



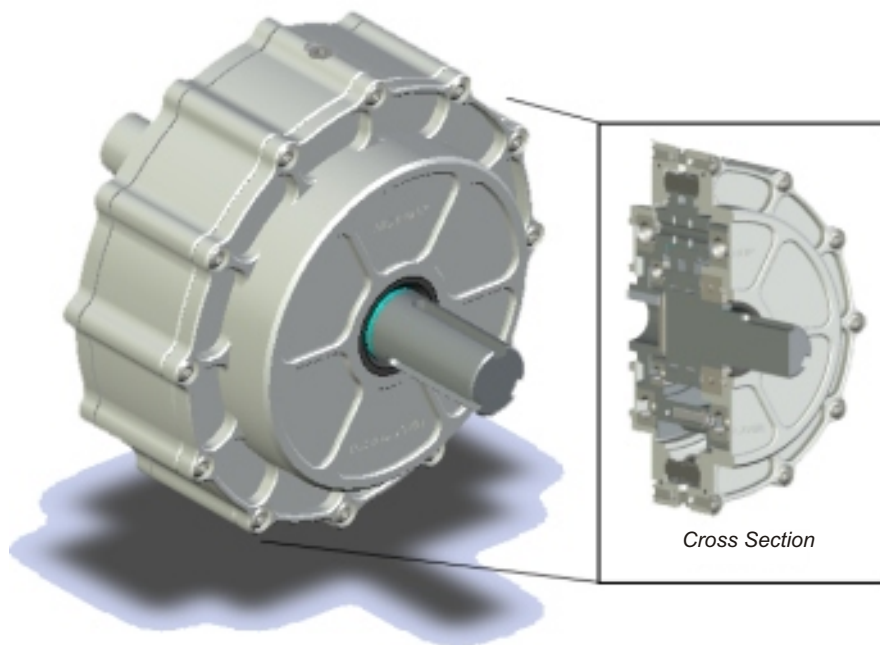
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*White Paper*

## A Brief Discussion of Speed Increaseers

*When a speed reducer may be used as a speed increaser, when it cannot, and why.*



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*When a speed reducer may be used as a speed increaser, when it cannot, and why.*

*Not all speed reducers can be used as increasers. The best candidates for use as a speed increaser are spur and helical gears.*

*Torque kills speed reducers, speed kills speed increasers.*

*Bearing life is directly impacted by speed and reducing load can have an offsetting effect on bearing life.*

### **Purpose:**

To explain when a speed reducer may be used as a speed increaser and when it cannot, and why.

### **Discussion:**

Speed reducers are widely available in a multitude of ratios and power ratings; can they be used as speed increasers in addition to being used as speed reducers? The answer is, sometimes under some limited conditions.

Some types of reducers cannot be used as increasers. Many worm gear reducers and some cycloidal designs will not back drive as an increaser. In the more common case of the worm reducer, if the lead angle of the worm is less than  $10^\circ$  the gear set is self locking. In this case the frictional forces in the gear mesh cannot be overcome by a torque applied to the worm wheel [1].

Spur and helical gear reducers are the best candidates for use as a speed increaser. Generally, a helical or spur gear speed reducer may be used as a speed increaser within the same speed and power range for which it is rated as a speed reducer. For example, a 4:1 ratio, helical gear speed reducer rated at 5 HP, 1750 RPM input can be used as a 1:4 ratio, helical gear speed increaser rated at 5 HP, 438 RPM input. In this case the resulting gear and bearing loads and shaft speeds are the same in both applications. This case is often not very helpful.

Why can't the 5HP reducer be used as a 20HP, 1750 RPM increaser? The torque loading across the unit is the same as the reducer, 720.3 lbf-in on the low speed shaft and 180 lbf-in on the high speed shaft. Torque kills speed reducers, speed kills speed increasers. At 1750 RPM input, the output speed is 7000 RPM. The higher speed operates the gears, bearings, lubrication and seals beyond their design range.

Gear tooth loading is affected by speed, the higher pitch line speeds in the speed increaser will de-rate the gear capacity in a non-linear relation to shaft speed, the unit has less load capacity. Even at reduced load (5HP, 1750 RPM input) depending upon the accuracy of the gearing, the dynamic load effect may be nearly equal to the load reduction effect [2].



