Comparison Between *oms* Hypodrive Gear Units AZHP & EC 2-25Lift and Worm Gears Of The Same Output Power Rating

The *oms* Hypodrive gear units are two stage gear units with a bevel gear input stage and spur gear second (output) stage. The input stage is a highly optimized hypoid bevel gear stage of the GLEASON® type in ground quality. The output stage is an optimized helical spur gear stage, also in ground quality.
The manufacturing technology of the gear toothings are in accordance with the quality requirements of the automobile industry.
The outer dimensions of the gear units and the layout of the motor and the braking unit is similar to those used with standard worm gear units for escalator traction machines.

Picture 1: AZHP 2

Picture 2: EC 2-25 Lift without traction sheave

A comparison between worm gear and *oms*Hypodrive type of gear units will be made for elevator applications in apartment houses and for heavy duty applications in public areas and for freight elevators, comparing the following characteristics, based on the same output power and momentum.

Volume of Gear Unit:
The volume of the *oms*Hypodrive gear unit is more than 30% smaller than a comparable worm gear or worm-helical unit.

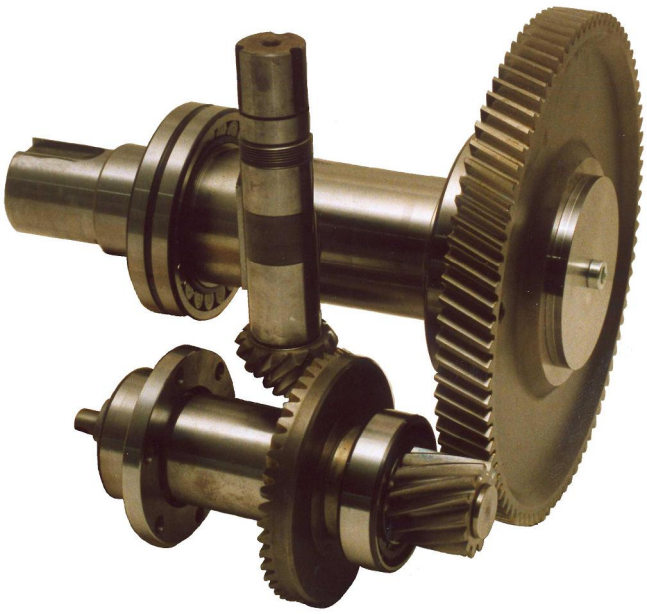
Efficiency:
The efficiency of the *oms*Hypodrive gear unit (96 – 97%) is approx. 10% higher than that of a comparable good worm gear unit (84 – 87%) at rated load. That means losses of 3 – 4 % for a *oms*Hypodrive gear unit, versus 13 – 16% for a worm gear unit. At loads smaller than the rated load, the *oms*Hypodrive gear units performs even better compared to a worm gear unit.

Sound Emission:
The sound power level of the *oms*Hypodrive gear units are well below the allowed sound levels as required by the major manufacturers of elevators and is comparable to well designed worm gear units. This feature is due to the optimized manufacturing technology using the most advanced GLEASON® grinding and measuring technology.

Performance:
The *oms*Hypodrive gear units can be used continuously at their maximum output power level for indefinite time, without overheating the gear units. A worm gear unit with comparable reduction ratio may not be used continuously at it's maximum power level for more than about one hour without an additional external oil cooler or a blower cooling the gear unit, due to its high thermal losses. Also, for continuous use, a worm gear has reduced output power and momentum above $T_{AMBIENT}$ > 30°C, so substantial reduction in capability for realistic operating temperatures in the elevators traction machines environment has to be taken into consideration.

Wear of Toothing:
The gear toothings of the *oms*Hypodrive gears are calculated for indefinite lifetime and are safe against tooth cracking as required by the safety margins claimed by the EN-81-1:2010 standard. The hardened and ground teeth flanks show a surface smoothing after initial putting into operation, without any abrasion.
For comparison, be reminded that worm gear and worm-helical gear units can only be designed and build with a finite lifetime due to the abrasion of the bronze worm wheel, which is load dependent.

