

Design of New Systems of Controlled Speed Drives

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American Gear Manufacturers Association



TECHNICAL PAPER

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ABSTRACT:

Processes in chemical industries and power plant stations require to a certain extent variable speed drives of high power capacity. In contrast to controlled hydrodynamic or friction clutches a new system of hydrostatic controlled superimposed planetary gears was developed. Design and calculations as well as efficiency comparisons to other systems will be described. Practical experiences in the drive of large boiler feed pumps will be explained which prove the reliability of these drives.

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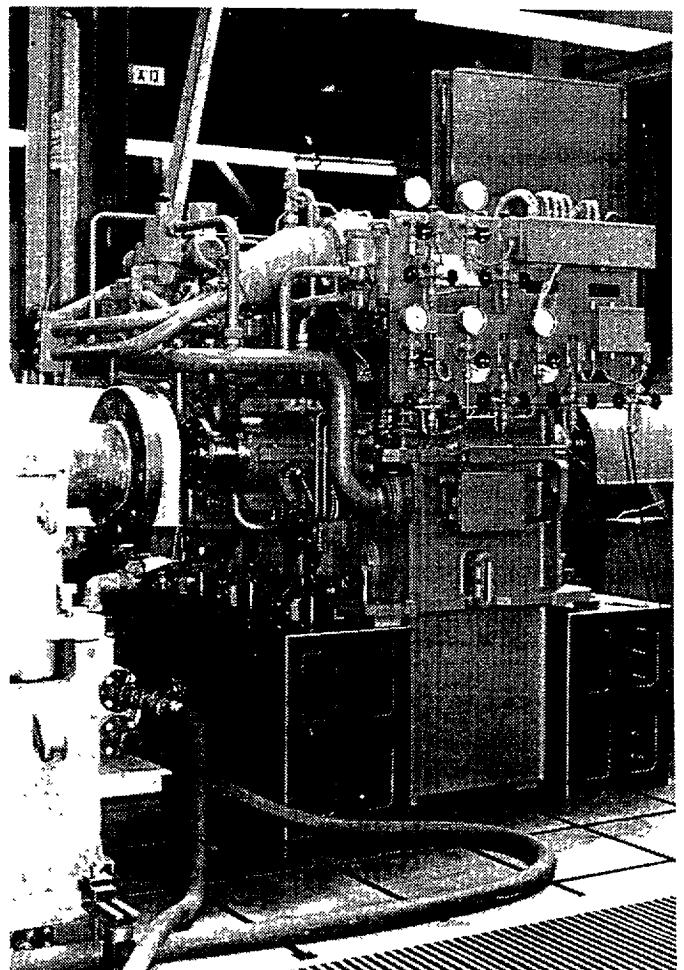
Augsburg, West Germany

Introduction

The history of speed variation is approximately as old as that of the prime mover. Since the speed of a prime mover operated at the design point is not suitable for every driven unit, transmissions are necessary. This requirement gave rise to the design of a variety of gear configurations: lever cam gears, flexible drives, transmissions, chain drives, toothed wheel gearing. A unit driven at a given speed cannot meet all the tasks with which it may be presented. Fig. 2. The operation of machine tools, for instance, must be compatible with the materials to be processed. Supplying machinery has to deliver quantities in accordance with their design, vehicles are driven at various speeds.

Fig. 1:

RECOVAR, controlled speed drive gear unit, built for driving a 2800 MW boiler feed pump, operates in a Finnish peat-fired power station



Speed adjustment, indispensable for cost-effective operation

Disregarding solutions where the drive speed is influenced by changing the energy flow (internal-combustion engines, turbo-machinery, phase shifting of electric machines), we distinguish between

- actuators on the driven unit or plant and
- speed control between prime mover and driven unit.

The delivery rate cannot always be varied by machine-mounted actuators and, if so, only at high expense, for instance, by varying the blading/guide vanes of turbo-machinery. This possibility will not be treated in this article.

The particular advantage of speed adjustment for energy input is shown by comparing the throttling of pump delivery. Fig. 3 shows the flow loss in a pump which, as the delivery rate rises, causes an increasing drop of the pressure head (1). The losses (2) due to wrong admission of the medium - pulse loss - increase, the more the operating condition deviates from the design point. The reason for this is shown in Fig. 4.

If the volume is throttled at rated speed, backflow occurs, i.e. a certain amount of the medium delivered circulates at the entry to the wheel. The power input required for this useless vortex is shown on Fig. 3 by area (2).

