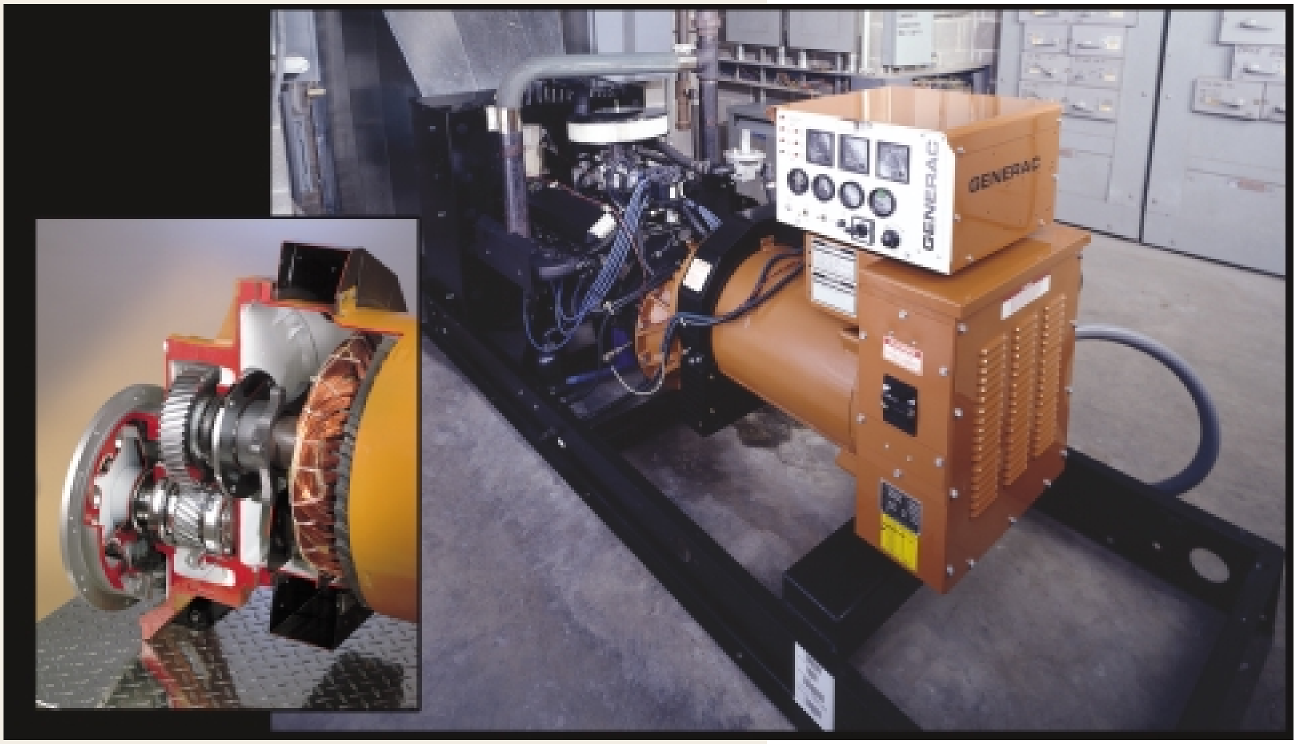
Technical Perspective

Gear Driven Generators



Gear Drive Cutaway | 100 kW Gear Driven, Natural Gas Engine Generator

INTRODUCTION:

In addition to our complete line of direct drive generator sets, Generac offers gear driven generators at certain kilowatt ratings where high value can be achieved. The key is to take advantage of additional power available in engines designed for and very capable of operating at speeds above 1800 revolutions per minute (rpm). By coupling the engine to a gear reduction unit, the engine can be operated at a higher rpm while the gear drive reduces the revolving shaft speed for powering the alternator.

