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"ENERGY SAVING THROUGH SPEED ADAPTATION BY USING OPTIMISED GEAR STAGE IN VARIABLE SPEED HYDRO COUPLINGS"

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Abstract— *This paper deals with the energy saving through speed adaptation by using optimized gear stage in variable speed hydro coupling. Boiler feed pump is considered as the heart of boiler whole water required for boiler is being provided by it. Boiler feed pump is used in boiler feed water system to increase the water pressure ,high enough so that it can be pumped to boiler. BFP is single out as the major auxiliary power consumer in a power plant consuming around 25% of the total auxiliary power consumed by the utility. Reduction in gear ratio leads to speed optimization hence auxiliary power consumption reduced to 34% . In case of abnormal lowering of grid frequency, the modified pump will not be able to cater full load demand and this situation demands of running of the standby pump. New modified gear set can be reverted back to original set with minimum downtime.*

Keywords*—Boiler, APC, Gear ratio, Frequency.*

1. INTRODUCTION

In a thermal power plant, the BFP is one of the critical auxiliary machines that are equivalent to the heart of the plant. In thermal power generation, high-pres- sure steam is used to drive a turbine, which in turn rotates the generator directly connected to the turbine to generate power. The steam is produced by feeding hot water to the boiler from the BFP. This means that an unexpected stop of the BFP completely stops power generation and therefore the BFP requires a very high level of reliability. In recent years, with the popularization of renewable energy, thermal power generation re- quires load adjustment for a stable power generation system as well as operation under severe conditions such as rapid changes in load. The BFP is also required to provide even higher levels of capabilities and reliability because it must operate in more severe conditions such as partial load operation and increased frequency of start and stop actions. In a power plant approximately 8-9% of the power produced is consumed by the utility itself for running its auxiliary equipments.

Boiler Feed Pump is singled out as the major auxiliary power consumer in a power plant, consuming around 25% of the total auxiliary power consumed by the utility.

2. GEAR RATIO MODIFICATION

Following the mantra' **"**Energy saved is Energy produced**",** in this Paper an attempt is made to present the study report carried out on variable speed hydro couplings employed in Thermal Power Station, to minimize the energy loss through speed adaptation by adopting optimized gear stages in the existing hydro couplings of Boiler Feed Pumps. Though the drive mechanism of Boiler Feed Pumps in Thermal Station is of geared variable speed hydro coupling with a design slip of 1.8% , the actual operating conditions vary at site as the pumps are designed to operate at MCR conditions, where as in reality the operating speed of the pump is found to be lesser by over 10-12% which amount to considerable energy loss.

3. OPTIMISATION OF THE GEAR STAGE

The maximum speed requirement of Boiler Feed Pumps for continuous operation at full load is around 4950 rpm only against a design maximum output speed of 5440 rpm, which reveals that the present operating slip is around >10 % against the design slip of 1.8 % Energy saving in BFP drive by change of gear stage in Hydraulic couplings is one of the proven methods to reduce the APC%. Since the hydro coupling's primary speed is designed based on pump's design speed, this power loss can not be minimized unless the primary speed of hydro coupling is suitably optimized based on the actual operating conditions of the pump.

In order to reduce the primary speed of the hydro coupling, the existing gear ratio needs to be redesigned. So, A viable option is replacing the existing gear stages with an optimized gear stage.

Since, only the primary speed of the hydro coupling needs to be reduced in accordance with the maximum speed attained by the pump during normal operation, replacing the existing gear wheels with new ratio is expected to give the desired results. For the current study purpose, the speed of 4922 rpm attained by the pump for full load generation of 300 MW is considered.

To accommodate envisaged pump's operating restrictions & limitations, certain extra margin was added to this normal operating speed and the pump's design speed is considered as 5100 rpm.

4. COMPONENTS OF COUPLING

Hydraulic Fluid couplings works on the hydrodynamic principle.

It consists of a Primary wheel (pump wheel) and a secondary wheel (turbine wheel) both enclosed suitably in a casing. The primary wheel and the secondary wheel are bowl-shaped and have large number of radial vanes.

There is no mechanical interconnection between the primary wheel and the secondary wheel (i.e. the driving and driven units) and the power is transmitted by virtue of the fluid filled in the coupling. The impeller when rotated by the prime mover imparts velocity and energy to the fluid, which is converted into mechanical energy in the rotor thus rotating it.

Housing **:**
The mechanical gearbox and the coupling are jointly accommodated in a closed housing. The oil reservoir is flanged on the housing bottom.
Coupling :
Primary shaft and primary wheel,
Secondary shaft and secondary wheel,
Shell (flanged on primary wheel, enclosing the secondary wheel)
Scoop tube housing with scoop tube control.
The primary shaft is connected with the driving machine via the gearbox and the secondary shaft is connected with driven machine via coupling. Primary wheel, secondary wheel and shell form the working chamber
Power Transmission:
The Hydraulic coupling transmits power wear free from a driving machine to a driven machine.
Power is transmitted as follows:
Between driving machine and GEARED VARIABLE SPEED COUPLING through a connecting coupling.
Between input shaft and primary shaft through a step-up gear.
Between primary wheel and secondary wheel through the working oil.
Between GEARED VARIABLE SPEED COUPLING and driven machine through a connecting coupling.

