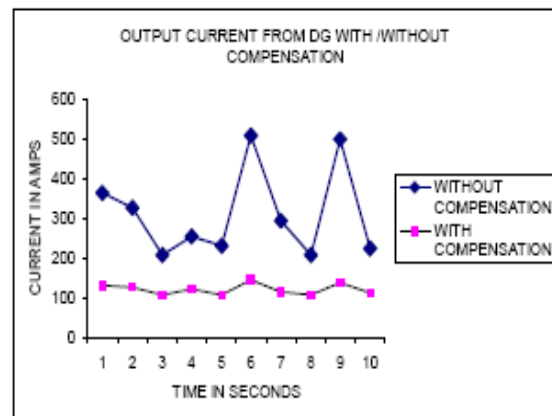
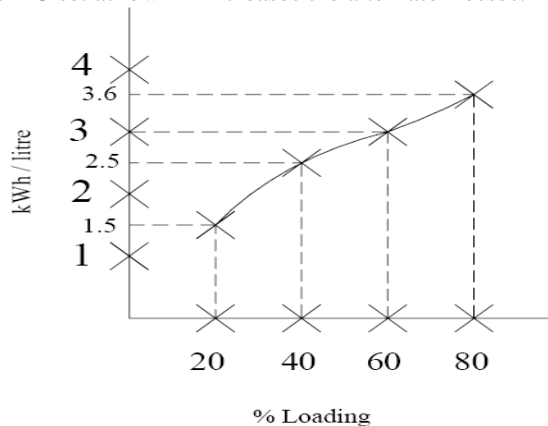


ACHIEVE DIESEL SAVING IN GENSET!

- We are used to low cost electricity from the EB grid till now. And today we are forced to run our DG set to meet our production demands, but at high cost of electricity. **Given below are the finer points of DG operation and maintenance to get the optimum units per liter at sustained efficiency over years.** Till date, many industries were talking about the ampere output drawn from the genset as the basic criteria to load the same and are inefficiently loading the DG set. **Running at the optimum Rated KVA Loading is the priority to get the better UPL when other parameters of genset are healthy.**

FINE TUNE THE DG SET OUTPUT PARAMETERS TO GET BETTER UPL

- Firstly the motor load survey in our industry indicates the motors are loaded between 50 to 80 % (except the utility compressor motor which goes above 100 % at times. That too, the user reduces the CA discharge pressure and brings down the loaded KW less than FL rating of motor). Hence considering majority of load mechanisms, the loading and utilization is averaged around 70%, **it is wise to operate the DG set so as to get at 400 – 405 volts** instead of 415 -420 volts at heavy load end motor terminals at the plant. **This gives instant savings in Diesel and without compromising the loading levels.**
- Also majority of loads like pumps, fans and compressors etc are centrifugal type and that too not loaded fully. Here **it is wise to reduce the DG set frequency from 50 Hz + to 48.5 Hz + after** studying all the loads into consideration. Again instant savings in Diesel from day 1 is possible. The overall volt & Hz optimization is done after taking into account of the instant & average values of the loading pattern of macro sum of machines as well as the individual motor loading is assessed.
- The DG set is rated by KVA only and hence how much KVA we can take from the DG set is the focus point now.** The power factor of the electrical system depends upon the nature of characteristics of the load. If the load ends are compensated so that **an average of 0.8 to 0.9 max at the load end, then we can efficiently make use of the DG set.**
- We have to see to it that the PF is around 0.8. **If the PF of load is less than 0.8 PF, alternator gets overloaded** and the energy losses thro the alternator increases. **If PF of load is more than 0.8 PF the engine gets overloaded.** Hence operating the DG set at low PF increases the alternator losses.