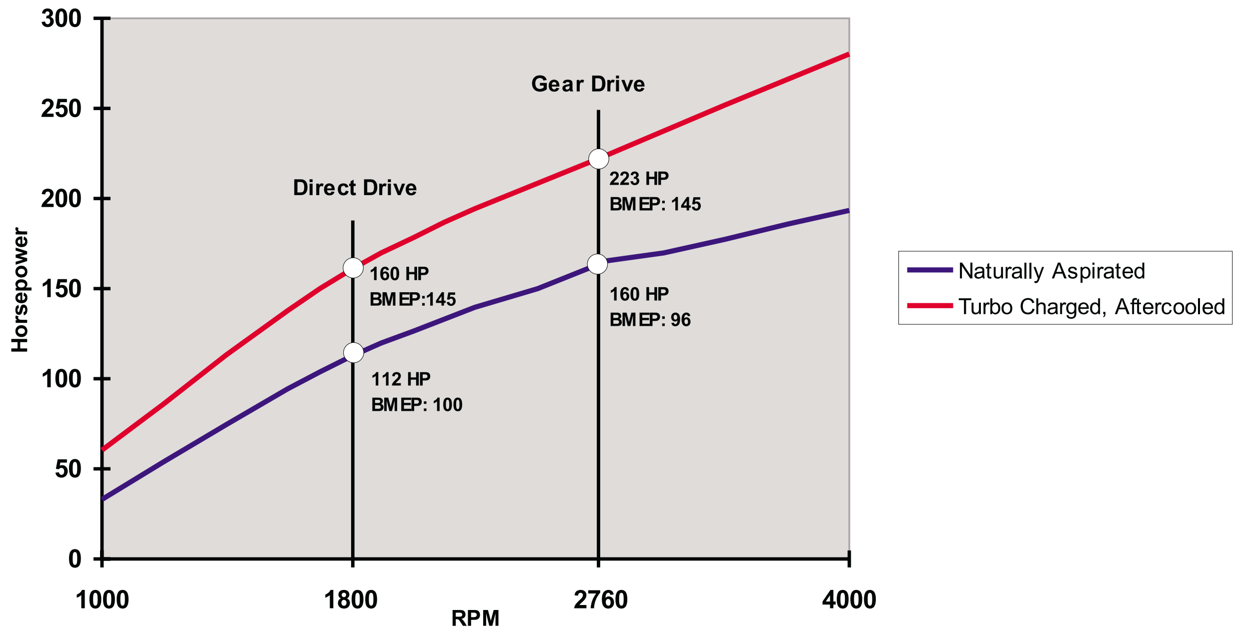
Introduced in 1983, Generac gear driven generators have been successfully installed in thousands of locations. They have a very high reliability record. To date, there have been no reported failures of the gearing used in these units. We are the only manufacturer offering gear driven generators, and we're proud of that distinction.

KEY POINTS:

- Principle Of Operation
- Simplicity Of Design
- Lower Generator Cost Per Kilowatt
- Reduced Engine Stress
- Improved Transient Load Response
- Sound Level Comparison
- 10 Year Warranty Coverage

PRINCIPLE OF OPERATION:

Direct drive generator engines run at 1800 rpm in order to drive a 4-pole alternator at the required speed for producing power at a frequency of 60 Hertz. The chart below shows a horsepower curve for a typical automotive engine as used in our generators:



As you can see, peak horsepower is achieved at a speed above 1800 rpm. Therefore, to achieve additional power from a given engine, we can:

- Operate the engine at an optimum speed for increased power output, in this case 2760 rpm.
- Utilize the gearbox to reduce shaft speed to 1800 rpm; in this case a 1.53:1 reduction gear set is used.

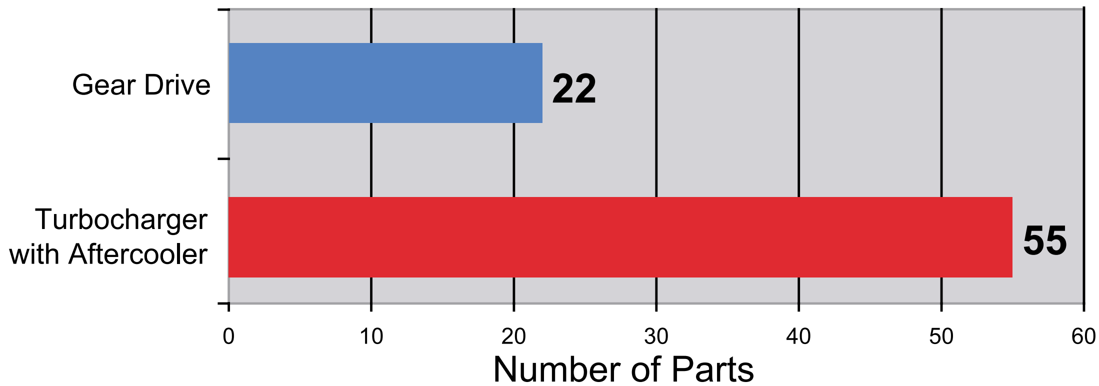
In this example, we have used a gear drive to produce 160 HP compared to 112 HP, or 43% additional power using the same engine.

