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Efficient Operation of a Generator

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Abstract -: Generator which is either portable (or) standby provides electrical power. The Generator is one of the important tool in power system circuit. And the electric generators housed in power plants provide nearly all the power for today's electric grids. As a result, they play a critical role in today's power mix. Usually the electrical generator working procedure is to convert the mechanical energy from an external source to electrical energy as an outcome. There are enormous volumes of text books on this theory like basic working procedure, construction and classification and also operation. Today the main focus is on the efficiency of generator. If the generator is operated at high efficiency, then the electrical energy obtained would be greater. However, there is little information available on their practical aspects, unless one has to work on them practically to maintain the efficiency constant at a good level. This paper explains the practical aspects of a generator to maintain a good efficiency. Suitable examples are given as appropriate places for their understanding and ease to work at field.

Index *Terms* - Electrical generator, load applied, efficiency, outcome maintenance, fuel.

I. INTRODUCTION

Electrical energy is one form of energy that cannot be separated in life in this modern era. Along with the passing time the energy needs are increasing continuously while the fossil energy resources are increasingly decreased even depleted, so it takes an effort to exploit various renewable energy in scale household [1]. Now the technology is well developed to improve the production of the electrical energy. One of them is to improve the efficiency of the electrical equipment's i.e., generators, transformers [2], motors etc. which is used for the production, transmission and consumption of electrical energy. Without depending on the size of all the generators, either DC (or) AC, depending on the principle magnetic induction whose image is shown in fig 1. An EMF is induced in a coil as a result of a coil cutting through a coil. As long as there is relative motion between a conductor and a magnetic field, EMF will be induced in the conductor [3]. Nowadays no one wants to invest more often than they have to in their equipment. So that running backup and prime power generator efficiency is important.

Fig. 1 A Diesel Generator Model

II. GENERATOR EFFICIENCY

All the generators, whether diesel or natural gas and without depending on the application a load setting value and operation are designed to provide power in the most efficient manner possible. Similar to every generator set will have an optimal workload to fuel consumption sweet spot. Because the fuel consumption of different engines is at different rates. Almost at higher workloads always the fuel is burned most efficiently. The efficiency of the generator is usually achieved at the higher end value of the load setting at which the generator was designed to maintain.

$$\% \text{ efficiency} = \text{output/input} \times 100 \quad (1)$$

e.g.

If a residential generator has a rating of 15KW. If we run the generator at two different loads of 10KW and 6KW. The fuel consumption is less at the load of 10KW when compared with the 6KW load.

III.TYPES OF GENERATORS

There are mainly three types of generators: -

i. Standby and prime powered diesel generators: These generators are usually optimized to run at 50-80% of rated load.
ii. Continuous rated diesel generators: These generators are usually optimized to run at 70-100% of the total rating.
iii. Natural gas generators: Without depending on the application and the rating of the generator almost all the natural gas generator sets are always optimized to run between 70-100% of total load rating.

IV. LOADING PATTERN

These are the load setting percentage values of different types of generators at which the maximum efficiency is obtained [4]. Running the generator on a light load up to long periods of time will have the impact on health of the equipment. It also likely leads to unscheduled downtime, higher maintenance cost and decreased fuel efficiency. Recommending consumers to remain the load within its optimal range is key to maintain good generator efficiency.

Fuel Consumption (what is the best fuel for generator):

In today's modern era, diesel generator sets normally require less maintenance compared to the gas units. The fuel cost for 1KW produced with diesels is normally 30 to 50% less than gas units.

1800 RPM water cooled diesel units normally operates 12000 to 30000 hours before maintenance is required.

1800 RPM water cooled gas unit normally operates 6000 to 10000 hours so that gas units has shorter life than the diesel unit. An image of diesel tank model is shown in fig 2.

Fig. 2 Fuel tank of a diesel generator model

Per unit fuel consumption of diesel generators:

Generated unit = total generated KWH/ total consumed diesel

Approximate diesel fuel consumption at different loads for differently rated transformers is shown in Table 1.

