Energy Conservation Strategy for Thermal Power Plants by using Voith Variable Speed Drives

Strategija za uštedu energije u termoelektranama koristeći Voith hidrodinamičku spojnicu sa promenljivim punjenjem

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VARIABLE SPEED DRIVES

AREA MANAGER SERVICE

Abstract: Technology advances. Plants which originally were efficient may today be uneconomic. Voith Turbo has experience for decades in hydrodynamic power transmission and offer full engineering from one source: advice, design, commissioning and world-wide after-sales-service.
In practice the requirements for which a unit was originally designed change within the course of time. When this occurs it can produce technical problems which are so complex that the only reasonable solution is the retrofit of the unit. Voith analyses the problem, weather it is a thermal overload or unforeseen vibrations or control difficulties. Then on the basis of this analysis, Voith works out remedial proposals.
Analysis, diagnosis and improvement measures, such as speed adaptation by exchanging gear stages under observation of the laws of hydrodynamics, increase the economy of the existing plant.

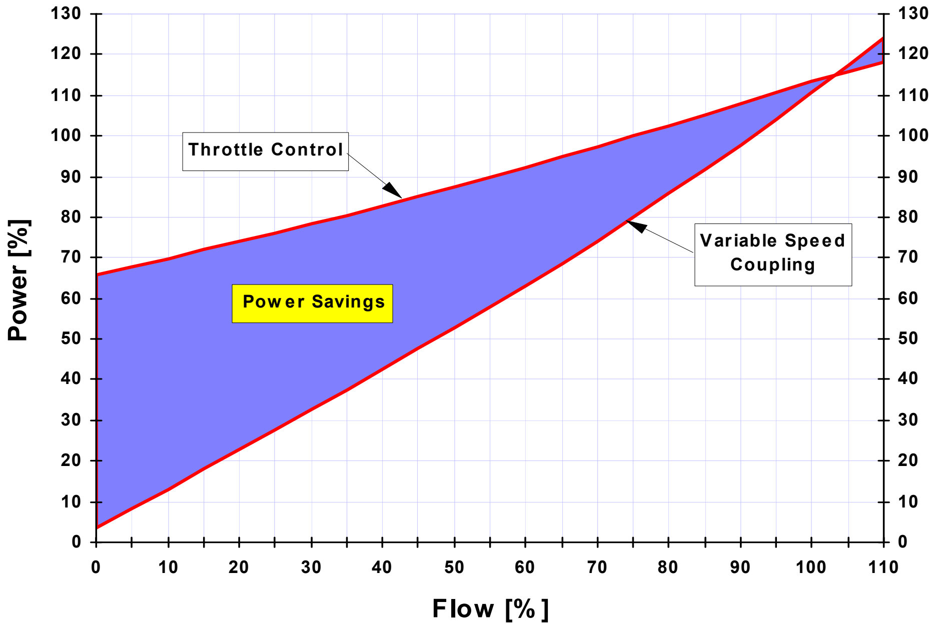
Key words: Economical Consideration, Energy Saving by Speed Optimization, Potential Applications for Variable Speed Couplings, Hydrodynamic power transmission, Power Plants.

Apstract: Usled tehnološkog razvoja elektrane koje su u vreme projektovanja imale zadovoljavajuću efikasnost danas mogu biti neekonomične. Voith Turbo ima dugogodišnje iskustvo kada su u pitanju hidrodinamički prenosnici snage i s tim u vezi može ponuditi sve, od savetovanja, projektovanja, nadzora pri puštanju u rad i u svetu razgranatu servisnu mrežu. U praksi se zahtevi za rad mašine, prvobitno projektiovane za odredjene uslove rada, menjaju tokom vremena. U slučaju kada se ovo desi jedino rešenje je retrofit/optimizacija mašine jer u protivnom dolazi do raznih tehničkih problema. Voith analizira problematiku, da li su u pitanju termičko preopterećenje, nepredvidjene vibracije ili problem upravljanja mašinom. Na bazi rezultata dobijenih analizom, Voith daje predlog za rešenje novonastale situacije. Analiza, dijagnoza i mere za poboljšanje, kao što je adaptacija broja obrtaja promenom reduktorskog stepena a vodeći računa o zakonima hidrodinamike, dovode do povećanja efikasnosti postojeće elektrane.