- The above two figures - Courtesy article by Meher capacitors – Captive gensets need Capacitors.**
- The above two figures indicate that the loading at 60 % is 3.00 UPL and at 80 % loading is 3.6 UPL. In fact, the UPL curve is flat from 60 % onwards and hence we have to load the genset above 60 % always. Hence considering the generator health as priority, **we can plan for higher loading up to 85 % for old set and 90 % for new genset.** Also the capacitor compensation on the load demand side shows the DG output current curve is smooth compared to saw tooth wave output for loads without capacitor.
- If now the lean production calls for less than 50% only as the load to genset size, please study the macro economics of **annualized diesel losses from existing 2.5 UPL to the proposed 3.8 UPL (you are losing 35 % in diesel annual costing now).** This warrants you to go in for an optimum sized genset and you then can plan to daily operate big /small size genset suiting to seasonal fluctuating load demand.
- Hence to have control over the DG output in terms of KVA, KW, and the PF, automation of DG set energy parameters is one of the ways to take the best of the genset. **So the Maximum Demand Controller MDC if retrofitted to the existing genset then, it will cap the max demand from the load to the genset.**

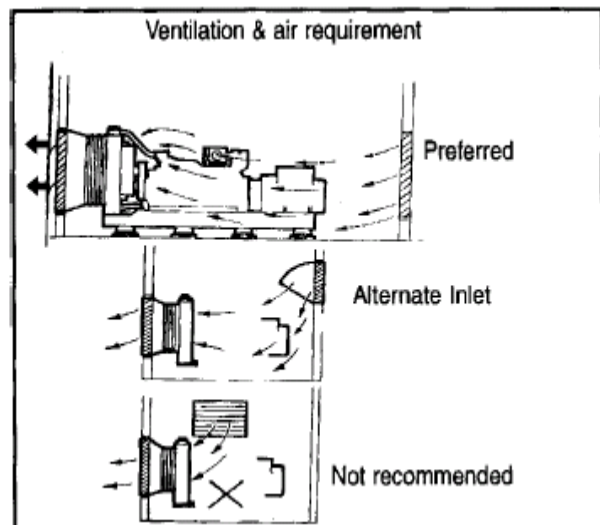
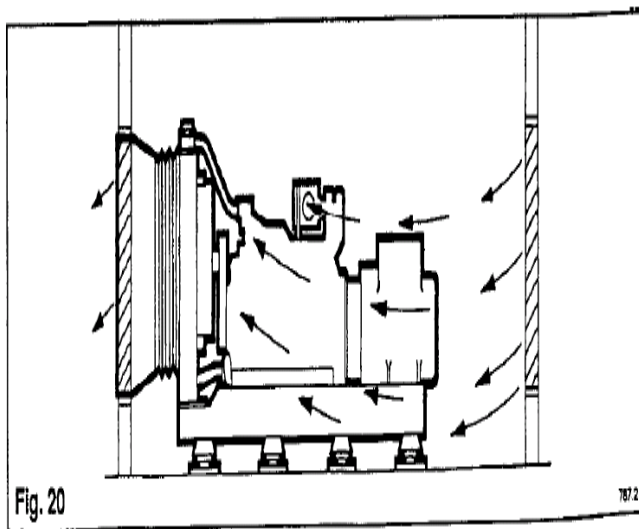
- The user can think of **replacing ordinary KWH meter in his genset with this MDC** which gives KVAH, KWH, and average PF and **this not only acts to monitor but also control the max KVA demanded by the load automatically.**
- **And either the existing APFC is to be made to Dual set point type like 0.8 PF for DG utility and 0.99 for EB utility** can be made use of or separately retrofit the Automatic Power Factor controller to the genset system and the above two retrofits ensure the genset is put to efficiently supply to load. This can be decided after taking the above KVAH, KWH readings etc.
- The above standard APFC is talked about provided **our genset feeds only to the linear electrical loads.** If the loads are non linear, then first step is to arrest the non-linearity say harmonics at the load end at least attenuate the harmonic levels. Then the capacitors at the APFC are added with reactor coupled harmonic detuned filters so that they do not amplify the harmonic current & volts and not to act as danger to the genset. **House arresting harmonics at its source, the load end is IMPORTANT.**

