Generator Power Factor

Understanding Power Factor

Q. "If an AC generator is rated 480 volts and 900 amperes at 0.8 power factor, why can't the generator produce 900 amperes at 480 volts at 1.0 power factor?"

A. "It can, or cannot, depending on how the generator set has been set up and rated." How's that for an answer!

In reality, the generator is capable of producing 900 amperes at 480 volts, but the engine side of the unit is not sized to be able to deliver the horsepower (kW) to permit the generator to carry the load at the rated speed under all conditions.

The answer lies in the difference between apparent power and real power:
Power factor is defined as the difference, expressed as a percentage, between the voltage and current sine waves. It is critical to understand the generator does not produce power factor – the load does. Therefore, the generator set must be able to react to power factor in the load.

Leading or Lagging Power Factor?

- Power factor can be leading or lagging, or in some cases, at unity.
- A leading power factor can be caused by capacitor-intense loads, a lightly loaded synchronous motor or an induction motor that is being driven by its load.
- Lagging power factor is caused mainly by induction motors.
- Unity power factor can be found in loads dominated by electronic devices or resistance loads such as lights and heaters.
- Average industrial loads include many motors, so the recognized standard is 0.8 lagging power factor. Leading power factor is practically unattainable with today's loads.

The key here is to keep in mind PF will affect the genset's overall output capability.

Assuming the same current output, both following statements could result:

1. Any PF in excess of rated (greater than 0.8), the genset output is limited by engine horsepower.
2. Any PF less than rated (0.8) output is limited by generator amperage.

Physics at Work

Today's generators can typically produce electricity at 93.5% efficiency; the rest is lost in windage, bearing friction, and heat losses. Further, 1 hp is equal to 0.746 kW of power which is equal to kVA times the power factor. These two considerations give us enough ammunition to figure horse power needed to produce a given kW.

For example, a CAT C18 genset is rated at 600kW at 1800 rpm. The following engine horsepower is needed to deliver that power from a 93.5% efficient generator:

$$\frac{600 \text{ kW output required}}{.935 \times 0.746} + 20 \text{ fan hp} = 880 \text{ hp}$$

Note: This equation indicates that an 880 hp engine must drive the generator. (This gives no consideration to overload capability.)

The C18 genset engine is factory set to provide 894 hp. So based on the formula presented, the CAT C18 engine meets the horsepower needs to produce slightly over 600 kW.

The kVA is equal to the rated voltage and amperage multiplied by 1.732 divided by 1,000. Therefore, the kVA for the above generator is:

$$\frac{480 \text{ volts} \times 900 \text{ amperes} \times 1.732(\text{constant})}{1000} = 750 \text{ kVA}$$

What does all this mean? It means if we know we will have a load causing the power factor to increase beyond 0.8, we can oversize a generator end. While the real power rating of 600kW remains unchanged, our apparent power kVA rating is increased to allow for a higher power factor.

Generator Power Factor

Note: Because kW equals kVA times the power factory (0.8 lagging power factor is the NEMA standard) the true output of this generator is 750 kVA times 0.8 which equals 600kW.

Summary

Power Factor is one of the most challenging issues we face when applying generator sets, but here's the most important thing to know about power factor. It is created by the load and the generator must be capable of reacting to it. The industry standard for generators is for them to be rated for up to a 0.8 power factor. If your loads are likely to exceed this power factor, an oversized generator can solve this problem without having to oversize the entire generator set. Knowledge of exact load requirements assures proper equipment selection. A complete audit of the load profile will help estimate the power factor, helping you and Cashman Power Solutions to size the best unit for the application

The finest software tool on the market for sizing generator sets is Caterpillar's SpecSizer Program. It can be downloaded for free here.