Picture 3:AZHP 3



Picture 4: *oms* Hypodrive Input and Output Stage (Patents pending)

Oil Volumes, Oil Temperatures and Oil Changing Intervals:

The *oms*Hypodrive gear units use substantially less oil than a comparable worm gear unit. Nevertheless the operating temperatures of the *oms*Hypodrive gear units will be approx. 30K to 35K lower than for a comparable worm gear unit, with the shelf live of the oil in an *oms*Hypodrive gear unit approaching many times that of a worm gear unit. Due to the much lower heat generated from a *oms*Hypodrive gear unit, the thermal stress for the surrounding materials, electronic equipment, controllers etc. is much less when using an *oms*Hypodrive gear unit as compared to using a worm gear unit. This translates into much longer service intervals for the surrounding equipment, too. For the *oms*Hypodrive gear unit itself, this translates into lifetime lubrication (35.000h).

For data on the oil consumption over lifetime for both commercial and public applications, the cost impact of the oil usage in terms of the amount of oil needed, and the number of oil service operations required, a detailed comparison of oil service related cost is given in the appendix.

Economical Aspects

General Maintenance:
The maintenance aspect is another cost benefit for the hypoid technology, although it is difficult to quantify according to specific regional conditions. Therefore, the calculation of the cost advantage of the *oms*Hypodrive traction machines compared to worm gear based machines will focus only on: energy efficiency, lower oil consumption and the associated cost of oil exchange.

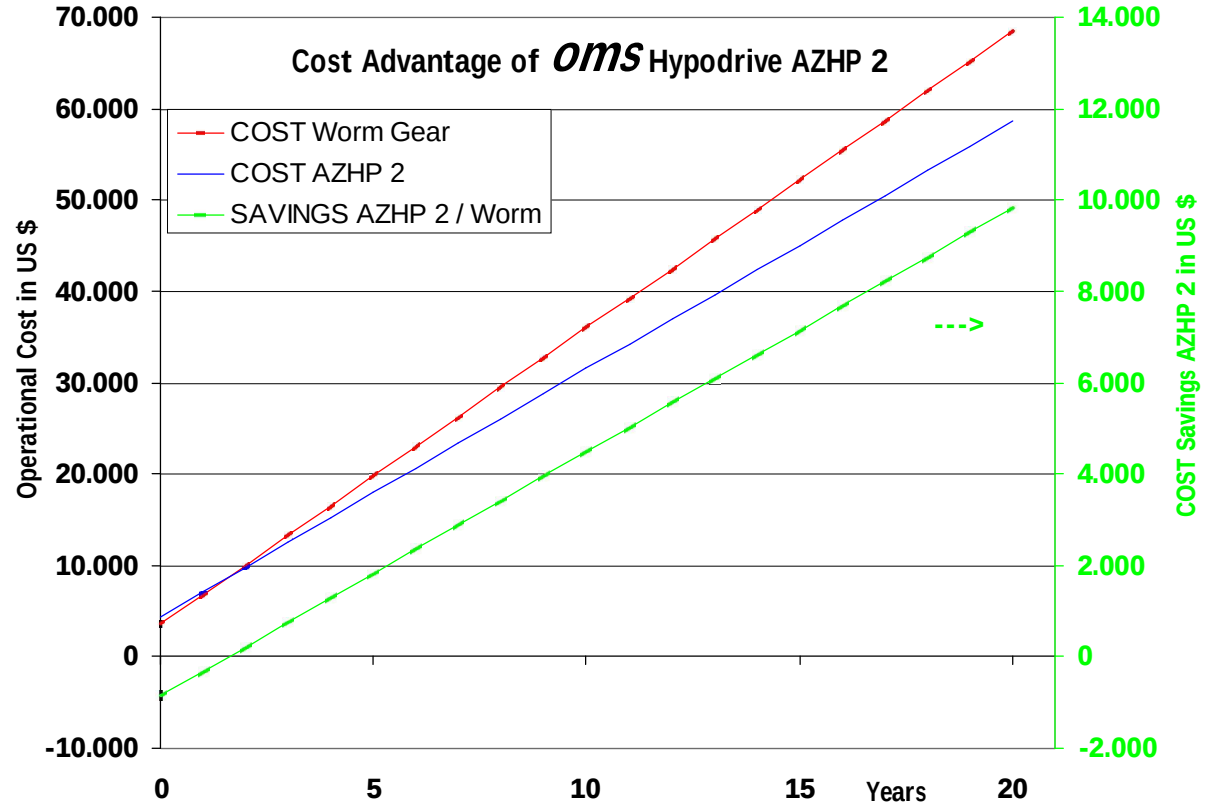
The *oms*Hypodrive unit needs a check of the oil via the oil level gauge initially after 5.000 and then after each additional 5.000 hours time of operating time. This is many times the oil exchange interval for a *complete oil change for worm gears* (6,000h).