4 SYSTEMS IN DG INPUT TO FUNCTION AT MAX EFFICIENCY - AIR, FUEL, COOLING & LUBRICATION

AIR - INTAKE , EXHAUST & STAKE PARAMETERS

Improper ventilation can lead to

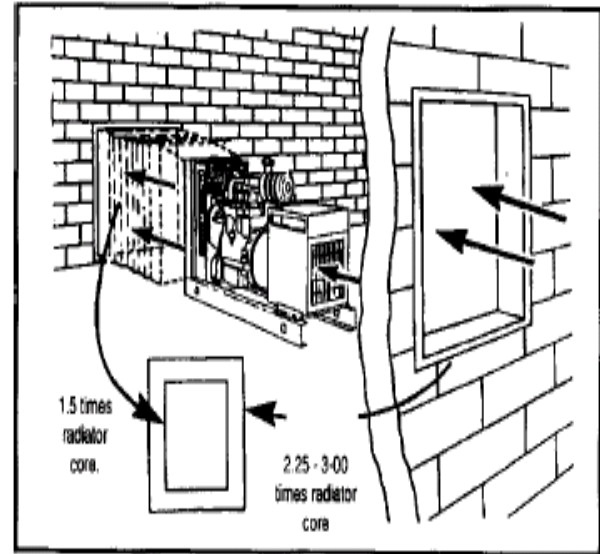
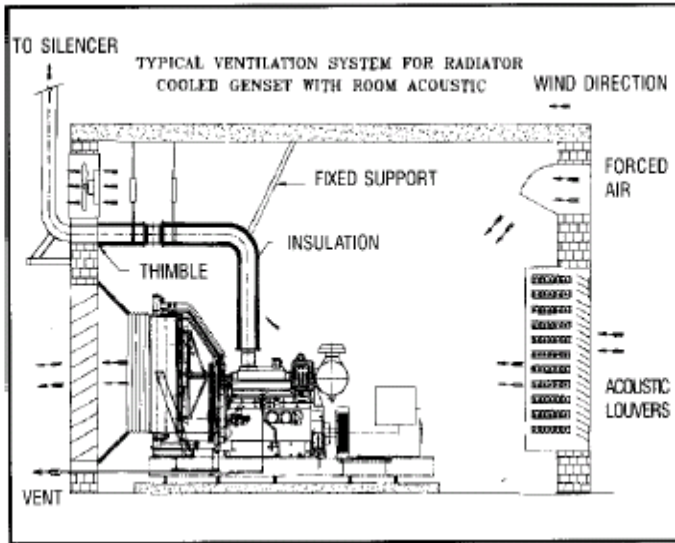
- Poor fuel efficiency,
- Poor performance of genset,
- Failures of rubber components,
- High exhaust temperature and related failures,
- Unbearable working condition due to high room temp.
- High temperature rise in generator windings and possible failures / insulation properties deterioration
- Ventilation of the generator room is done to remove heat and fumes dissipated by the engine, alternator, and its accessories & to provide clean and fresh combustion air.
- DG Set building should be cross ventilated. Increase in air intake temperature from 25°C to 40°C, the air fuel ratio decreases by about 5% resulting in increase in fuel consumption in the range of up to 2% depending on engine design
- In DG set, the **early choking of air intake filter leads to Low power, Black smoke, and turbo-charger failure.**



Courtesy Cummins genset Installation Instructions

- In the DG set **the Higher back pressure at exhaust leads to Lower fuel economy,** High exhaust temperatures and related failures Poor performance of the engine, Less durability of the engine, Exhaust system must create minimum back pressure.
- Provide louvers in front of the radiator and behind the alternator to avoid unwanted dust entry in the DG Set room when the genset is not in operation.
- RADIATOR COOLED H X - Provide sufficient space in front of radiator to allow proper flow for air leaving from radiator.