Ključne reči: Ekonomski aspekti, ušteda energije adaptacijom broja obrtaja, upotreba spojnica sa promenjljivim punjenjem, hidrodinamički prenos snage, elektrane.

1. ECONOMICAL CONSIDERATIONS

The use of variable speed couplings can dramatically reduce auxiliary energy consumption in a power plant. This is even more valid if the plant goes into cycling during the day and / or weekend.

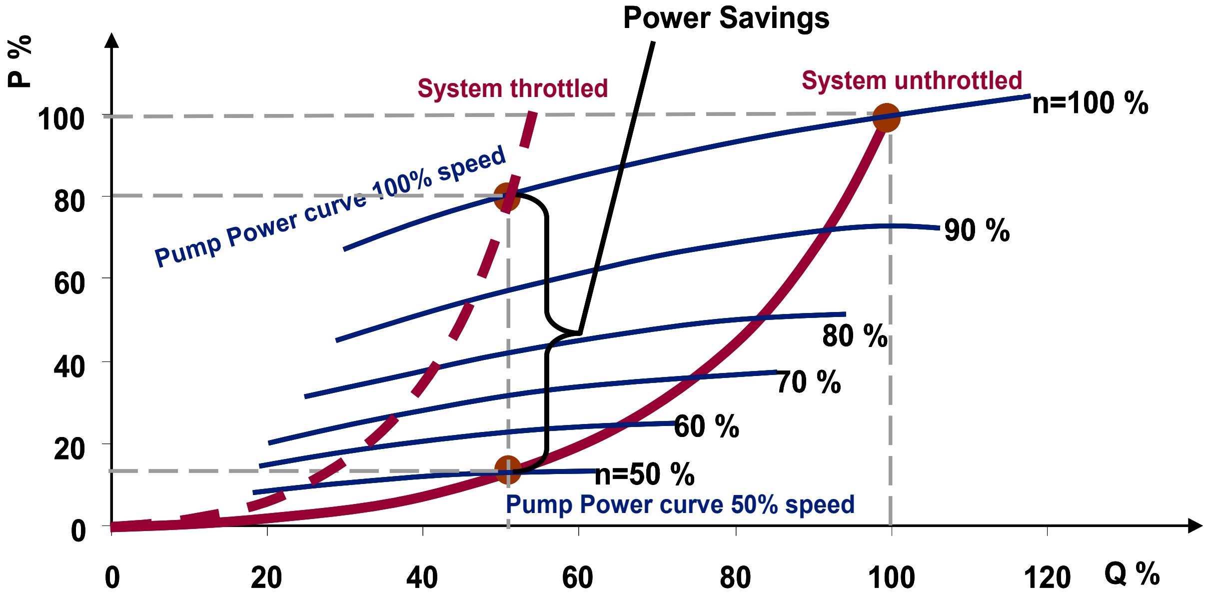


2. TYPE OF POWER PLANTS AND POTENTIAL APPLICATIONS FOR VARIABLE SPEED COUPLINGS

2.1 Steam Turbine Power Plants (Please refer to Attachment 1)

- Boiler Feed Pump

The boiler feed pumps have by far the biggest energy saving potential in a power plant. They consume the major part of a plant's auxiliary energy.



The diagram shows that with throttle regulation, the throttle valve has to raise the boiler resistance curve even during full load operation. Each flow rate reduction required can only be achieved by artificially further raising the boiler resistance curve. The delivery throttling therefore decreases the unit's efficiency since the power throttled off cannot be recovered. With speed regulation of the pump only a relatively small speed change is required to cover the whole boiler load, and the pump efficiency does not change very much. Furthermore when the delivery rate drops the speed and pump loading also drop, this means extended pump life due to reduced wear.

- Boiler Fan

Depending on the plant layout there may be ID Fans (Induced Draft), FD Fans (Forced Draft) PA Fans (Primary Air) or GR Fans (Gas Recirculation) involved. While inlet guide vane is suitable for base-load power plants, speed variation is first choice when part-load operation is required.