A worm gear and a worm-helical gear usually has to be replaced after approximately 25.000 h of operation due to the wear of the worm wheel. Due to the wear resistant toothing technology used in the *oms*Hypodrive gears, the lifetime of the *oms*Hypodrive as compared to worm gears is limited by the finite lifetime of the bearings only. This means that an *oms*Hypodrive gear unit may be refurbished by just replacing the bearings and a new oil fill for another 25.000 hours of operation.

Break Even Point:
The comparison between the *oms*Hypodrive and worm gear drive shows that the efficiency of the hypoid technology is significantly influencing the break even point of the investment for the escalator traction machine, due to its much lower energy usage.

Also a major influencing factor is the oil consumption of the gear box and the associated cost for the oil service. In this respect the *oms*Hypodrive machines deliver an outstanding performance, which is not met by any other currently available technology suited for elevator traction machines of the same performance.

As shown in the following diagrams, all this adds up to shorten the break even point in favour of the *oms*Hypodrive machines. The moderately higher price of the *oms*Hypodrive technology has only a negligible effect on the total operational cost over the lifetime of the machine.


Cost Advantage of oms Hypodrive AZHP 2
COST Worm Gear
COST AZHP 2
SAVINGS AZHP 2 / Worm
--->
Operational Cost in US $
COST Savings AZHP 2 in US $
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
-10.000
14.000
12.000
10.000
8.000
6.000
4.000
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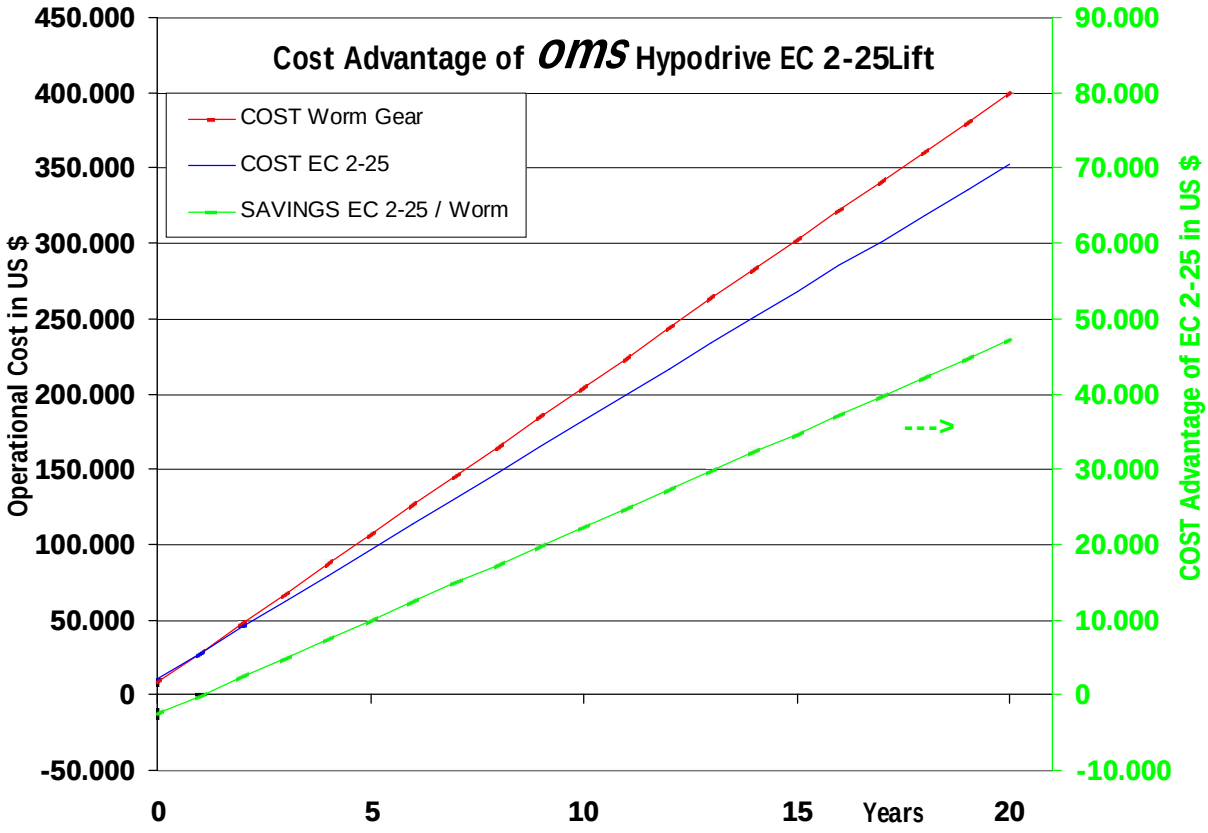
0
-2.000
0
5
10
15
Years
20