- The engine's radiator fan is of the pusher type to propel the air from the room. The opening in the wall in front of the radiator is 1.5 times the area of the radiator. The engine is to be placed 1.2 to 1.5 meter away from the opening. **The area in front of radiator is clear and open to atmosphere.**
- **TYPICAL VENTILATION SYSTEM FOR RADIATOR COOLED GENSET WITH ROOM ACOUSTICS**



- **Courtesy Cummins genset Installation Instructions**

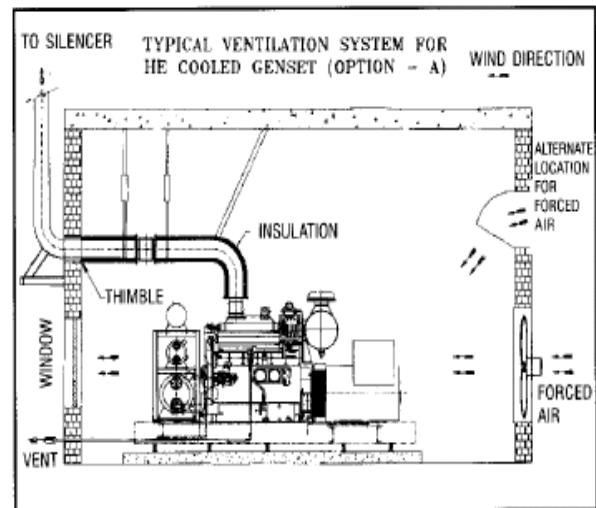
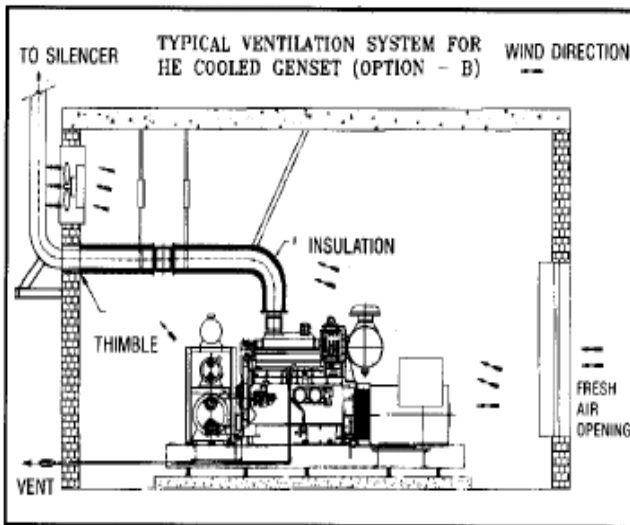
- Exhaust fans of adequate capacity are provided at the top of the room. Windows (minimum size 4 ft. x 3 ft.) are provided at the front and rear of the engine to facilitate cross ventilation for engine alternator.
- Ample air on both sides of DG. Arrangement to supply fresh air, to air cleaner is to be made in case of poor ventilation.
- The temperature in the engine room must not rise more than 5°C above ambient temperature.
- Lagging on exhaust pipe to be provided. A rain cap should be provided over the exhaust pipe's mouth outside the building. The rain cover should be of about 60 degrees. The outer diameter for the rain cover should be 2.5 times the pipe's diameter away from the pipe's mouth EXHAUST OUTLET The pipe outlet should be bent.
- **It should be such that the outgoing gases do not enter the powerhouse again at any time frame of the year.**
- Normally the pipe outlet should be bent in the direction of the wind and the end should be cut at an angle of about 30 degrees. DG Set building should be cross ventilated.
- Air temperature up to 38°C – NO PROBLEM Temperature near air cleaner ambient temperature + 5°C For 1°C increase in air temperature exhaust temp. Increases by 6°C. For every 5.5°C rise in air intake temp. 2% less HP from the genset. Exhaust temperature limits the loading and KVA on DG Set. **So monitoring exhaust temp is important to know about the possible running rating of engine and the loading possible.**
- The exhaust piping and the silencers shall be insulated using 50mm thick mineral wool inside the container & up to the exhaust stack. The insulation shall be cladded with 24G aluminium sheet.