5. PROCEDURAL STEPS FOLLOWED FOR OPTIMIZATION

Analysis of design parameters.

Analysis of last three years operational parmeters.

Optimisation with risk assessment :

In case of abnormal lowering of grid frequency, the modified pump will not be able to cater full load demand and this situation demands running the standby available alternate BFP.

In case of emergency situation load fluctuation ie upto 10% more than designed must take care of drum level by matching feed water flow, Drum level, Main steam flow.

6. CONCLUSIONS

The new gear stage should include primary wheel and shell to avoid possible problems of unbalance (combination of new and old parts).

No modifications required in the hydraulic coupling to install the new gear stage

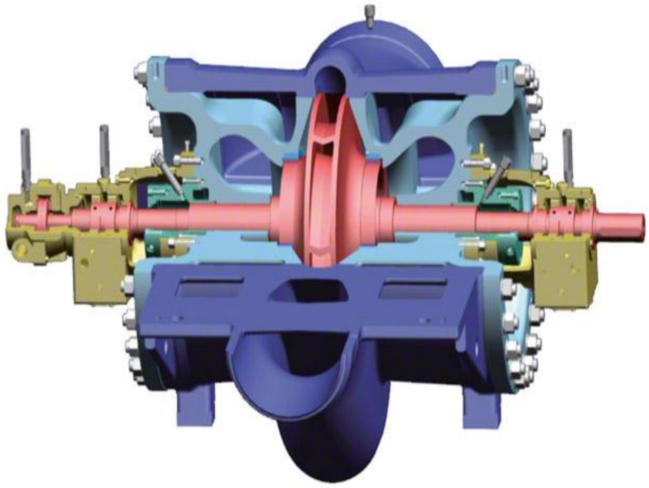
This means that in case of any emergency, the old gear stage can be put back in the coupling with ease in a very short time

Changing of optimized gear stage job can be carried out at site and completed within 2-3 working days.

The investment for modification is paid back within a very attractive period varying from 6 months to 2 years.

The new gear stage ensures another 15/20 years of service without necessity of change of internals in normal operating conditions

Possibility of reduction of Hydraulic oil temperature due to reduction of power losses.



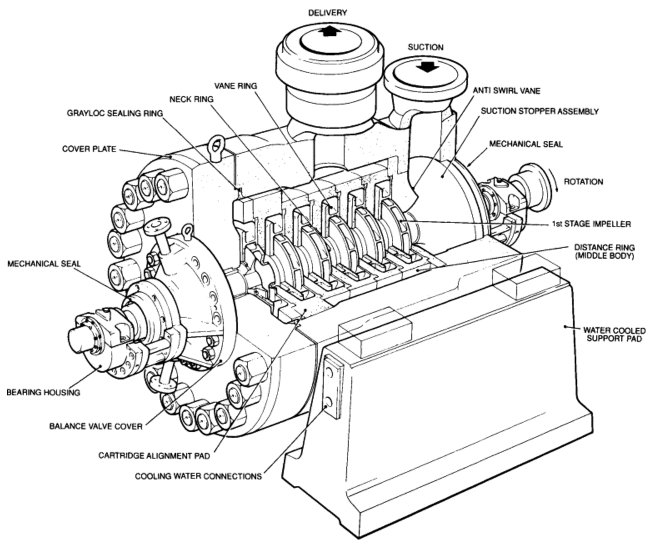


Figure 1.Section view of Boiler feed pump

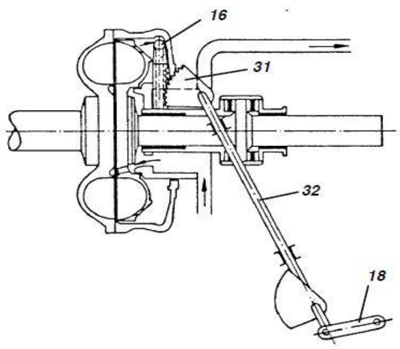


Figure 2. Components of Voith coupling

18 Adjusting lever 16 Scoop tube
31 Tooth segment
32 Control shaft

POWER CALCULATIONS FOR NEW GEAR RATIO

1. Pump's design speed (assumed) = 5100 rpm
2. Rated slip : 1.8%
3. Calculated primary speed of hydro coupling (N1) = 5194 rpm + 1% allowance
= 5246rpm
4. New gear ratio : 1: 3.52 (5246 rpm)
(for calculation purpose the new primary speed is considered as 5246 rpm)
5. Power consumption @ 4922 rpm = P1/P2 = (N1/N2)3
P2 = 4515/(5246/4922)3 = 4515/1.21
= 3731 KW
6. Power consumed by motor = 4475 KW
7. Power loss with optimized gear stage = 4475-3731 = 744 KW ----------(2)
8. Design power of the pump (P1) : 4515 KW
9. Input speed (motor) : 1490 rpm
10. Design speed of pump (N1) : 5531 rpm
11. Observed speed (N2) : 4922 rpm
12. Motor current : 435 amps
13. Power consumed by motor = 1.732 X V X I X PF
= 1.732 X 6.6 X 435 X 0.9 = 4475 KW
14. Power consumption of pump at speed 4922
= P1/P2 = (N1/N2)3 = 4515 / (5531/4922)3
P2 = 4515/1.419 = 3181 KW
15. Power loss with present gear stage = 4475-3181 = 1294 KW ------------ (1)

