Fans Two Speed Fan Motors	General Routing Principles Single & Dual Engine Applications Multiple Engine Applications Special Application Routing	Radiator Sizing Radiator Fan Sizing. Moveable Louvers. Refrigeration Equipment. Exhaust Pipe Insulation. Ducting Considerations. Brief of silencing (Passive& Active techniques) Advance techniques like heat pipes

A. Statement of Requirement

Optimum design of an acoustic enclosure for a diesel generator set (Ratings 40kVA) which satisfies the following clauses

1) The enclosure should act as a containerized portable vessel along with the generator set (DG set) feasible to be used for frequent mobile applications.
2) Proper air ventilation for DG set should be available.
3) Noise reduction should be achieved as specified under the Centre Pollution Control Board (CPCB) Norms.

III.SYSTEM DESIGN

A. Ventilation (Preferred Design)

In ventilation airflow calculations, systems have a Routing Factor of 1Outside air is brought into the engine room through a system of ducts. These ducts should be routed between engines, at floor level, and discharge air near the bottom of the engine and generator as shown in figure1. Ventilation air exhaust fans should be mounted or ducted at the highest point in the engine room. They should be directly over heat sources. This system provides the best ventilation with the least amount of air required. In addition, the upward flow of air around the engine serves as a shield which minimizes the amount of heat released into the engine room. Air temperature in the exhaust air duct will be higher than engine room air temperature.

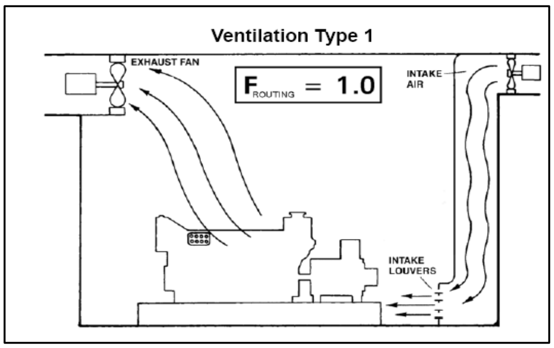

Fig1. Ventilation (Preferred Design)

B. Power Modules

Power modules generally utilize radiator cooled diesel generator sets. The power module enclosures trap the radiated heat from the engine and generator, and direct it through the radiator, decreasing cooling capabilities 8 to 10°C (14 to 18°F). Even with doors open, radiators can de-rate 5 to 7°C (9 to 13°F) when enclosed.

C. Louver Operation

Louvers which open from the discharge pressure of the radiator fan are discouraged. Rain, ice and snow can render them inoperative within a short time and result in engine overheating and shutdown. Do not wait to activate the louvers until the engine warms up. In an emergency, the engine will be loaded immediately and require full airflow. Open the louvers as soon as the engine starts and install them to open fully in case of an emergency. Heat sensors needlessly complicate the system and their malfunction can reduce airflow to the engine which can cause shutdown.

D. Cooling System Design

Remote Radiator Cooling: Remote Radiator Airflow generally assumed there will be no external restrictions to airflow. If this is not true, restriction must be considered in sizing and selection of a cooling fan and drive motor.

E. Remote Radiator Fan Motor

Remote radiator cooling systems require the use of an electrically driven fan. This fan must be connected to the emergency power source. Size of the motor is determined by the fan size and fan speed.

F. Heat Exchanger Cooling

If the engine is to be heat exchanger cooled, the system will require a reliable raw cooling water source and controls to regulate water flow during Genset operation. The system will also need a reliable method of starting and stopping water flow automatically. The heat exchanger cooled system may be used with a cooling tower. Shell and tube type heat exchangers are connected such that raw cooling water flows through the tube side of the heat exchanger, and engine coolant through the shell side. Tubes are more easily cleaned and the potential for fouling is much greater on the raw water side. For economic reasons, the raw water flow can be regulated by varying the flow of raw cooling water through the heat exchanger. This control can be accomplished with a temperature actuated control valve. The thermostatic bulb for this control must be in the engine jacket water discharge line. The control valve should be a fully modulated type with a minimum flow setting. NEVER attempt to regulate engine water flow. Water flow regulators are used only if raw water is from a city or well water source. Do not attempt to regulate flow if a cooling tower is used. Maintain at least 2 ft/second of water flow through the tube side of the heat exchanger. Heat exchanger cooled systems using city or well water, and cooling, tower heat rejection, however, will not be protected on the tube side of the heat exchanger, nor interconnecting piping and cooling tower as engine coolant is not circulated through these components. These systems must be heat traced, and have sump heaters installed to protect the various components when the Genset is on standby. It must also be noted that if an antifreeze solution is used in the shell side of the engine cooling system heat exchanger, local codes may restrict the discharge of the tube side cooling water after flowing through the heat exchanger.