*Speed has a dramatic effect on lubrication. Grease lubricated gears have a lower capacity and life than oil lubricated gears.*

*The life of the oil reduces as the shaft speed increases. The heat generated by the rubbing action of the lip seal on the shaft is directly related to shaft speed. Load has no effect on seal loss, only speed.*

Bearing life is directly impacted by speed. A ball bearing operating within its speed limit will have its life reduced by a factor equal to the ratio of the speeds [3]. If the bearing is operating beyond its speed limit, the life reduction can be significantly greater. The output shaft speed of 7000 RPM will likely take the bearings beyond their speed limit. Reducing load can have an offsetting effect on bearing life [3].

Lubrication is dramatically impacted by speed. High speeds can result in churning losses in oil lubricated gear boxes, where the oil type and fill level have been determined based upon the requirements of a low speed gear reducer. The churning losses may exceed the capability of the unit to dissipate the heat leading to reduced gear and bearing life and possible thermal runaway. Oil temperature is related to oil viscosity, the key factor in the lubricating ability of the oil. Higher oil temperature means lower viscosity thus reduced gear and bearing load capacity. Grease lubricated gears and bearings have more limited load and speed capability, thus lower capacity and life than oil lubricated components. Churning losses are not affected by load reduction, they are speed driven. The gear reducer has a limited ability to dissipate these additional thermal loads.

Lip type oil seals are rated based upon shaft surface speeds. For any given oil seal installation, as the shaft surface speed increases the life of the oil seal is reduced. A four to one increase in shaft surface speed is significant, leading to a significant reduction in seal life. In addition, the heat generated by the rubbing action of the lip seal on the shaft is directly related to shaft speed [4]. An increase in shaft speed creates a corresponding increase in seal loss which adds to the heating of the lubricating oil, adding to the thermal degradation noted above. The seal losses are speed related and not affected by load.

In summary, helical and spur gear reducers generally may be used as speed increaseers within the operating range for which they were designed as a reducer. Operating a gear reducer at higher speeds as a speed increaseer will lead to significantly reduced load capacity and life, even at significantly reduced loads. Catastrophic failure due to thermal runaway is possible since lubricant churning losses and seal losses are speed dependent and not reduced with load. The gear reducer has a limited ability to dissipate these increased thermal loads.



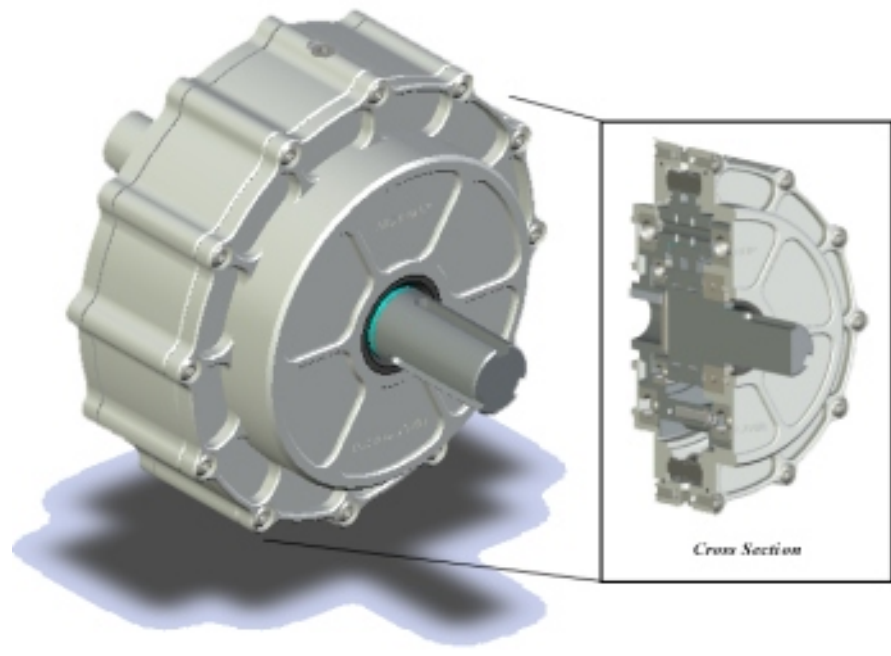
### ***References***

[1] Machine Design, Theory and Practice, Deutschman, Michels, Wilson. MacMillan Publishing Company, 1975, page 631.

[2] Ibid, pages 554-556.

[3] Barden Precision Ball Bearings, Catalog C-20, Rev. 10/96, page 107.

[4] Fluid Sealing Technology, Muller, Nau, CRC Press 1998, pages 84-85.



**Cross Section**