Sustainability Outlook

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MAKING DIESEL POWER VIABLE: INTEGRATING POWER FACTOR CORRECTION SOLUTIONS IN DIESEL GENERATORS

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"Power Factor (PF) is the ratio between the apparent electrical power provided to an electrical circuit and the actual power consumed by the circuit"

Backdrop

With the continued erratic state of power supply and the need of industries for uninterrupted throughput of products to sustain economic sustainability, more and more businesses have shifted to relying on Diesel Generators (D.G) as an important secondary source of power and not merely a temporary backup solution. As the usage has increased, so has the need to find ways to improve DG efficiency.

A recent study of large industrial clusters conducted by cKinetics revealed the significant prevalence of DGs working with sub-optimal power factors (PFs) in a vast majority of manufacturing units. The underlying aspects are different from that of the more commonly used Automatic Power Factor Correctors (APFCs) for Utility power and hence a different approach needs to be taken while developing a PF correction solution for DGs.

Reasons of lower power factor in DG

While the mix of different loads with their unique power factor impacts is the primary reason for the overall reduction in the power factor of an electrical layout, there are other reasons which significantly affect the power factor output of a DG. All these reasons are primarily connected to the fundamental limitations of a diesel generator: A DG is an island source of power with the absence of a network of sources and loads to cross compensate or counter load it, hence has a limited ability to meet sudden and large demands of reactive power. Building on this limitation, the following reasons can be associated to lower power factors in industrial DG installations:

1. Oversizing- Plant designers usually oversize a DG or limit the loading of DG owing to a much prevalent myth that 0.8 is the 'Designed' power factor of diesel gensets. essentially leading to liberally sized diesel guzzlers who do not deliver the full version of their economic capability. The alternator of the DG is no different from that of larger variants connected to utility power turbines with scaled down proportions; it is by design capable of delivering the exact amount of its rated KVA. Hence the '0.8' is not a design variable, it is more of a thumb rule deduced from the fact that the average power factor in an industrial electrical layout with the common set of inductive (PF values .8 to .85), non-linear (PF values .5 to .65) and Linear (Unity PF) is '0.80'.
2. Unbalanced phase loading - With most industrial electrical layouts, loads are more liberally connected on different power phase lines simply because physical limitations of the process layouts are easier to visualize as compared to the electrical balancing on each line. This doesn't prove to be a major problem in the grid connected situations where primary correction of one phase maintains the sync in the rest of them from the utility side owing to the macro effect of a grid. But with the captive DG set, syncing the phases is not even an advanced function built into its power electronics.

3. Compensation load - From the published reports on effect of various power factors on the DG and identifying safe zones by leading alternator manufacturers and integrators like Cummins, it is evident that close to unity power factors are achievable and safe but poor PF for longer durations has greater negative impact. Hence traditional PF correctors with their switching response rates of 150 milliseconds or more prove to be hazardous to the life of a DG in constantly shuttling loads. For safer and consistent correction of PF in a DG the response should come within a waveform accounting to less than 20 milliseconds.

Dealing with PF correction in DG

By taking the above mentioned limitations as system boundaries, various power electronics developers and experts have designed robust power factor correction systems. These systems use the same principles of the conventional APFC but differ greatly from them on aspects such as the control logics and consequently the controller hardware which are more advanced and sophisticated. This corrective mechanism in common language is called reactive power compensation whereby an exact mirror image of the tracked power factor is created to correct it in real-time.

This necessitates the use of three things:

1. Thyristors with Solid state relays - As the name suggests, unlike traditional magnetic induction based relays, these are made of solid state electronics (semiconductors) which helps eliminate transient currents and drastically reduces the time lag between consecutive switch overs of capacitors.
2. Multiple current sensors - For every electrical phase of the layout there should be a current transformer to help virtually balance the load and correct the power factor on each phase line.
3. PLC or Micro-processor based controllers- With the added phase wise data parameters and calculating power for correction determination, micro controller based controllers prove to be sluggish in these applications; hence hardcoded PLCs or faster micro-processors are needed.

Impact

Correcting the power factor using these advanced power factor controllers offers some advantages which are most apparent in the following areas:

1. Loading capacity - The most direct impact of better power factor from the DG is that more loading can be done on the same DG hence allowing for better servicing of its capital and operational expenses.
2. Alternator Efficiency - The copper losses associated with the alternators are directly proportional to the square of the current it delivers. Hence the correction of PF leads to lesser current per unit power delivered having an exponential effect in reducing the associated copper loss.
3. Over-heating and voltage fluctuations - Due to reduced currents in the total system, over-heating and voltage fluctuations induced in the windings and transmission network due to shuttling of loads is remarkably reduced which further saves T&D losses.

All the listed impacts directly improve the plant economics for a DG and can lead to both financial and ecological benefits. An overall reduction of 5-7% of energy cost from the DG is achieved as a consequence of 10-12% improved efficiency as compared to traditional DG systems without correction. Depending on total hours of running, a conservative estimate of 6 to 20 months of capital investment breakeven can be achieved easily. Since these are robust electronic systems, minimum risk is involved in downtime from failure and maintenance is minimalistic too.

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