G. Coolant Treatment

Engine coolant should be treated with a Diesel Coolant Additive (DCA) to minimize corrosion of the engine and cooling system components. A 50/50 ethylene glycol antifreeze solution is recommended for all Genset engines. This will provide freeze protection and increase the boiling point of the engine coolant. A solution can be increased to 65% but freeze protection is reduced after 65%.

H. Air Flow System

Air inlet faces the direction of prevailing winds. General equations for Air flow calculations is as given below.

BTU /Minute $V(cfm) = QM/ 0.0181 \times \Delta TF$

BTU /Hour $V(cfm) = QH/ 1.085 \times \Delta TF$

$V(m3/min)= kW \cdot hr/ 0.02015x\Delta Tc^{\circ}$

I. Engine Mounted Radiator Cooling

The radiator, water circulating pump, fan and fan drive are mounted to the Generator Set base rails by the factory. This method of engine cooling is the most economical, but may require large ventilation vents and ducts. An added advantage of this arrangement is that the cooling air removes radiated heat from the engine, generator, and other equipment located in the emergency power system room. The only remaining design work with the engine mounted radiator is arranging a method of providing air to the room, and exhausting it from the radiator.

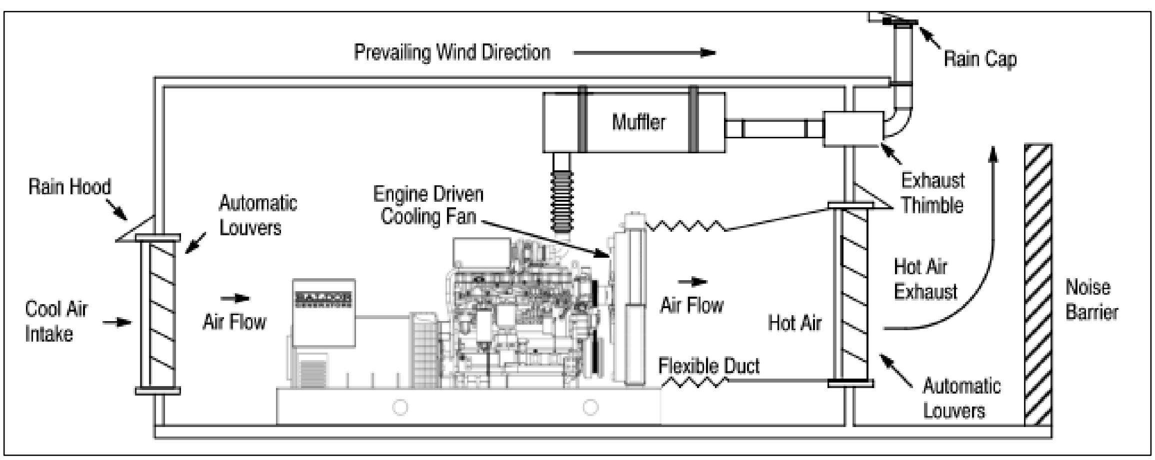

Fig 2. Engine Mounted Radiator Cooled System with Wind/Noise Barrier

The ideal setup for cooling air would be to arrange the inlet or inlets such that relatively clean, cool, dry air is drawn across the electrical switchgear, generator, and engine. The air is then drawn into the radiator fan, and is blown through the radiator and exhausted by duct work outside the building. Air inlets must be sized to minimize air restriction and provide the quantity of air required by the radiator fan, engine combustion air, and any other air exhausts which might be used in the room. On engine mounted radiator cooled systems, the engine mounted fan will handle 0.25" of water column. This is combined intake and exhaust restriction. The room air intakes must be located so as to minimize drawing exhaust fumes and other outside contaminants into the room. Be very cautious about the location of the engine exhausts in relation to room air intakes. Also, when locating the inlet and outlet, the consultant should consider prevailing winds and noise. Motor operated louvers or properly designed and sized gravity louvers should be used on the air intake and exhaust to minimize static pressure drop.