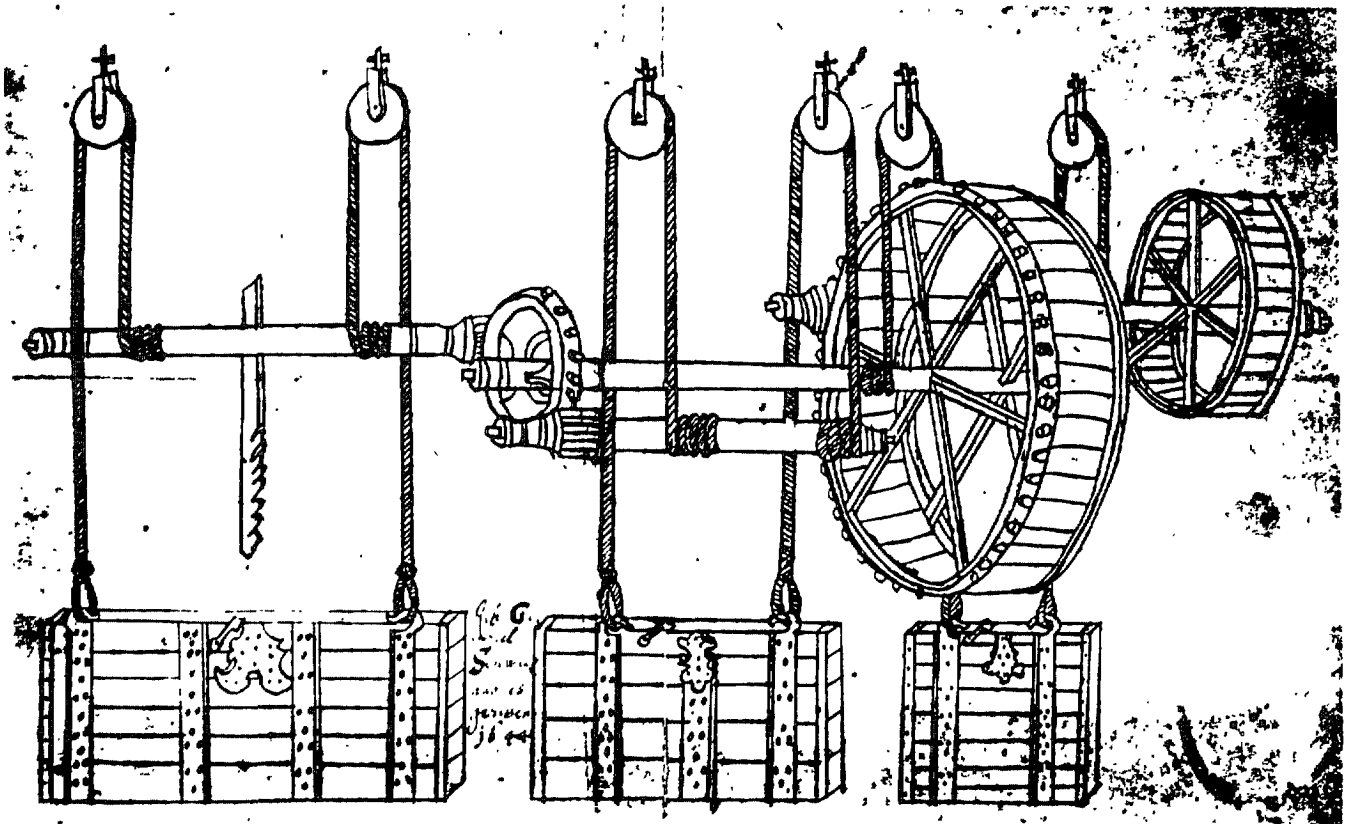
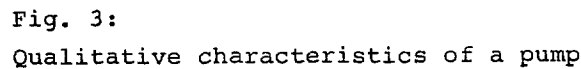


Fig. 2: Lifting drive for a sluice gate at the river through Augsburg. The small-size tread wheel serves to provide the necessary breakaway torque. The big wheel is for rapid lifting and lowering of the sluice. This exemplifies a system-tailored adaption of the transmission ratio in 1644. (Ruckdeschel, Institute of Technological History, Augsburg)



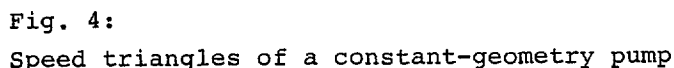
The figure consists of two vertically aligned graphs sharing a common x-axis representing Supply Quantity Q (m^3/h) from 700 to 1700.

The top graph shows Supply height H (m) on the y-axis, ranging from 0 to 40. It contains three downward-sloping curves labeled "Pump characteristics" and one upward-sloping curve labeled "Resistance characteristic".

The bottom graph shows Power absorption (kW) on the y-axis, ranging from 0 to 1200. It contains two curves: "Power absorption with throttle control" (the upper curve) and "Power absorption with variable-speed drive" (the lower curve).

Vertical dashed lines connect the operating points on the top graph to the bottom graph at Q values of 700, 1200, 1500, and 1700.

Fig. 5:
Power absorbed by a pump with throttle and
speed control



- rated speed/rated volume
(design point)
- rated speed/partial volume
(throttled operation)
- partial speed/partial volume
(variable-speed operation)

Existing technical solutions for speed
adjustment

In drives offering the possibility of speed adjustment we consider the following

- hydrostatic gears (lower power limits, therefore without branching off of power - e.g. by means of a superimposed planetary gear train, unsuitable for high power equipment)
- slip coupling (friction or hydro-dynamics)
- non-slip planetary superimposed gearing