- Cooling Water Pump

Depending on the season the temperature of the cooling water changes and thus the cooling capacity. In order to adapt the water flow variable speed couplings are being used to increase the water flow in summer and to reduce it in winter.

- Condensate Pump

The amount of condensate changes similarly to the feed water flow.

- Coal Mill

Different coal quality leads to high power losses in case of direct drives in order to achieve the power requirements. Geared Variable Speed Turbo Couplings improve the controllability and the economy of the coal mill.

2.2 Combined Cycle Power Plants (Please refer to Attachment 2)

- High-Pressure Boiler Feed Pump

Modern combined cycle power plants have steam capacities of 200 - 300 MW and thus the savings are comparable to steam turbine power plants.

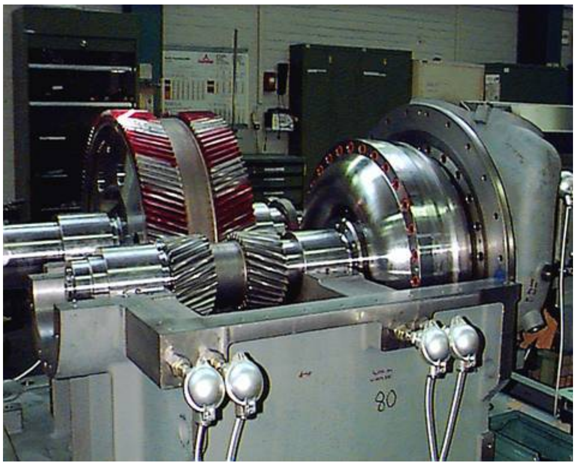
3. TYPE OF PROJECTS

3.1 New Power Plants

The easiest way to reduce the auxiliary energy consumption of a power plant is to specify from the very beginning (project stage) the drives for the various pumps and fans. It is very important to specify heat rate / fuel consumption not only for base-load conditions but also for part-load conditions. Deviations in energy consumption from the bidders can then be easily compared and evaluated. Unfortunately, many projects overemphasize on capital expenditure and forget about Maintenance and Operation Cost. The best approach is actually to carry out a life-cycle cost analysis based on 25 years operation.
An assessment of the different drives will show the energy saving potential.

3.2 Speed Optimization Projects (Existing Steam Turbine Power Plant)

(Please refer to Attachment 2)