Remote Mounted Radiator Cooling

The radiator can be mounted remotely (not mounted directly at the engine). The remote/close system uses the same radiator type except it is mounted in another room or outside, but within close proximity to the Genset. The remote radiator may be mounted either vertically or horizontally. In general, the radiator will have an electric fan to provide cooling air and may be able to utilize the engine mounted coolant pump to provide coolant flow. The piping system friction and head loss between engine and radiator must be calculated and not exceed the capacity of the engine pump. If the maximum coolant friction head loss external to the engine is exceeded, a hot well system must be used. Before designing the piping system using an auxiliary pump and hot well, the consultant should look very closely at increasing the system's pipe size. Electric motorized Power Exhaust louvers should be connected to the standby Genset and controlled to open whenever the Genset is running. Operable outlet louvers should be temperature actuated on remote radiator or heat exchanger cooled units. Louvers have resistance to air flow. Openings with louvers should be twice the area of an unobstructed opening to provide proper air flow. At times duct work is necessary to provide cooling air for the room. Duct work must be sized and installed according to SMACNA Standards. The electric fan and auxiliary pump, if used, must be connected to the emergency power system. Radiator and cooling fan must be sized to provide the cooling capacity required at an acceptable sound level. Remote radiator and heat exchanger cooled engine cooling systems will not have an engine driven fan. As a result, the consultant must provide a means of supplying air to the room, and exhausting it. The air movement must be provided by an electrically driven fan. This fan may be located in the air inlet or exhaust opening. If the fan is located on the exhaust side, care must be taken to not create a high negative pressure in the room and starve the engine of combustion air.

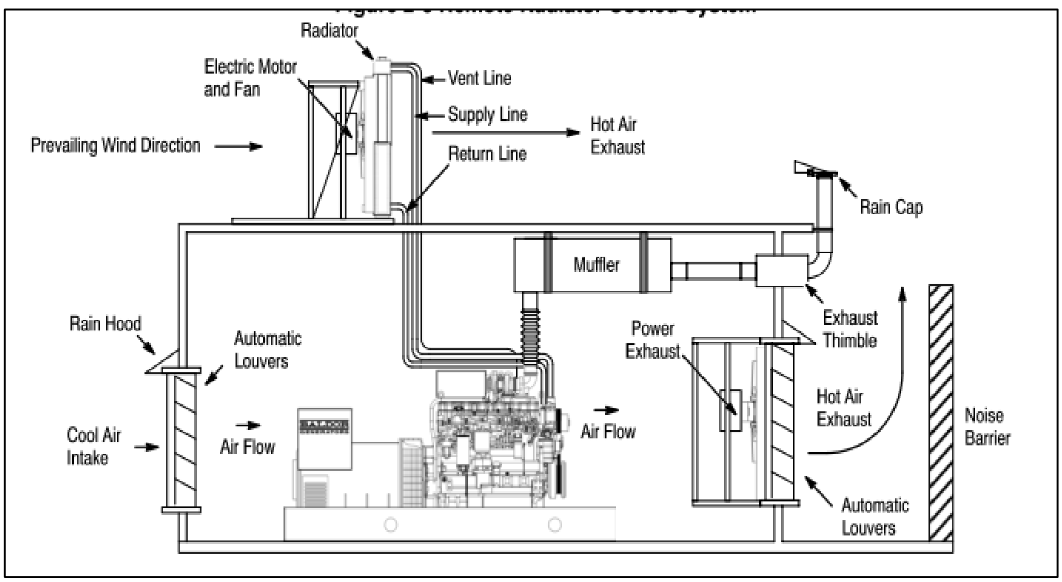

Fig3 Remote Mounted Radiator Cooling

IV. CONCLUSION

Heat transfer is one of the most difficult tasks in thermal management and directly influences cost, reliability and performances. Increasingly complex systems are driving increased challenges in integrating effective thermal management methodologies. In this project, we discussed various design aspects & their considerations and performance evaluation of generating set at various locations inside container. The endurance run was also carried out to measure the temp rise at various locations. The voltage & frequency regulation ,temp rise at various locations where recorded which was within acceptable range irrespective of the load and Speed. The operating parameters such as engine noise, Lube oil temp, cylinder head temp and other components are also studied. The overall performance of the generating set was quite satisfactory during testing after certain modification on proto unit.

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