DG set with conventional dry type air filter

Air intake retrofitted with Electrostatic Air Filter

- **C I I – UNEP CASE STUDY AT SHREE CEMENT AND THE U P L OF DG SET IMPROVED 3.50 TO 3.64 = 4 %**
- **What we learnt is that, Diesel is not the only input to concentrate in genset.** Big industries are deeply concentrating in the quality of air intake to the genset. This improves the sustained health of the DG set. For small gensets, we can think of ducting out the Air intake out of the hotter skid to a cooler zone in the DG house and implement large area pre filter retrofit.
- **Now in any industry we see the trend, first they put the Power-less roof ventilators on their DG house only.** The roof vents do an excellent work to remove the hot radiating air from the insulated DG exhaust. This automatically forces positive cross ventilation across the DG set area.
- **TYPICAL VENTILATION SYSTEM OPTIONS FOR HEAT EXCHANGER COOLED GENSET ref – CUMMINS**



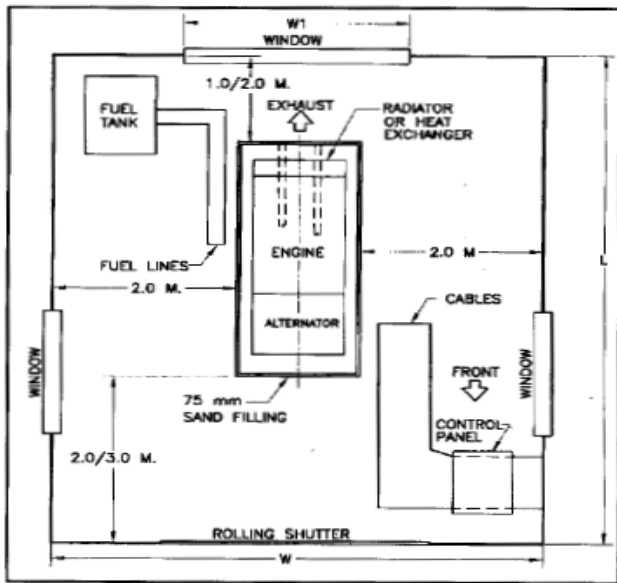
- **COURTESY –CUMMINS GENSET INSTALLATION RECOMMENDATIONS**
- The DG set OEMs give the set in acoustic enclosure and prefers the genset to be mounted on the open terrace area in the building. This is not only to avoid noise pollution to the interiors' but also the genset gets ample & abundant air supply across the skid. **But as a user we should give umbrella type sun shade protection with sufficient head room and all sides open area.** This is followed by the Telecoms buildings in the open terrace, for all their HVAC condensers and other equipments.
- **The DG set, Compressor OEM finds it practical to manufacture & despatch any equipment in an acoustic enclosure.** But in our tropical zed region, the many of the users while running the set, keep doors and windows etc to avoid starvation of air inside the hood. Some users are providing duct into air intake and duct out the heat exchanger exhaust to restore ambience in the room. That is they keep the air intake along with pre filter away from the skid and bring in only the duct to the genset.
- Here the user monitors the DP across the air intake filter and never allows the pressure drop to happen across the filter. So a **DP indicator is a must to be viewed regularly for choke in air intake which may lead to higher diesel consumption.**
- **Few users are relocating the heat exchanger from the DG skid to out of the house** (as well as the screw compressor from the skid) and put the HX in the open area all side open with sun shade protection adjacent to the building. Ultimately it is in

the hands of the user to comfort the DG set (or the compressor) by ambient cooling and take the best output from the same efficiently and effortlessly.