Cost Advantage of oms Hypodrive EC 2-25Lift
COST Worm Gear
COST EC 2-25
SAVINGS EC 2-25 / Worm
--->
Operational Cost in US $
COST Advantage of EC 2-25 in US $
450.000
400.000
350.000
300.000
250.000
200.000
150.000
100.000
50.000
0
-50.000
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0
-10.000
0
5
10
15
Years
20

Remarks: The Difference in the investment of the *oms*Hypodrive and Worm Gear Drive appears to be negligible in view of the difference in operational cost. The higher energy and maintenance cost of a worm gear drive as compared to the *oms*Hypodrive are determining the slopes of the ascending cost graphs. This accumulated difference over lifetime is not only much larger than the cost difference of the two gear types, it is also much larger than the *initial purchasing cost* of either elevator traction machine!

Examples given are for an elevator for apartment house applications, with *oms*HypodriveAZHP 2, and for shopping centre or freight elevator applications with *oms*Hypodrive EC 2-25Lift. Both diagrams are based on current unit cost and energy cost as of September 2011.

Conclusion

Due to its much better efficiency, its highly optimized gear toothing and its low thermal output, the *oms*Hypodrive gear units achieve a much higher level of usability as compared to a worm gear unit. The *oms*Hypodrive gear units will pay itself off within a very short time of operation.

The cost savings due to the higher efficiency of the *oms*Hypodrive and the lower total cost of service adds up to more than many times the purchasing cost of these elevator traction machines. Savings for the AZHP 2 amounts to about US $ 11,000 as compared to a worm gear drive, and for the EC 2-25Lift to about US $ 50,000 as compared to a worm gear drive over the lifetime of 20 years. The respective differences in the initial purchasing cost of the two machine types is already reflected in both diagrams.

In our resource hungry world, with continuing price increases for materials and resources, and most recently very dramatic increases in energy costs, this shows very clearly the advantages of using a *oms*Hypodrive gear units as the traction machine in elevators.

Of course the cost savings potential will scale with the power of the elevator traction machines. Now one can easily figure out what this will mean in terms of cost savings for a metro or railway station, airport or any other building with a multitude of elevators, or what huge operational cost benefits may be expected when extending an already existing metro or railway line.

The *oms*Hypodrive machines are environmental friendly elevator traction machines, regarding their minimized usage of resources like energy and lubricants.