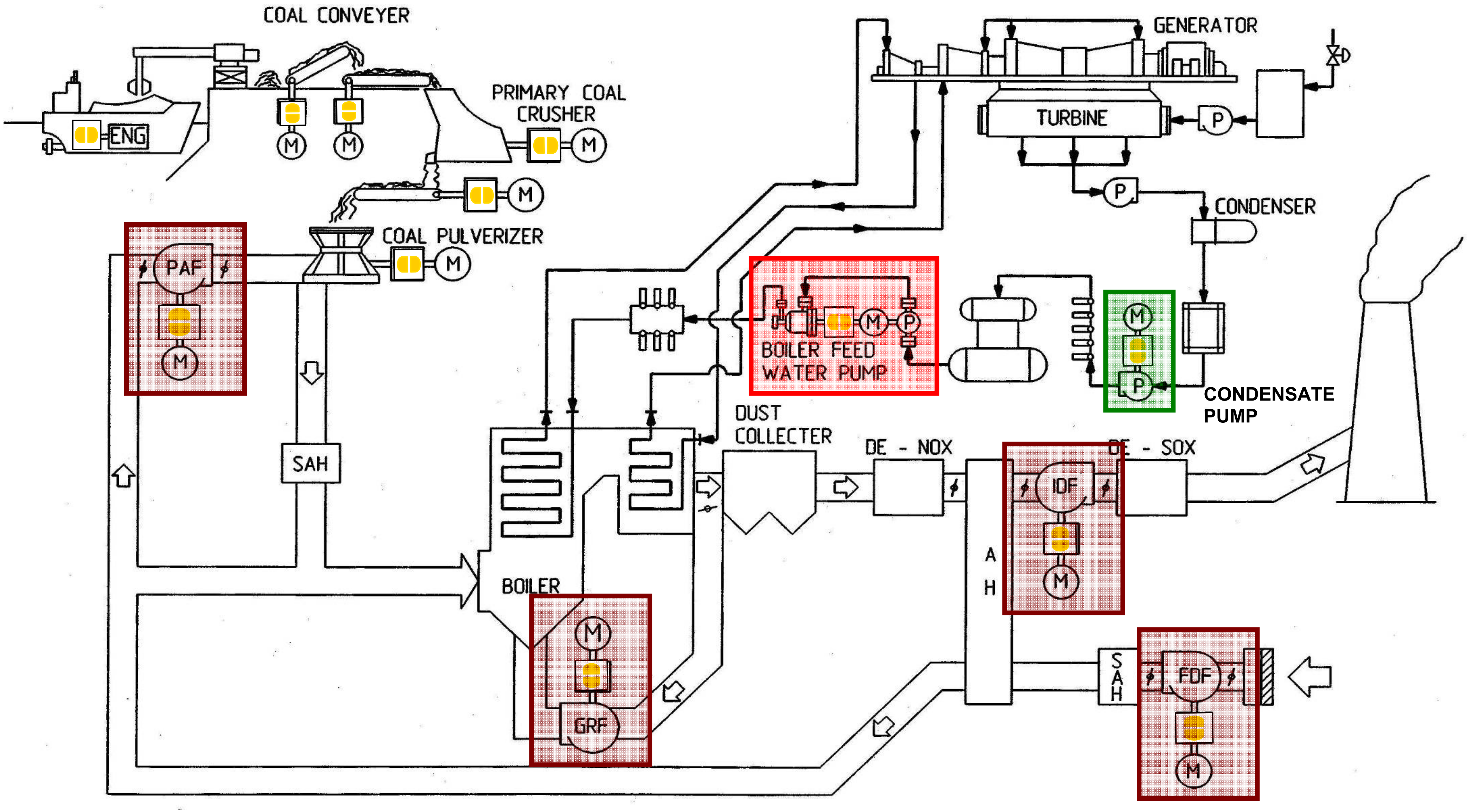


This applies only to Geared Variable Speed Couplings operating a driver with a parabolic torque characteristic. Typically, they are installed at the Boiler Feed Pumps in a Steam Turbine Power Plant. Because of design margins and contract guarantees often the actual speed of the boiler feed pumps is much lesser than the maximum possible speed. In this case the change of the step-up gear will result in reduced energy consumption. An easy pre-estimation for potential energy saving by a gear optimization can be carried out with a calculation program on site. Data which must be known are the original layout of the pump, the coupling type and size and the maximum pump speed ever needed.

