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ENERGY SAVINGS IN PAPER MACHINE VACUUM SYSTEM - HOW TO UTILIZE MODERN VACUUM AND NIP DEWATERING TECHNOLOGY

by
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Abstract :

Energy is a significant cost factor in papermaking. Besides the pulp production, paper machine lines consume significant amount of energy, when the production volumes are high and the unit processes are heavy users of energy. Out of these, the pumping cost and paper machine drives are the heavy users. New technologies in process design, pumping principle and variable speed electric drives can cut the pumping energy bill dramatically.

At the same time, there is a constant pressure for higher productivity, better process control and reduced emissions. On the other hand, new technologies are emerging to tackle this challenge. But how much energy can be saved without putting paper production in risk? And what else is available to improve the vacuum and dewatering performance?

In paper industry, we are used – for a good reason – to be rather conservative in applying new inventions. Savings in one cost factors tend to be marginal in relation to overall cost and income. Any disturbance in production, however, will cost a lot in lost profits.

Vacuum pump choice and mode of operation has a significant impact on energy consumption. Further on, these vacuum elements often represent big portion of the friction increasing machine drive loads. Dimensioning the system can be a tricky task, because so many variables are involved, and many of them (such as raw material, water quality, water temperatures) are often beyond the control of the machine personnel. By utilizing energy efficient variable speed turbo technology and efficient water removal concepts, both highest production performance and best energy efficiency can be reached.

Benchmarking brings you on the map

But how much is much? We tend to rely on old standards and accumulated experiences of paper machine suppliers. But are these really the right ways to approach the problem? The dimensioning levels are based on “the worst case scenario” and represent the maximum levels of each position. Running the machine with these levels and then using valve control is like driving a car with full motor power and controlling the speed with brakes.

The answer for this search of reasonable level, is benchmarking. There are a high number of producers making comparable paper grades using the same kind of technology as you are. There is rather limited amount of choices in technology. Doing comparisons between different PMs, the potential can be estimated. This helps in focusing the efforts in the machines where potential is likely to be high. Ecopump Oy and later Runtech Systems Oy has collected a databank of over 500 vacuum systems of different grade paper machines.That offers a good population for comparing each case against what is usual in the industry.

In figure below, the specific power consumption (kWh/ton) of the vacuum system power of a large number of fine paper machines shown, as a function of the machine size (ton/hour). The size has little impact. While the speed increases the tonnage, it also puts higher vacuum requirement to be able to handle the web and water. But more interesting is the rather big variation: some run their machines with 40kWh/ton, some need over 120kWh/ton. For 30tph machine as an example, this difference in capacity need represents about 1 MEur cost annually. And often, there are other costs involved with the higher capacity than just the energy: more water, more maintenance, only to mention.