Table1: Fuel and Load

S. No	Generator Size	Approximate diesel fuel consumption			
		25% load (lt/hr)	50% load (lt/hr)	75% load (lt/hr)	Full load (lt/hr)
1	8KW/10KVA	0.9	1.2	1.7	2.1
2	10KW/12KVA	1.0	1.4	2.1	2.6
3	12KW/15KVA	1.3	1.8	2.6	3.2
4	40KW/50KVA	4.3	6.0	8.6	10.7
5	80KW/100KVA	8.3	11.9	16.1	21.4
6	160KW/200KVA	14.1	22.9	32.7	42.8

From the table 1 mostly for all the generators irrespective of the rating their efficient operation is at 75% load i.e., either the fuel efficiency(or) generator efficiency, as shown in fig. 3.

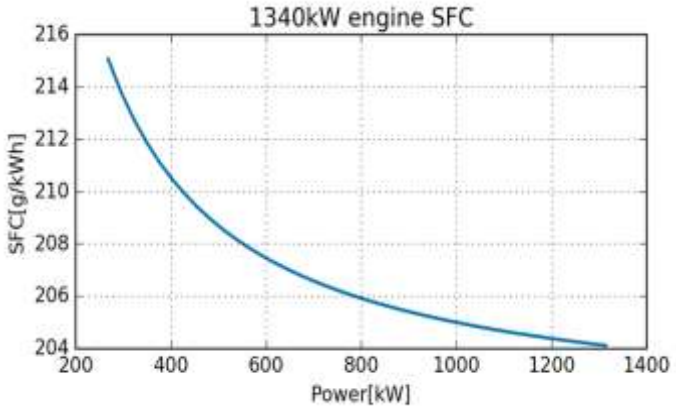

Fig. 3 Example of load % & Sp. fuel consumption

Bureau of Energy Efficiency (India), has notified star ratings for DG sets [5] w.e.f 1.1.2016, as shown in table 2.

Table2: BEE Star ratings

Star level	Specific fuel consumption (g/KWH)
1 Star	>302 & ≤ 336
2 Star	>272 & ≤ 302
3 Star	>245 & ≤ 272
4 Star	>220 & ≤ 245
5 Star	≤ 220

V. OTHER TIPS FOR EFFICIENT OPERATION

1) Operating Speed: -

The frequency of the generated voltage is dependent on the number of field poles and the speed at which the generator is operated.

$$f = NP/120 \quad (2)$$

Where,
f = frequency (HZ)
P = total number of poles
N = rotor speed (RPM)
120 = conversion from minutes to seconds and from poles to pole pairs.

Own advantages and drawbacks of 1800RPM four pole sets are the most common and least expensive in large generators. They offer the best balance of noise, good efficiency, cost and engine life. And 3600 RPM two pole sets are smaller and light weight, best suited for portable and light duty applications, which are not suitable for heavy duty.
e.g.:
If a vehicle is operated at 90km/hr versus 45km/hr; when the vehicle is operated at 45km/hr the vehicle will last longer with less maintenance and with good efficiency so the operation of the generator at a rated operating speed will make it to work efficiently.

2) Maintenance: -

Establishing a planned maintenance schedule is a paramount to the reliability of the generator. For example, if the generator set is located in an extremely cold or hot climate, or if exposed to salt air, the system may require the specific needs to work efficiently, such as maintenance and checking the equipment in more frequent intervals.

3) Preventive Maintenance plans: -

It should include some of the plans for the efficient operation of generator set, such as oil changes, cooling system service, fuel system services, testing the starting batteries, Regular exercise of the engine underload.

4) Some of the DO'S and DON'T'S specified by the manufacturing companies of the generator sets for efficient operation are given below [6]:

DO's: -
a) Plan maintenance.
b) Train personnel.
c)Test under real world conditions.
d)Follow manufacturer directions and local regulations.