- **TYPICAL DG SET ROOM INTER DIMENSIONAL LAYOUT & ROOM VENTILATION ref CUMMINS –**

3) DG Set room air requirement in Cu. Meter per Min.:

Parameter	275 kVA	320 kVA	400 kVA	500 kVA	600 kVA
Total air requirement for DG Set.	605	625	854	1065	1286



Engine room ventilation can be estimated by the following formulas :

$$V \text{ (cfm)} = \frac{H}{0.070 \times 0.24 \times \Delta T} + \text{Engine Combustion Air}$$

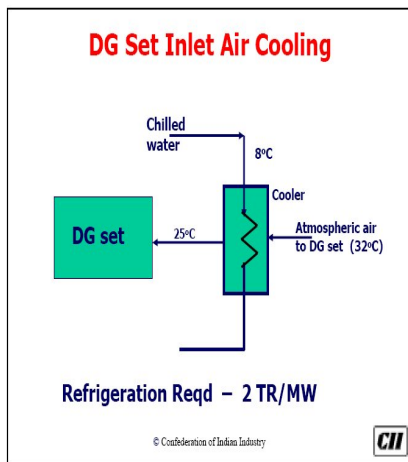
or

$$V \text{ (m}^3\text{/min)} = \frac{H}{1.099 \times 0.017 \times \Delta T} + \text{Engine Combustion Air}$$

V = Ventilating air (cfm) (m³/min).
 H = Heat radiation (Btu/min) (kW).
 ΔT = Permissible temperature rise in engine room (°F) (°C).
 Density of air at 100°F = 0.070 lb/cu ft (1.099 kg/m³).
 Specific heat of air = 0.24 btu/°F (0.017 kW/°C).
 Assuming 38°C (100°F) ambient air temperature.

• **COURTESY –CUMMINS GENSET INSTALLATION RECOMMENDATIONS**

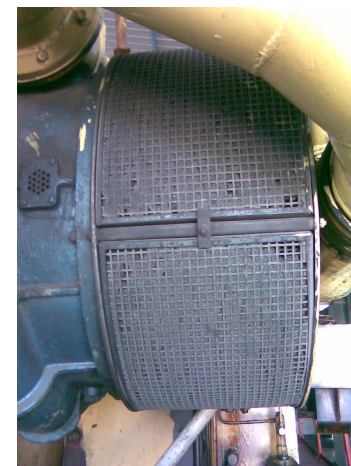
- Please consult with your OEM whether your DG set room size, air requirements are met with the existing arrangements. Why so much emphasis is given because, many industries are using genset room as unofficial store room stacking hesitant-to-throw materials and hazardous wastes since the DG was used sparing before and now the condition is different !
- Please see DG set choked air intake below at a Forging unit and the visible symptoms are seen at the exhaust smoke colour.
- Blue colour of smoke shows excess lubricating oil or worn out piston scraper rings.
- Grey smoke is the result of dirty fuel injector or the engine overloaded. To clean fuel injector and maintain proper loading
- Black smoke is due to incomplete combustion of fuel which is due to choked air filter or improper compression. So to clean the air filters, replacing piston rings or eliminating valve leakages aforesaid problems can be solved in existing old gensets.



Inlet Air Cooling

Description	Before inlet air cooling	After inlet air cooling
% Loading of DG sets	75.4	79.8
Specific Fuel Consumption (Gm/kWh)	231	226

10°C drop in inlet air temp. ~ 2 % fuel savings



• **COURTESY C I I PRESENTATION 2004 ON DIESEL GENERATORS**

DG CHOKED AIR INTAKE

- **The 1000 KVA DG set needs only 2 TR to reduce inlet air by 10 * C and achieve 2 % Diesel savings.** More than the savings, the DG set the loading can be increased to optimum values and DG set does not starve due to overheat surroundings.

