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Technical Paper

on the subject “Economic Feasibility of Adjustable-speed Drives“
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Top: There are many publications dealing with energy saving through the use of adjustable speed AC motors. The present paper is a contribution to this discussion, showing further ***system benefits*** in blowers and fans and outlining the ***economic feasibility*** of the investment. The actual savings have been measured for a period of 2 years.

Activities in Western Europe towards exploring the energy saving potential of machines with a square-law torque vs. speed characteristic go at least as far back as the so-called oil crisis, which was caused by rising oil prices in the seventies and eighties. Adjusting the speed of such machines can considerably reduce their power consumption as compared with regulating the flow rate by means of a damper-type throttle.

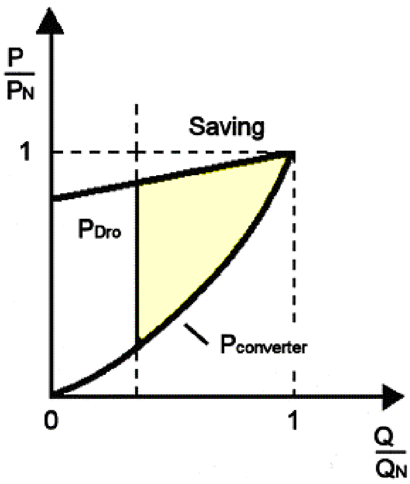

Fig. 1
Energy saving potential of machines with a square-law torque vs. speed characteristic

If the torque is a square-law function of the speed, a decrease in the flow rate and speed reduces the motor shaft output even according to a cubic law. This opens up a wide area for reducing power consumption.
Increasing use is being made of this with pumps and blowers driven by frequency-converter fed AC motors.

The power consumption characteristic curves of blower drives for three different principles of air flow regulation are compared below.

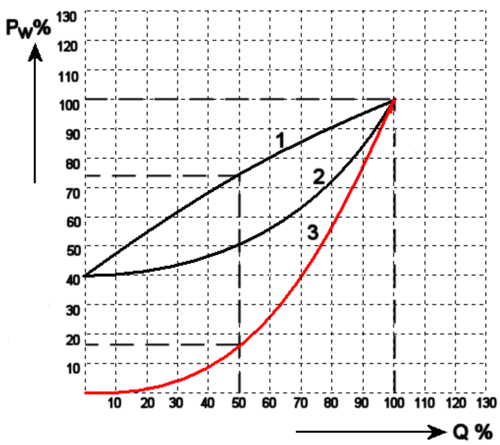

Fig. 2
1 throttle-type regulation
2 variable inlet-guide vane
3 speed control

For an air flow of 50 % of the maximum designed value Fig. 2 shows a power consumption of 73 % for throttle-type regulation and of only 50 % for variable-inlet guide vane regulation. This is further reduced to only 14 % for speed control!
In evaluating these figures it should be borne in mind that the 100 % rating of the blower corresponds to an approximately 115 % boiler bad level.

The average annual air flow is much lower. It has still to be reduced by the design margin and then ascertained according to the mode of Operation as district heating station or base bad power plant. The assumed 50 % level is often a realistic average value.

The energy saving potential of large blowers is considerable. Blowers rated at several megawatts are encountered in power stations and industrial applications. Taking, for example, a fresh-air blower for the boiler of a power station with a driving power of, say, 1500 kW, and assuming an average air flow required in operation of 65 *%,* the possible saving of power is 500 kW! There are often many of these fans in large power stations. With 24 hours Operation of, for example, 24 blowers and station auxiliaries energy costs of 0.20 DM per kWh 20 million DM can be saved every year.