SIMPLICITY OF DESIGN:

Another method used to achieve more horsepower from a given engine is to add a turbocharger or turbocharger with aftercooler. Many generators in the market currently use this method. However, compared to turbochargers, gear drives:

- Add significantly less parts to a generator than a turbocharger / aftercooler package (see chart below)
- Operate at much lower speeds and temperatures than turbochargers

Typical Part Count Comparison: Turbocharger with Aftercooler Versus Gear Drive



Gear drives provide a simple, yet well established and widely accepted technology for obtaining additional power from an engine. Consider this – every conventional automobile has helical gearsets in it (in either manual or automatic transmissions), but only a few have turbochargers. Which are you more comfortable with?

LOWER GENERATOR COST PER KILOWATT:

As indicated above, engines with turbochargers and aftercoolers are more complex than those with gear drives. Related to this is the lower cost for gear driven generators. The table below illustrates the lower market price per kilowatt for gear driven generators:

Estimated Cost Per kW*	Configuration	Kilowatt Output	RPM	BMEP
$179	7.4L NA / GD	100 kW	2760	96
$190	7.4L TA	100 kW	1800	145

NA = Naturally Aspirated   TA = Turbocharged and Aftercooled   GD = Gear Driven
*Typical model with enclosure

Therefore, if low cost is a significant factor in a generator application, the gear drive unit is an attractive method of achieving more power from a lower cost, smaller displacement engine.

REDUCED ENGINE STRESS:

The table above also demonstrates another benefit of gear driven units. That is, for a given power output, a gear driven engine is not worked as hard as a turbocharged or turbocharged and aftercooled engine. A turbocharger increases engine power output by compressing air and forcing it into the cylinders during the intake stroke. Compared to the turbocharger approach, the gear drive lowers engine stresses in two aspects:

LOWER BMEP

Turbocharging increases engine power by increasing cylinder pressures during fuel combustion. Cylinder pressures are often expressed as Brake Mean Effective Pressure, or BMEP. This is a measure of the theoretical average cylinder pressure, expressed in pounds per square inch, or psi. BMEP is calculated from an engine's horsepower output, displacement and operating RPM. Higher BMEP, or chamber pressure, results in higher forces on the following engine components:

- piston rings
- connecting rods
- crankshaft
- head gaskets
- piston wrist pins
- connecting rod bearings
- crankshaft main bearings
- valve seals

Most of these components are wear items with wear rates related to operating forces. Therefore, lower BMEP is equated with less engine wear and better engine life. With lower BMEP, the engine is considered to be working "more comfortably".

BETTER EXHAUST HEAT REJECTION

Another disadvantage of turbocharging is that it utilizes exhaust gases to power the compression of intake air. This in effect diverts heat rejected to the exhaust back into the engine. Net combustion chamber and exhaust gas temperatures are higher. Higher temperatures are also a factor in higher engine wear rates.

