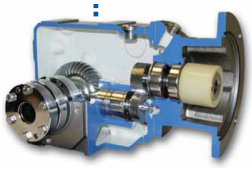
Shop Tech Talk January 2009

Q. How efficient are the different types of gear boxes?

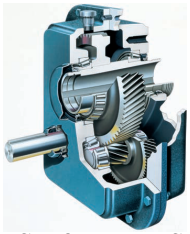
Worm Gear Gear Box



Right Angle Helical Bevel

Inline Helical Gear

Cycloidal Speed Reducer



Shaft Mount Speed Reducer

Planetary Gear Box

When considering the overall efficiency of a gear drive system we should look closely at not only the motor but also the efficiency of any driven speed reducer. We should also look at the lubrication oil used in the gear box as decent savings in efficiency may be possible.

High efficiency motors on their own provide an approximately 3% improvement in operating efficiency, but with efficiency losses for most gearboxes (excepting planetary types) of anywhere between 5% (Helical) and 30% (Worm) per stage, the positive saving can quickly become a negative.
This is not the case with planetary gearboxes, which minimise efficiency losses to just 1% per stage.

Here is a comparison between a standard right angle worm drive gearbox and a right angle helical bevel gearbox. Note how in the worm box the efficiency falls from 93 to 63% whereas the helical bevel falls from 97 to 95% over the same ratio range

Grove Gear Right Aqngle Worm Gearbox							Stober Right Angle Helical Bevel Gearbox K Series					
Size	Ratio	Input rpm	Output rpm	Input HP	Output HP	Efficiency	Ratio	Input rpm	Output rpm	Input HP	Output Torque	Efficiency
224	5	1750	350.00	3.889	3.628	93.29	5.177	1750	338.03	5.76	1042	97.03
	10	1750	175.00	3.082	2.809	91.14	10.073	1750	173.73	3.7	1301	96.93
	15	1750	116.67	2.303	2.028	88.06	13.851	1750	126.34	2.44	1181	97.03
	20	1750	87.50	1.828	1.557	85.18	20.327	1750	86.09	2.14	1522	97.15
	30	1750	58.33	1.319	1.049	79.53	27.95	1750	62.61	1.81	1772	97.26
	40	1750	43.75	1.04	0.778	74.81	39.454	1750	44.36	1.07	1455	95.70
	50	1750	35.00	0.847	0.602	71.07	50.492	1750	34.66	0.77	1364	97.42
	60	1750	29.17	0.674	0.466	69.14	55.542	1750	31.51	0.72	1407	97.69
	80	1750	21.88	0.455	0.288	63.30	79.615	1750	21.98	0.65	1772	95.08

Efficiency = Horsepower Output / Horsepower Input
Horsepower Output = Output Torque x RPM Output / 63,025
Output torque in inch lbs

*****This boost of efficiency at the higher ratios comes at a higher cost as you might imagine.*****

Please see next page for more information:

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If you have a lot of gear motors in your plant it is easy to see how these losses in efficiency can add up. Also the worm gear losses are per stage so if you have 'piggyback' units where 2 worm gearboxes are connected together then the efficiency of the overall unit will be the product of the 2 stages. So if you had a 10:1 and a 30:1 together the overall efficiency would likely be in the range of .91 x .79 = 72% overall, i.e. an overall loss of efficiency of 28%

Here is a chart with more information on efficiencies of the different types of gearing.
Planetary gearboxes, minimise efficiency losses to just 1% per stage. They are the most efficient type of gear box.

Type	Normal Ratio Range	Efficiency Range/gear set
Spur	1:1 to 6:1	98-99%
Helical	1:1 to 10:1	98-99%
Double Helical	1:1 to 15:1	98-99%
Bevel	1:1 to 4:1	98-99%
Worm	5:1 to 75:1	20-98%
Crossed Helical	1:1 to 6:1	70-98%

The Shimpo Circulute 3000 cycloidal type speed reducer has an efficiency of 95% over the ratio range of 11:1 to 71:1

The standard shaft mount speed reducer contains all helical gearing in both single (5:1 ratio) and double reduction units (9:1 to 40:1 ratio) with an efficiency of 98.5 % per gear set.

Lubrication of Gearboxes

With regard to energy efficiency, some gear oils are more energy efficient than others due to their lower coefficient of friction. Polyglycols, for example, absolutely shine as the most efficient and lowest wear type of oils, particularly in high-sliding applications such as worm and hypoid gears. In these applications, PAGs offer a lower coefficient of friction within the gearbox, resulting in less power loss.
Synthetic oils are more energy efficient because they have better oxidation and thermal stability, which means the gear oil lasts much longer. One could expect to change a mineral oil every 5,000 hours, whereas PAOs or synthetic hydrocarbon oils can last approximately 15,000 hours before a change-out. In addition, PAGs can last as long as 25,000 hours at the same temperature.
For OEMs, gear oil affects several design considerations, including the reliability of their final product. How much a manufacturer will increase the energy efficiency of a gearbox by using high-quality gear oil depends on the gear type.
The biggest increase can be realized in gear types that are challenged in normally lower efficiencies such as worm drives. Our worm gear test rig runs at approximately 60 percent efficiency with a mineral oil. With a PAO, efficiency goes up to 70 percent and with a PAG it rises to 78 percent. With the efficiency increases, the temperature of the gear box drops. This decrease in temperature increases the life of the gear system. This may not sound like a big deal if you have one or two gearboxes in your plant, but if you have hundreds of gearboxes, then that energy usage really adds up.
In summary, most OEMs and end users find that the extra cost of high-quality gear oil is worth the investment and that synthetic oils are proven to be the best. By choosing high-quality synthetic gear oil, end users will save energy and reduce operating costs through reduced maintenance, longer oil change intervals and less wear.
This lubrication article was compiled from a pdf available at Klüber Lubrication
http://www.kluberna.com/pdfs/improving_energy_efficiency_with_proper_gear_oils.pdf

Note:
PAGs are Polyalkylene glycol based fluids,synthetic ,known as compressor lubricants
PAOs are Polyalpha olefin based fluids,synthetic, most commonly used,high performance
For more information see http://www.machinerylubrication.com/article_detail.asp?articleid=930

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