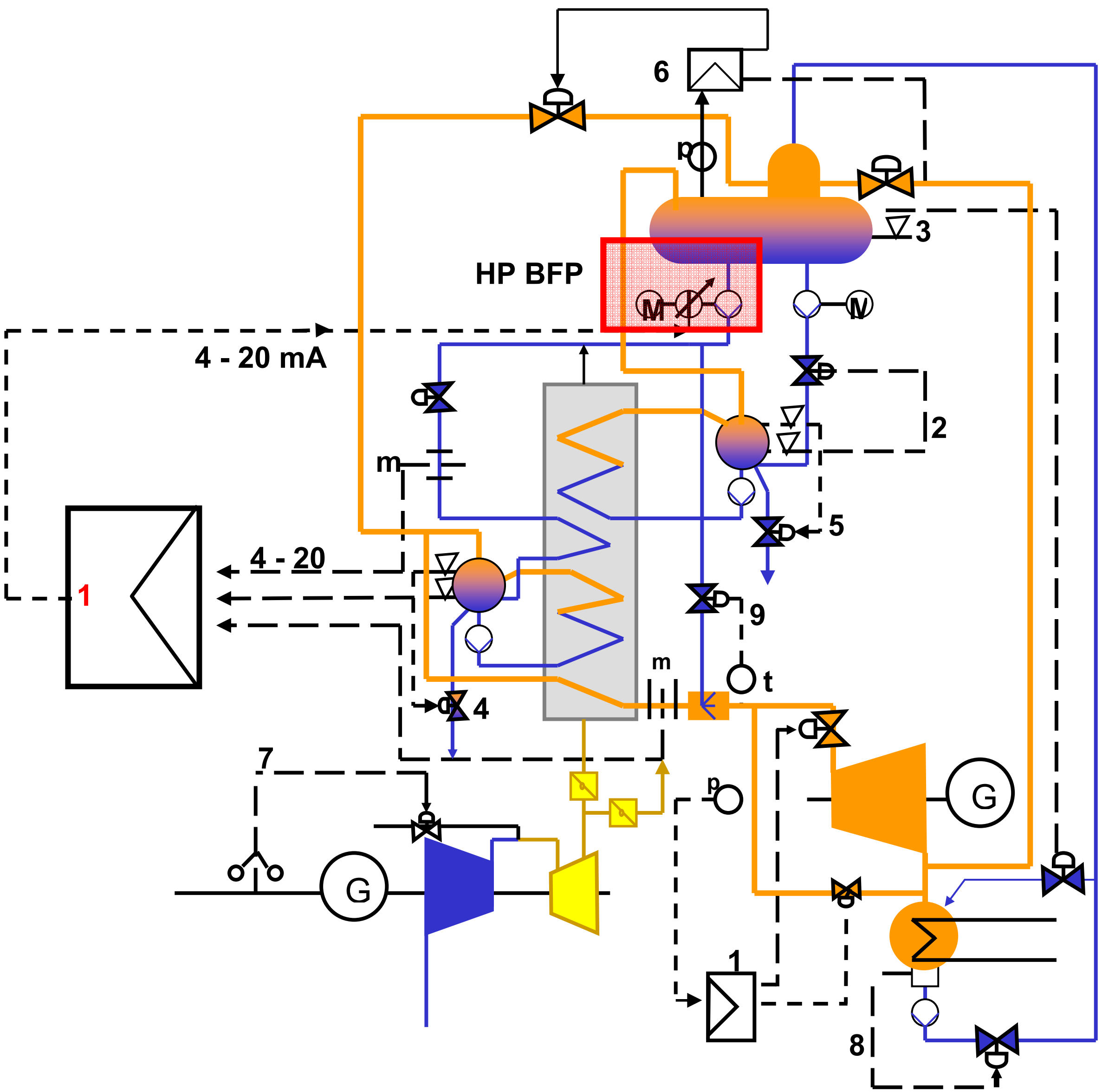
3.3 Retrofit Projects (Existing Power Plants)

All fixed-speed (direct) drives have some energy-saving potential. An individual assessment will show the possible savings and amortization times. Boiler Feed Pumps have in general the highest savings / cost ratio.

Attachment 1: *Fluid Couplings in a Steam Turbine Power Plant*



Attachment 2: *Fluid Couplings in a Combined Cycle Power Plant*



Closed loop control circuits for the combined cycle power plant with single pressure steam turbine

1 = HP drum level control (Three point control)
2 = LP drum level control (single point control)
3 = Level control of the feedwater tank
4* = HP drum level control with emergency bleeding
5* = LP drum level control with emergency bleeding
6 = Pressure control for the feedwater tank
7 = Frequency control
8 = Hotwell level control
9 = Live-steam
10 = Bypass and steam turbine pilot pressure control
p = Pressure measurement
t = Temperatue measurement
m = Flow rate measurement
▽ = Level measurement

Can also be designed with valves, depending on the size of the drums.