DON'T'S: -
a) Ignore the fuel maintenance.
b) Ignore the battery.
c)Ignore the precautions.
d)Ignore local regulations

5) Wet Stacking: -

One of the most prevalent problems with diesel engines running below their designed load capacity for extended periods of time is the phenomenon known as wet stacking [7]. It will occur when unburnt fuel is exhausted due to low operating temperatures. When this fuel is exhausted from the combustion chamber, its starts to build up in the exhaust side of the engine, resulting in fouled injectors and a build-up of carbon on the exhaust valves. The effect of wet stacking is shown in fig. 4.

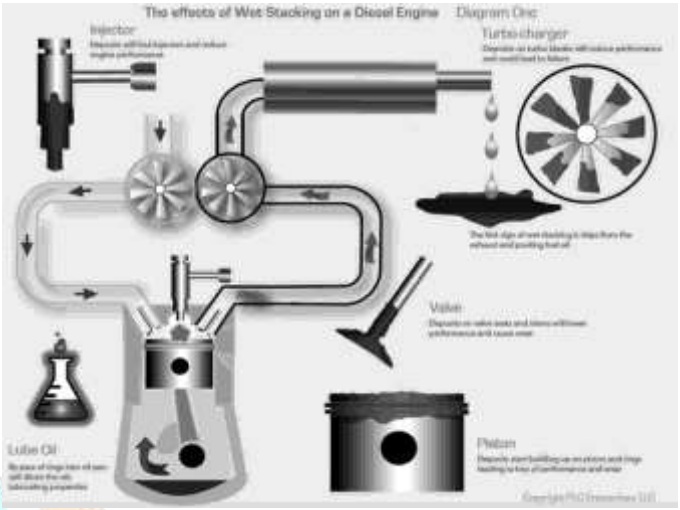

Fig. 4: Effects of wet stacking

To avoid the wet stacking and some other problems resulting from running the generator on a light load, it's important to run the generator within its optimal range as often as possible. There are some of the reasons for achieving the generator efficiency by reducing the problems carefully.

VI. LATEST TRENDS

Latest DG seta are coming with acoustic enclosures, as shown in fig. 5 for environmental protection and also energy savings.

Fig. 5 Acoustic enclosure of DG Set

Now PID controller are being used, as shown in fig. 6, on Engine side for smooth control and energy savings [8], which will take care of increased fault currents due to renewable integrations [9], retrofits [10] and other challenges in electrical engineering [11].

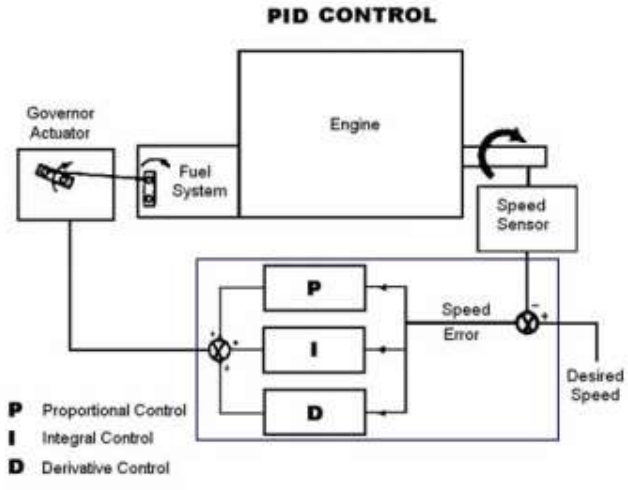

Fig. 6 PID controller for DG Set

VI. CONCLUSION

The efficient operation is discussed in detail. With an example in the case of the operating speed and load setting value, which can help us to maintain a good efficiency. Every person who are using the generators (or) looking after them either for household purpose or at industrial level have to make their generator sets to work efficiently, as per IEC standards [12]. Care also shall be taken towards safety of human [13], particularly with the percolation of Distributed Generation and Microgrids [14]and everyone should need to have a thought on maintenance [15] on each and every equipment used inside the generator sets which improves performance.

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