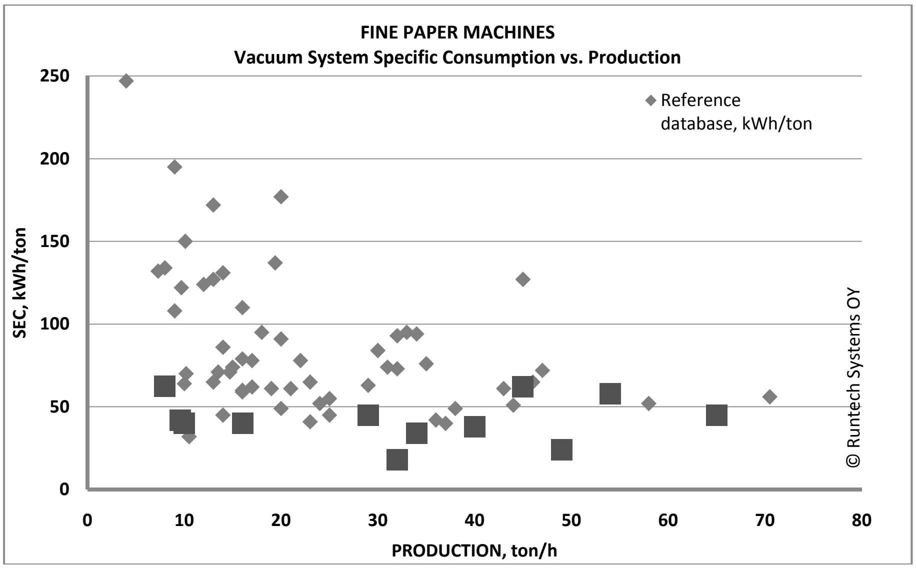


Figure 1. Specific consumption of vacuum systems, fine paper grades .
(X-axis shows the capacity of the machine in ton per hour, the Y-axis tells the vacuum system specific energy consumption in kWh/ton. The square shaped points are those equipped with variable speed turbo.)

Mapping the system dynamics with online Ecoflow Dewatering Measurement

Recognizing the high consumption is the first step, but the real task comes when choosing the right way to reduce it. You may know the overall overcapacity, but deciding the actions for each vacuum position and each vacuum pump requires some deeper thinking – and clear facts as solid ground for this thinking. Reliable measuring technology combined with experience helps in this. As dewatering is a key phenomen in the PM wet end, measuring it at least in key positions is essential for any vacuum optimization task.

In figure 2, the dewatering rates through nip saveall tray and uhle box of a pickup felt can be seen, as well as these two combined. The steam pressure in drying cylinders is shown, too, to verify the overall dewatering performance. . This test was conducted to find out the optimal vacuum usage. As it can be seen, lower vacuum results in lower uhle box dewatering. But the total dewatering is higher, due to better nip impulse and capillary effect. Moreover, the behavior is varying significantly by the age of the felt, and by the type of the felt. Measurements bring facts and knowledge to the art of paper making. Utilising them efficiently, one can:

- find the optimal vacuum levels
- select the best performing felts and fabrics
- schedule the fabric changes and cleaning shutdowns optimally
- locate the causes for process disturbances quickly

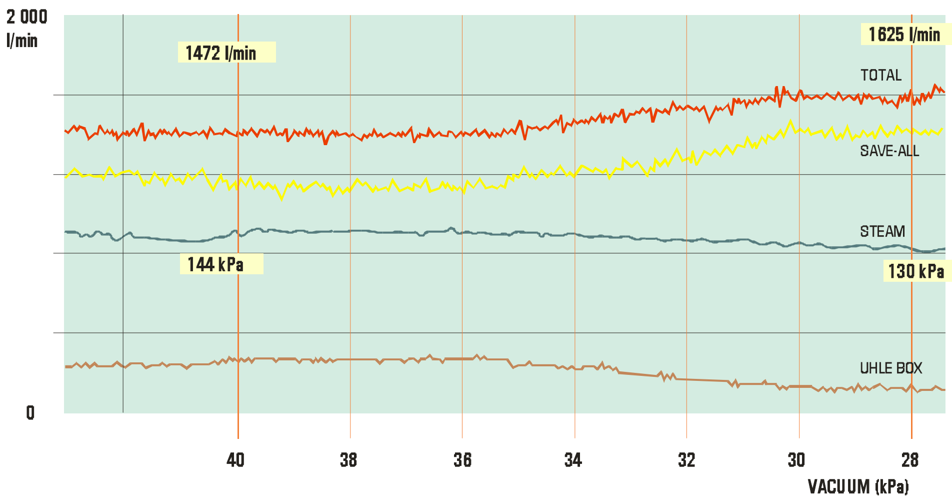


Figure 2. Felt dewatering values in relation to uhle box vacuum level

System controllability

The first big step in this adjusting the vacuums down can be done by reconnecting the piping and shutting down obsolete pumps.