HP = High-Pressure
LP = Low Pressure

Attachment 3: *Optimization Calculation Program*

Fill in necessary datas

Layout datas

Profile Diameter Dp	510	mm
Ppump	7600	kW
npump	6500	1/min
either nmotor		1/min
Z1		
Z2		
or n1	6667	1/min

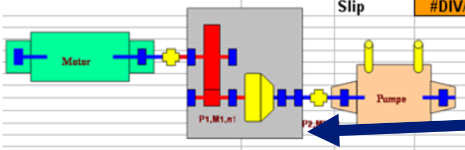
Actual maximum operation

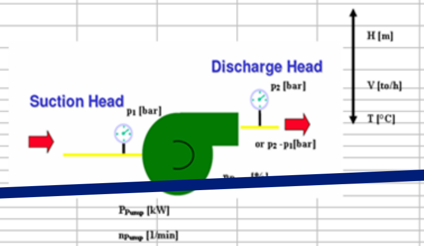
max. pump speed	5700	1/min

Boiler Feed Pump Drives — **Layout datas**

Input	Profile Diameter Dp	mm
Output	Ppump	kW
	npump	1/min
	either nmotor	1/min
	Z1	
	Z2	
	or n1	1/min
	Slip	#DIV/0! %

Codeword
Type
Serial No.





Exponent	2	parabolic	RK	14	15	16	17	18	19
P2max	#DIV/0!	kW	Dp	384	422	464	510	562	620

Actual maximum operation

max. pump speed		1/min							
nmot	0	0	0	0	0	0	0	0	1/min
Z2	0	0	0	0	0	0	0	0	
Z1	0	0	0	0	0	0	0	0	
n1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1/min
output speed %	40	50	60	70	80	#DIV/0!	100		1/min
n2	0	0	0	0	0	0	0	#DIV/0!	1/min
n2/n1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
s %	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	
P1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	kW
Pvs	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	kW
P2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0	#DIV/0!	kW

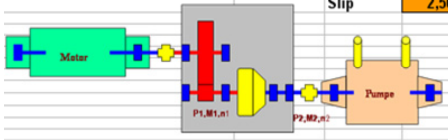
This form is used for the input of the layout data and the new maximum operating point (power-speed) which is defined by the max. output speed ever needed at 100 % scoop tube position.. This analysis can be carried out during an on site visit to get a easy pre-estimation for potential energy saving by a gear optimization.

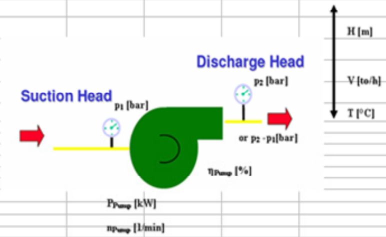
Read Power Savings (slip)

The improved condition with the optimized gear shows the possible power savings in KW per hour for a range of output speeds. This results in lower motor power consumption and represents the final operating savings.

Boiler Feed Pump Drives **Layout datas**

Input		Ppump	7600	kW
Output		npump	6500	1/min
	either	nmotor		1/min
		Z1		
		Z2		
	or	n1	6667	1/min
		Slip	2,50	%