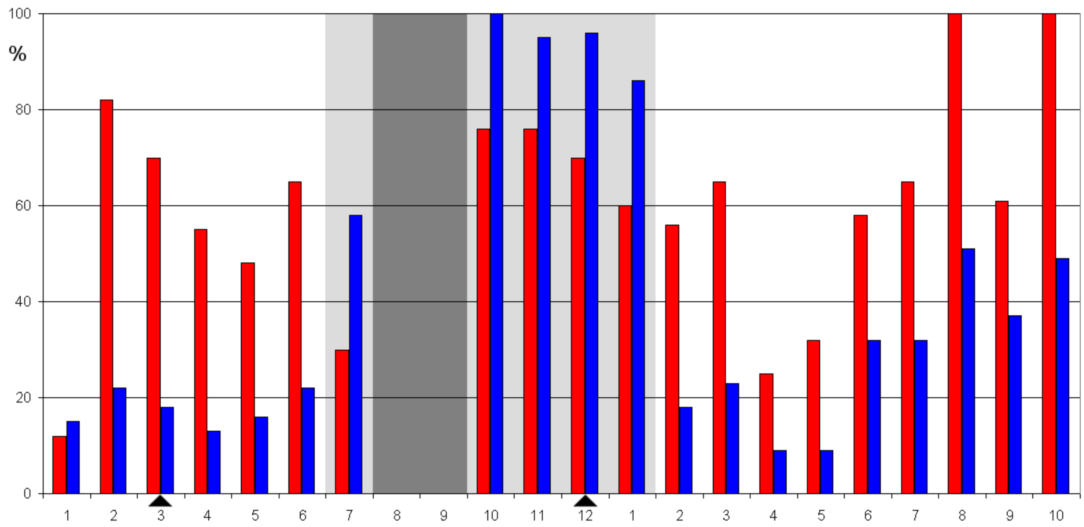

Fig. 3

produced steam

required driving power

uncontrolled, direct on line operation of motor

inverter operation

revision, downtime

Fig. 3 shows a very good ***comparison*** *between* a mechanical system (using variable inlet-guide vane regulation) and electrical speed adjustment through a frequency converter. As a special case both devices were installed on the same 720-kW fresh-air blower.

The monthly flow rates for the steam flow of a 1 60-t steam boiler and the consumed electric driving power were recorded for almost two years. During most of the months of that period the drive was operated in the frequency converter mode (U-mode). Compare, for example, December with March of the following year. In December the motor was operated direct on line (N-mode) with regulation of the air flow through a variable inlet-guide vane. In March the plant reached the same steam flow rate, in this case 70 *%,* using speed control. The driving power consumed and to be paid for was reduced to 18 % of the nominal power!

This means that the cost of the electrical speed control equipment frequently pays off within the first year of operation.
Reducing the station auxiliaries energy consumption in a power station is an important factor.

However, the efficiency does not only depend on the cost of energy. Sound emission and the possibility of controlling the systems must also be taken into account.

Fig. 4 shows the general variation of the *sound pressure level* with the flow rate for three different systems. Starting from the nominal point, there is a clear increase in the sound pressure level for the two mechanical systems, in particular, at values of 40 to 80 % of the maximum designed flow rate which frequently occur in Operation. The use of electrical speed adjustment reduces the sound pressure level in this example by up to 20 dB (A). The reduction as compared with the mechanical system is 20-30 dB(A), which eliminates the cost of sound-proofing measures.