COOLING WATER CIRCUIT

- Big gensets are designed to be water cooled and smaller sizes are coming as air cooled. The users who fall between big and small sizes of gensets **are now converting their air cooled HX to water cooled type so as to avoid engine overheat** in summer months and to maximize the efficiency, reduce the cooling losses and improve the loading levels.
- It is recommended to use clean water as cooling water in radiator. **Add additive coolant for better performance of DG Set.** Do not use hard water for cooling purpose it can damage the internal engine parts.
- Engine needs clean water. Never use hard water as it restricts the transfer of heat resulting in engine overhauling. **For proper heat dissipation and to avoid rusting/scaling, mix radiator coolant to water.**
- **WATER SPECIFICATIONS** total suspended particles less than 300 ppm. Total hardness of CaCO₃ should be less than 120 ppm. PH value of water at 25°C should be between 6 to 8.5.
- **WATER TEMPERATURE** 75°C to 93°C the cooling system should be so designed that difference between inlet and outlet water temperature = 6 to 10°C
- Quality of radiator water plays a very important role. **If possible DM water may be used and 20 % coolant to be used along with the radiator water. This will ensure at least 0.5 % saving of fuel in DG engine.**

LUBRICATION PROCEDURES

- LUBE OIL - USE OF THE WRONG GRADE OF OIL COULD LEAD TO Overheating of the engine, Sluggish performance, Excessive fuel consumption, Increased wear of bearings and other parts,
- **The lube oil consumption should not exceed 1 % of the fuel consumption.** Please check your lube log and the OEM reference and higher the lube consumption is indicated by chimney smoke, poor maintenance and less UPL
- **Maintaining the condition of the lube oil of DG set will ensure increased efficiency** of the engine and a saving minimum 0.5 % diesel consumption as compared to deteriorated lube oil.
- Condition monitoring may be started after every 250 hours with the help of portable analyzer kit costing around Rs.35000/-
- **Use 15 W-40 lube oil after talking to OEM in place of SAE 30 as recommended by OEM.**
- **Lube oil to be changed when the following conditions appear:** - Total Base Number TBN variation of 50 % of original value, Flash point 50* below the original value, and viscosity in centistokes 25 + or – original value.
- **Courtesy PCRA practical guide (COST Rs.250/- only) on Energy Conservation Jan 2009, contains many case studies.**

DIESEL – UNITS PER LITER – HOW TO DECREASE DIESEL INPUT AND INCREASE KWH OUTPUT?

- The increase in output KVA, KW and decrease in diesel is possible and concretely seen only after installing the Diesel flow meter on line. **Unless we instantly measure digitally and accurately with this meter, what all the savings and improvements goes unrecorded and we feel after many years of using the DG set, that whether we have really achieved something or not !** If you are a regular High consumer, the dip stick measurement is prone to practical parallax & resolution errors. It will be practically difficult for you to measure the diesel savings achieved by you during daily logging diesel inventory.
- **FOR IGNITION, DG SET REQUIRES THE FOLLOWING:** Requisite amount of clean air and proper temperature, Supply of clean fuel at proper viscosity, Injection and atomization of the injected fuel, Adequate compression temperature to promote ignition and proper combustion of oil.
- **Loading OF DG: Optimum Load the set between 65 – 85% loading. Minimum 50% Load BELOW THAT: unburnt,** Increase in ring gap, Increase in oil consumption. **Hence more the loading more the units per liter from 3.00 to 3.80** But loading beyond 85 % I in an old dated set does not give any extra efficiency, but it decreases engine life.
- **A poorly maintained injection pump increases fuel consumption by 4gm/kWh i.e. 2 % savings.** This is where the diesel is injected into the system and hence focus area is to condition monitor the fuel injection area, the pressures.