Appendix

The comparison of the *oms*Hypodrive and worm gear drives is based on the following assumptions for the application, respectively: elevator load is **95%** of nominal load (nominal load: max. cabin load = 100% load for constant velocity); power input to gear is corrected for by the gear efficiency O; both type of machines use the same type of synthetic gear oil. For the comparison of service cost for *oms*Hypodrive and Worm Gear Drive the cost savings potential due to the reduced handling and depositing cost for the waste oil has not been included.

Elevator for Apartment House Applications AZHP 2 (1:1 suspension 630kg, P = 7,5kW)

Average running time of elevator / day	5 h
Average running time of elevator / year	365 days
Average electricity rate in US $/KWh	0.20

	*oms*Hypodrive	Worm Gear Drive
Gear oil volume:	3.5l	15 – 17l
Gear efficiency: O	96%	85%
Gear output power to escalator at 95% load: $P_{OUT,\ 95\%}$	7,13 kW	7.13kW
Gear input power to escalator at 95% load: $P_{OUT,\ 95\%}$ / O	7,42 KW	8,38 KW
Average energy consumption / day: W_{DAY}	37,1 KWh	41,9 KWh
Average energy consumption / year: W_{YEAR}	13.540 KWh	15.300 KWh
Energy cost / year	US $ 2.710.-	US $ 3.060.-
Savings of electricity / year compared to		**US $ 352.-**
Savings of electricity / lifetime (20 a) compared to		**US $ 7.040.-**
First oil exchange	none	1.000h
Oil shelf life	35.000h	6.000h
Gear oil volume	3.2l	15l
Oil refill to end of lifetime (35.000h)	**0 l** (0 x 3.2l)	**195l** (7 x 15l)
Cost of oil for refills during lifetime (at US $ 15 / l)	**US $ 0.-** (0l x 15 $/l)	**US $ 1,575.-** (105l x 15$/l)
Cost of Service For refilling oil (at US $ 300 per service)	**US $ 0.-** (0 x US $ 300)	**US $ 2,100.-** (7 x US $ 300)

***oms*Hypodrive** cost savings: lower oil usage US $ 1.575.- and lower service cost: US $ 2.100.-

Total Savings in Oil-Service / lifetime (20 a) compared to **US $ 3.675.-**

Total cost advantage in favour of *oms*Hypodrive AZHP 2 US $ 10,715.-

Elevator for Heavy Duty Applications (shopping centres, freight elevators, 1:1 to 1:4 suspension, P = 36kW)

Average running time of elevtor / day	8 h
Average running time of elevator / year	300 days
Average electricity rate in US $/KWh	0.20

	*oms*Hypodrive	Worm Gear Drive
Gear Oil Volume	13l	25l
Gear efficiency: O	96%	85%
Gear output power to escalator at 95% load: $P_{OUT, 95\%}$	34,2 kW	34,2 kW
Gear input power to escalator at 95% load: $P_{OUT, 95\%}$ / O	35,6 kW	40,2 kW
Average energy consumption / day: W_{DAY}	285,0 kWh	321,9 kWh
Average energy consumption / year: W_{YEAR}	85,500 KWh	96.565 KWh
Energy cost / year	US $ 17,100.-	US $ 19,313.-
***oms*Hypodrive Savings of electricity / year compared to**		**US $ 2.213.-**
Savings of electricity / lifetime (20 a) compared to		**US $ 44.259.-**
First oil exchange	none	1,000h
Oil shelf life	35,000h	6,000h
Gear oil volume	13l	25l
Oil refill to end of lifetime (35.000h)	**0 l** (0 x 13l)	**600l** (7 x 25l)
Cost of oil for refills during lifetime (at US $ 15 / l)	**US $ 0.-** (0l x 15 $/l)	**US $ 2.625.-** (175l x 15$/l)
Cost of Service For refilling oil (at US $ 400 per service)	**US $ 0.-** (0 x US $ 400)	**US $ 2.800.-** (7 x US $ 400)
***oms*Hypodrive** :		
cost savings lower oil usage		**US $ 2.625.-**
cost savings lower service cost:		**US $ 2.800.-**
Total Savings in Oil-Service / lifetime (20 a)		**US $ 5.425.-**

Total cost advantage in favour of *oms*Hypodrive EC 2-25Lift **US $ 49.684.-**