8. Power Savings = (1)-(2) = 1294 KW – 744 KW = **650 KW**

Cost Economics:

Energy saved per pump = 650 KW

Energy savings per pump per annum = 650 * 24 * 365
= 5694000 KWHr
Energy cost per unit = 3:00 INR

Cost savings per pump per annum = 5694000 * 3
= 1,70,82,000 INR
Cost savings for Four pump per annum = 6,83,28,000 INR
(**Six Crore Eighty Three Lacks Twenty Eight Thousand**)

Formula for Slip Calculation :-

S = (1-N2/N1) * 100 [%]
Where, S = Slip
N2 = Output Speed
N1 = Input Speed

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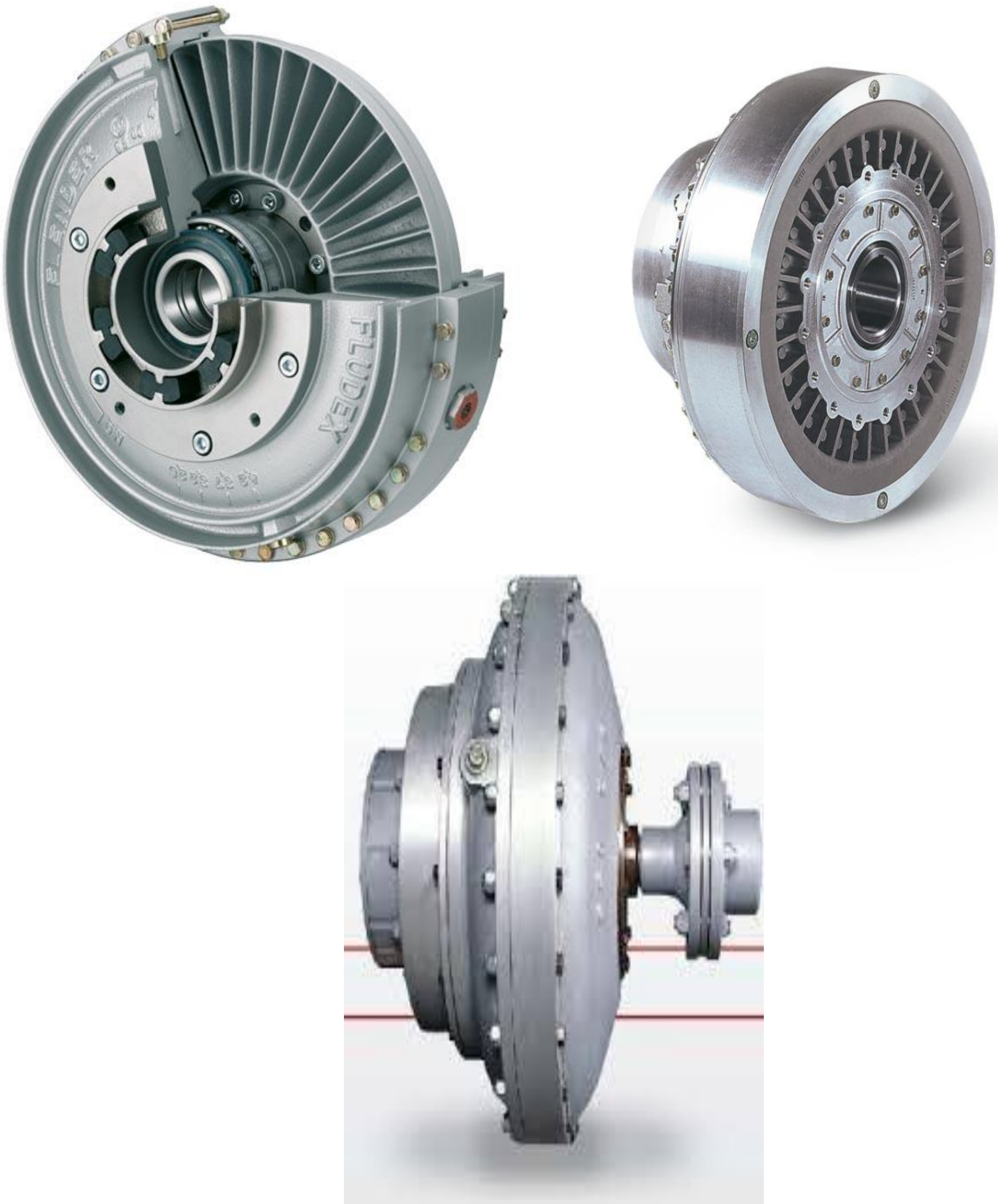

Illustrate diagram shows sectional view of coupling

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