- **A faulty nozzle increases fuel consumption by 2gm/kWh i.e. 1 % savings** Keep a spare nozzle and maintain the existing nozzle by regularly inspecting the same and cleaning based on condition monitoring
- **Blocked filters increase fuel consumption by 2gm/kWh i.e. 1 % savings.** The diesel has to reach the system clean and clear. Any partial blocks or pressure drops across the filter will increase the diesel consumption.
- **Measure fuel consumption per KWH, KVAH of electricity generated regularly.** Take corrective action in case this shows a rising trend during your day to day monitoring trend of the above
- Even the internal health of the DG electrical system is important. **Because even one bad cell in a battery will overwork the alternator consuming more engine power and fuel.** That is why some users prefer to keep the battery outside DG set hood so that the battery is cool, accessible to the user and they can condition monitor the same easily.
- It should be ensured the single phase loads are distributed evenly across the three phases so that **the unbalance between 3 phases is not more than 10 % of the total DG set capacity.** More the unbalance, this will lead to less UPL.
- **We have to avoid hot engine shut downs.** Run at low idle for at least 3 minutes to reduce and stabilize internal engine temp. It will maximize the turbocharger shaft and bearing life.
- Operate the engine oil sub system with the thermostat all over the year. A cold engine consumes more fuel.
- **Energy Additives can be used to counter injector nozzle choking in diesel engines.** The claims with regard to additives that can improve the energy efficiency in an engine should be weighed carefully & after trial runs only to decide on the same. Recently the industry is using Thermol D diesel additive and used by DG set OEM as well. **Apart from Diesel savings around 3 to 6 %, what is more important to the user is that the additive cleans injectors, improves injection pressure, improves lubricity to the pump, which helps in complete combustion of diesel and also cleans up the entire fuel system right from the diesel tank to the injectors.** To avoid the nagging tension of frequent routine maintenance of fuel injection area, this is better as its sustained use removes unwanted injector deposits, and improves engine to optimal performance.
- **The additive actually removes even the existing injector deposits, restoring the injectors to their original condition,** and the engine to peak performance. It improves life of fuel injection system and diesel pump. **This needs to be focus area for the DG set user.** Any transmission loss say up to the diesel tank to fuel injector is always less and the distribution loss is much more at fuel injection into the system. So, additive functions to reduce the distribution losses & is worth trying now!
- **Magnetic resonator added to the fuel injection line surrounding the line size** near the DG set skid is tried many industries has improved the DG set performance. Fuel injection is the focus area in the genset to achieve regular diesel savings. The calibration of fuel injection pump frequently done will show the scope for diesel savings.
- When some industry needs only for lighting as an emergency measure instead of running the main utility DG set, **it is better to go in for very small DG set for lighting back up in the nights.**
- **Many points above are from the latest PCRA Practical Guide to Energy Conservation booklet, worth paying Rs.250/-**
- **Typical energy balance of DG set** - Input: 100% Thermal Energy, Outputs: 35% Electrical Output, 4% Alternator Losses, 33% Stack Loss through Flue Gases, 24% Coolant Losses, 4% Radiation Losses. So the Energy Conservation activity is to focus on enhancing the electrical output on one side and reduce the losses at stack, coolant, radiation losses.
- **Only one third of input Diesel in KCAL is converted to Electrical output as KWH** and so the efficiency of generation of DG set is poor only compared to other means of generation but it is very user friendly and instantly performs. **Whatever steps we take to increase the power output and decrease the waste outputs like damage control exercise and this will definitely improve the sustained UPL say up to 20 % to the rated output of the given size & condition by the above.**
- **The low efficiency of the DG set is due to**
 - Ageing,
 - Inadequate maintenance,
 - inadequate operation practices,
 - Low capacity utilization,
 - Fluctuating load and deration effect.
- **Please understand your engine. Adequately comfort & Feed the cow now to milk more for years to come.**
- **So condition based monitoring of the same by first comforting thro above steps, definitely will achieve Diesel Savings!**
- Ashok.S / Coimbatore – BEE certified Energy Auditor / call 94437 20220 - contact – ashok.anbesivam@gmail.com
- Please visit my website www.energymeasuretosave.com for energy savings in Domestic & other Industry Utilities.