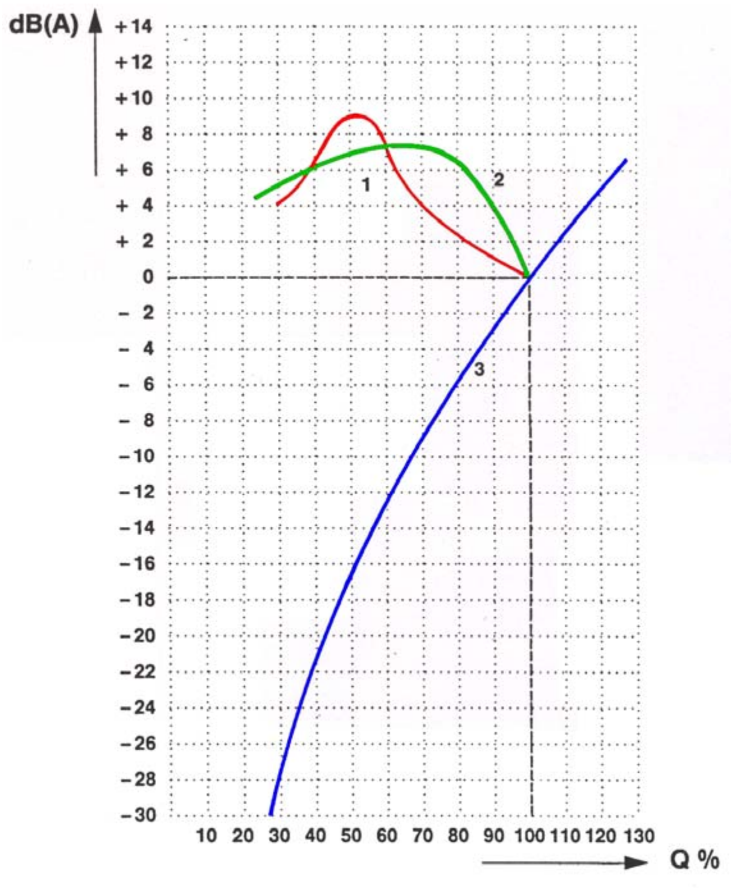

Fig. 4

Sound pressure level of fans

1 throttle-type regulation

2 variable inlet-guide vane

3 speed control

Modern production processes and power stations with flue gas cleaning require sensitive control. This problem can be simply and easily solved by means of linear control loop elements. Fig. 5 shows the *regulation characteristic* of fans using the different regulating systems.

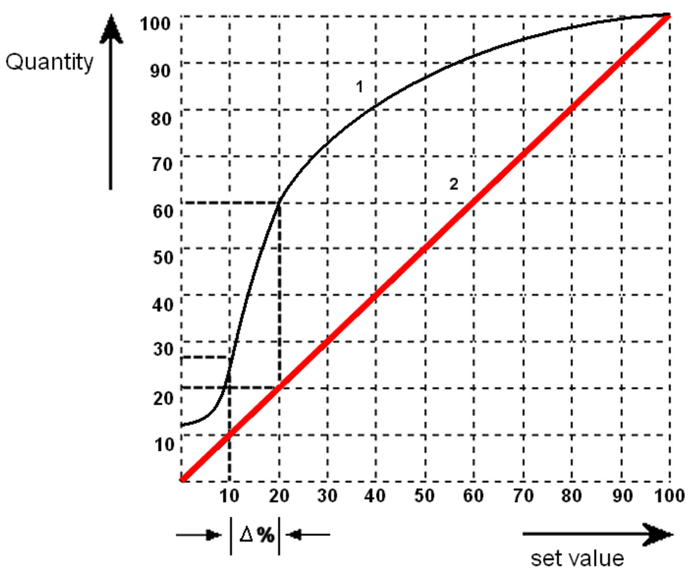

Fig. 5

1 Throttle/variable inlet-guide fan regulation

2 Electrical speed control

Characteristic 2 in Fig. *5* shows the linear relationship of the variation of the flow with the manipulated variable. The mechanical systems show a more or less heavy reaction, depending on the operating point. Because of its linear relationship the characteristic of the speed control system is ideal. Incidentally, this is also true of the time response.

The *availability* of modern frequency-converter fed synchronous and asynchronous motors is very high. Such systems are virtually maintenance-free.
An AC motor supplied from a frequency converter accelerates the large inertial mass of the blower at nominal torque from standstill up to the desired speed, requiring for this only the nominal current. On the other hand, the motors of the mechanical systems, which are operated directly on the line, require a multiple of the nominal current to produce only a partial torque. So, the bad on the electrical supply systems is reduced.

Summary:

Electrical speed control on pumps and blowers in industrial plants and power stations has considerable advantages. Besides the energy saving potential, which has been shown above by two examples of blowers with drive capacities of 720 kW and 1500 kW, respectively, there are other system benefits which ensure the economic feasibility. There is a great potential for taking economic advantage of this especially in the countries of Eastern Europe and overseas.