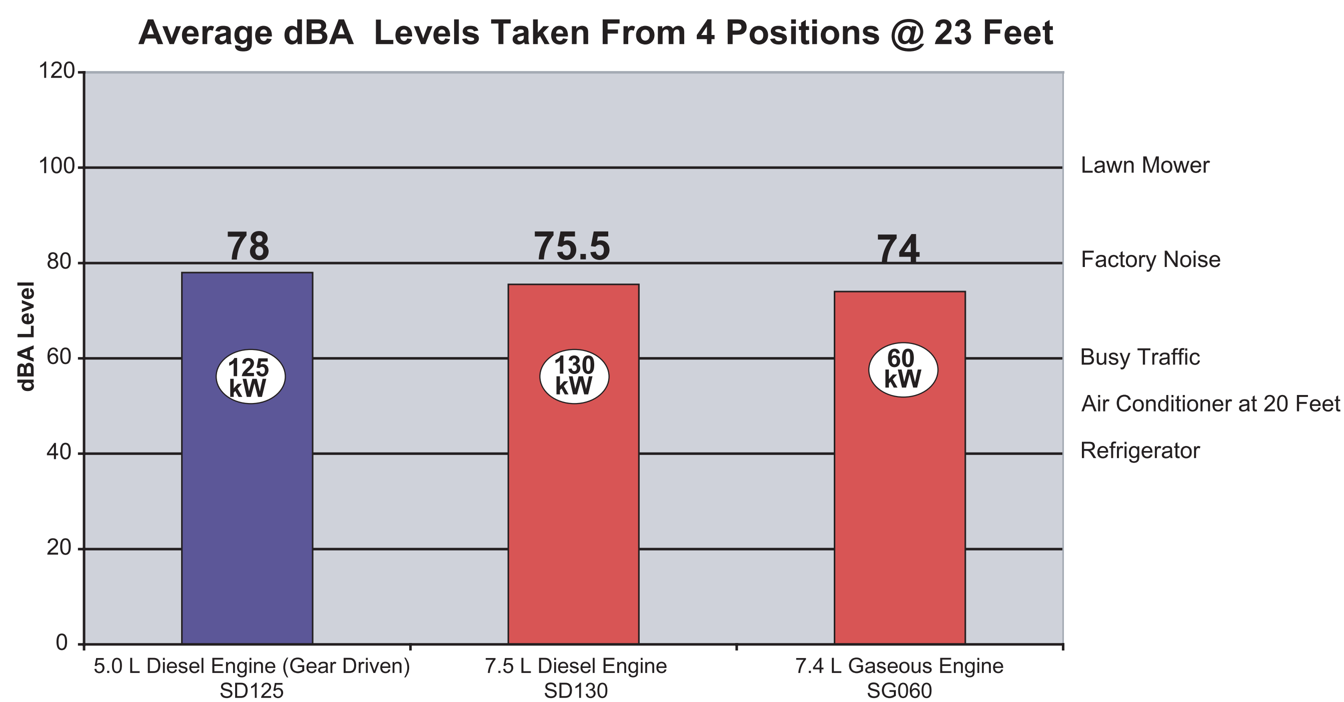
IMPROVED TRANSIENT LOAD RESPONSE:

An additional benefit of a gear driven generator is improved transient load response and better motor starting. Transient load response comes into play when starting electric motors or when transferring sudden loads. This is commonly referred to as "block" loading, such as when transferring a building's electrical loads to a generator. The transient response capability of the generator set is related to alternator characteristics as well as rotational energy stored in the running engine. Engine rotational energy is proportional to the square of rotational speed. Therefore, an engine operating at a higher rpm has more stored energy to transmit to the alternator during transient loading events.

Taking the previous example of the automotive engine operating at 2760 rpm, it has $(2760/1800)^2$ or 2.35 times the stored rotational energy as the same engine operating at 1800 rpm.

SOUND LEVEL COMPARISON:

One misconception about the higher engine rpm is that noise levels will be significantly higher. In actuality, comparison sound testing indicates a sound level increase of 2.5 decibels (dBA) at 7 meters. The accepted sensitivity threshold for the human ear to distinguish differences in sound levels is 3 dBA. Thus, the sound level increase introduced by a gear drive is virtually unnoticeable.



All generators were within standard sound attenuated enclosures when tested and fall within a four dBA range of each other

Notes:
1. All positions 23 feet (7 meters) from center of generator
2. Generator operating at full load
3. Test conducted on a 100-foot diameter asphalt surface

10 YEAR WARRANTY COVERAGE:

Generac gear drives have proven to be extremely reliable. Our confidence in them is reflected in our 10 year limited warranty, which covers gear drive parts for 10 years, and both parts and labor for 5 years.

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