Sunday, March 3, 2013

Energy efficiency of PM vacuum system equipment

1. General

There are many reasons, why the electric energy consumption of the PM vacuum system varies from one machine to another:

1. Paper machine geometry

The amount of suction rolls and suction boxes vary from one machine to another, and the required vacuum level differ depending on the machine geometry.

2. Vacuum system efficiency

The design of the vacuum system process and vacuum level control may cause efficiency losses at the system (bleed air or expansion losses). System efficiency losses take place, when the capacity of vacuum pumps or blowers do not match with the vacuum level or air flow from the machine.

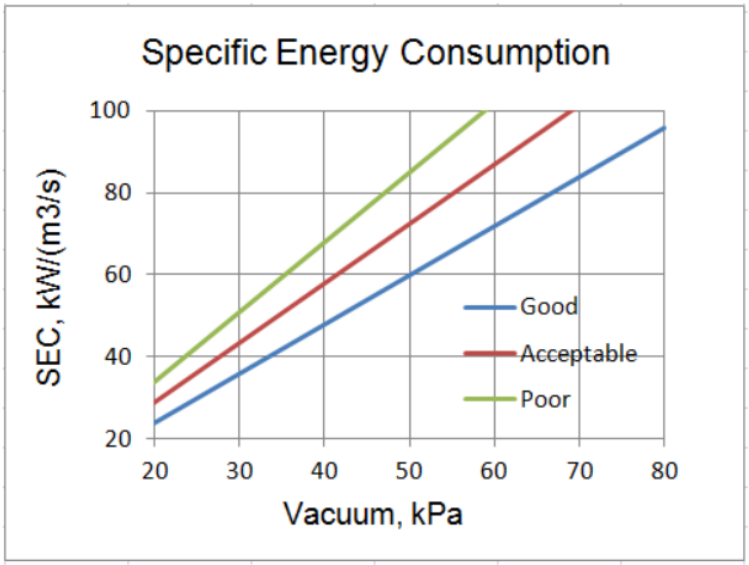
3. Efficiency of vacuum system equipment

The efficiency of equipment itself varies also. At the following is presented one example to evaluate the efficiency of vacuum system equipment (= fans, pumps and blowers).

2. Specific energy consumption

The required electric energy consumption of fans, pumps and blowers can be presented as a function of the vacuum level (compare to the picture 1).

The attached graph has been developed based on the best available technology at different vacuum levels, and can not be achieved with one single piece of equipment. at the whole operation area (low and high vacuum lelvels).



Picture 1: Specific energy consumption

The picture 1 presents a simple method for estimating the efficiency of equipment itself, and it does not take into account the system efficiency losses.

- Specific energy consumption is estimated based on the suction conditions of the blower or pump (air flow and vacuum level at the intake).

Based on picture 1, a "rule of thump" has also been developed, to estimate the energy consumption.

P (kW) = Q (m3/s) * p (kPa) * K (1)

Where K = constant, 1,3 ... 1.5

3. Elecric energy consumption and efficiency

Opinions of different vacuum systems are often presented, where one or another system is found to be better compared to the other ones. However, if the comparison is done based on the electric energy consumption, the result depends on many variables. The process desgn and control strategy plays also an important role in it.

Overall feasibility of vacuum system improvement (or new line investment) depends also on investment cost, required space (mill lay-out) and heat recovery. possibilities. Some general quidelines can however also be presented based on electric energy consumption.

1. At low vacuum positions (< 30 kPa) of the PM, a simple fan should always be considered first. The efficiency of liquid ring pump is always poor at a low vacuum, and the invesment cost of a simple fan is smallest.

2. At medium vacuum area (40 kPa ... 55 kPa) the the process system design plays an important role. Conrollability must be good when the requirements of the PM vary depending on the produced grade, PM speed and felt age.

   The efficiency of pumps is also acceptable, if the rotation speed is not too high.

   Multistage and singlestage turboblowers normally operate at at good efficiency at this vacuum level. Important is to be able to control vacuum and air flow according to PM needs (diffusor and variable speed drive needed to avoid system efficiency losses = bleed air and expansion).

3. High vacuum (> 60 kPa) can be achieved only with multistage blowers or liquid ring pumps. At well designed systems the diference at SEC is reasonably small.

   Sometimes pumps at the older mills have been selected to operate at high speed, and the efficiency can be very poor.

   Multistage blower normally operates at a good efficiency level. However, because of over dimensioning , or variating operation conditions, expansion may take place (= vacuum too high at the suction) and reduce the overall efficiency of the system. On the other hand, the multistage blower offers the possibility for the heat recovery (exhaust air at high temperature).

4. Summary

In general (especially at energy improvement projects) it can not be decided without a feasibility study, which system is the best one.

Even though fans and blowers often have better efficiency (low vacuum area), quite often 80 % of the energy savings can be achieved with 20 % investment (20 / 80 rule), when the operation of the existing system is optimised and controls are updated (instead of replacing old eqipment with new ones).

At existing systems the first action is always to make the benchmarking to find out weather the system energy consumption high or low compared to the other machines producing similar grades. (compare to the earlier article, block fall 2012, Benchmarkng).

This article offers an alternative method to find out the reasons for the high energy consumption at the vacuum system. Comparison of equipment efficiency often requires a more detail pre-engineering (air flow and vacuum level measurements at the machine)