Exponent	2	parabolic
P2max	8201	kW

Actual maximum operation

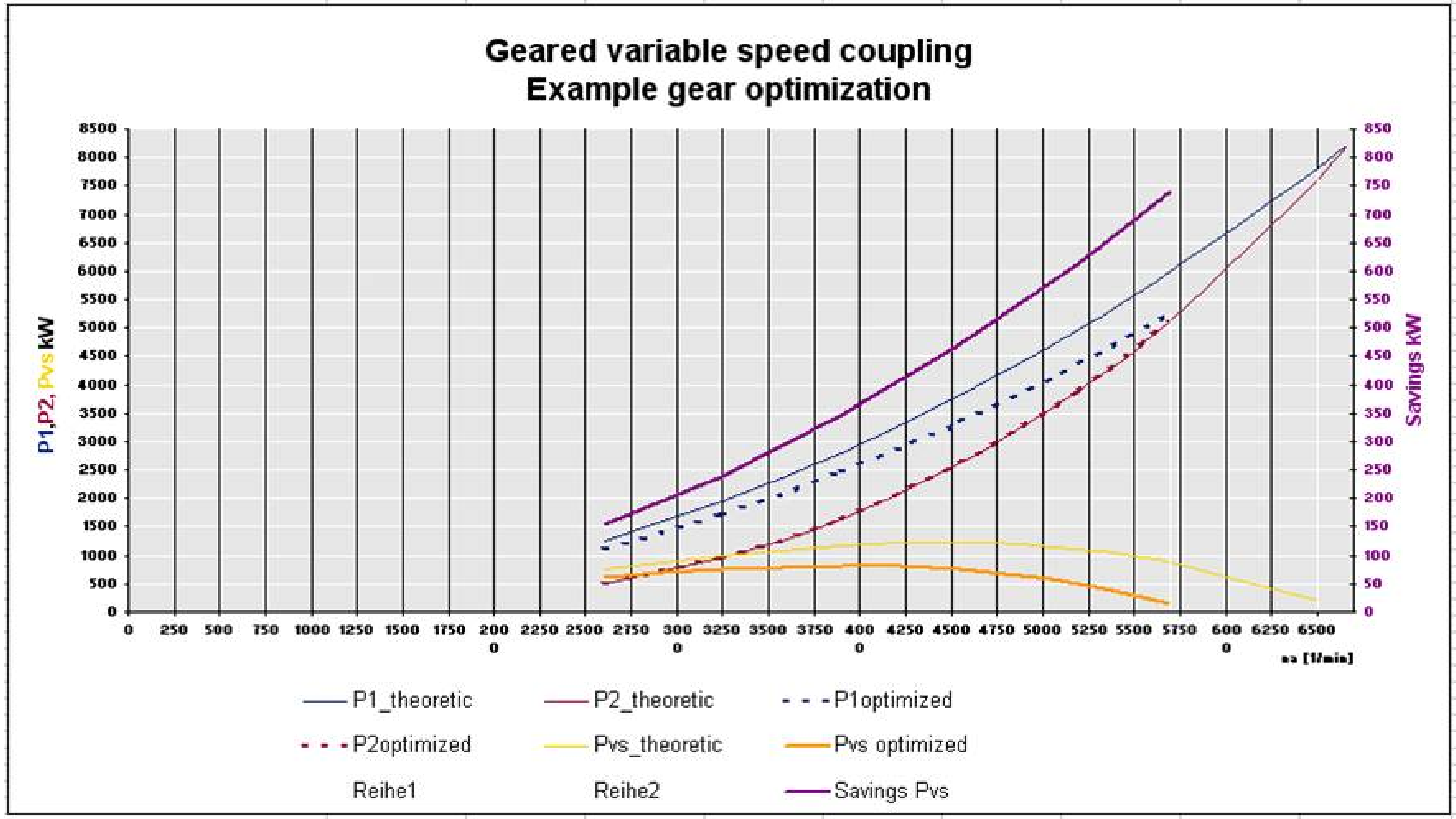
max. pump speed	5700	1/min							
nmot	0	0	0	0	0	0	0	0	1/min
Z2	0	0	0	0	0	0	0	0	
Z1	0	0	0	0	0	0	0	0	
n1	6667	6667	6667	6667	6667	6667	6667	6667	1/min
output speed %	40	50	60	70	80				1/min
n2	2600	3250	3900	4550	5200	5700	6500	6667	1/min
n2/n1	0,39	0,49	0,58	0,68	0,78	0,85	0,97	1,00	
s %	61,00	51,25	41,50	31,75	22,00	14,50	2,50	0,00	
P1	1247	1949	2806	3820	4989	5995	7795	8201	kW
Pvs	761	999	1165	1213	1098	869	195	0	kW
P2	486	950	1642	2607	3891	5125	7600	8201	kW

6500	0
6500	7795

5700	0
5700	5256

Optimized Gear

Minimum slip (estimated) %	2,5								
nmot	0	0	0	0	0	0			1/min
n1	5846	5846	5846	5846	5846	5846			1/min
n2	2600	3250	3900	4550	5200	5700			1/min
n2/n1	0,44	0,56	0,67	0,78	0,89	0,98			
s %	55,53	44,41	33,29	22,17	11,05	2,50			
P1	1094	1709	2461	3349	4375	5256			kW
Pvs	607	759	819	743	484	131			kW
P2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			kW
Pvs Savings	154	240	346	470	614	738			kW



This diagram summarizes the layout data and the new operating point and shows the Pvs curves. The difference of this curves are shown as the power savings over the speed range. Taking into consideration that boiler feed pumps are operating approx. 8000 hours / year the investment will pay back after a short operating time.