After that, the system controllability comes into the picture. The "good old" technology meets its shortages here. Water ring pumps often have rather limited control range, between the collapse of the water ring and the overload due to frictions in rotating the water. Old type multistage turbos cannot be operated with variable speed, due to mechanical resonances and/or only one or two large aggregates serving the whole PM. Fixed speed large aggregate means that vacuum control must be done with valves or guide vanes that significantly reduce the energy efficiency.

Combining the good things of the two old systems – power efficiency of turbo blowers and versatility of water ring pump systems – together with variable speed electric drive technology brings the energy efficiency to new level. All this comes without giving up the system reliability of multi-pump system. With traditional water ring pumps there is typically piping arrangement that allows backup connection system to function even when one of the water ring pumps is out of service. Or there is even a spare pump available to maximize the system availability. The same kind of arrangement is possible with a multiple turbo system such as Ecopump.

The above mentioned as background, a system consisting of 3-6 variable speed turbos is radically more energy efficient than the traditional alternatives . The power consumption can be brought down by 30..60% depending whether the old system is based on turbo or water ring technology.

The equipment to enable such a turbo consist of:

- High speed AC motor capable to operate from zero to to 500kW/10000rpm range
- Frequency converter configured to this rpm range
- One or two turbo impellers directly mounted on the high speed motor shaft
- High performance water and drop separation system

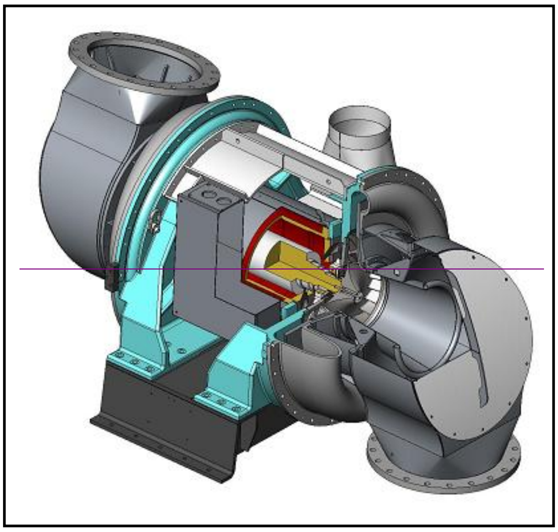


Figure 3. EP Turbo unit

The system consists typically of 3-6 turbos. The piping , is configured like typical water ring pump system, which offers good system control and backup possibilities. It also makes the system reliable and easy to operate. Turbo principle gives initially highest possible efficiency. On top of this, the speed control makes the savings from capacity control available.

From investment point of view, the controllable high speed offers good savings, too. Because of the high speed, the size of equipment is limited – which is reduces the floor space needed. Further on, the mass is low – and does not require heavy fundaments. Good balanced equipment does not vibrate much. But any vibrations are on high frequency, which makes the dampening with simple measures more efficient. Vacuum control is mostly done with the variable speed. This reduces the number of large (and often automatic) valves. Only the individual suction positions of, for example, wire suction boxes require control valves. When moving large amounts of air, making noise is unavoidable. But since the noise is of high frequency (around 2000Hz), it is rather easy to dampen, which reduces the cost of silencing and makes the system environmentally friendly. All these together: the total investment cost is lower than with traditional techniques.

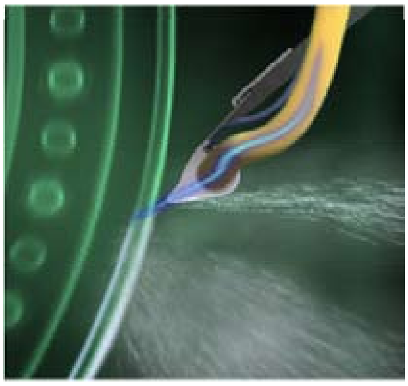
High speed turbos require some frequent maintenance, as all rotating machines do. The high speed means that the interval is shorter. On the other hand, the light weight means that the service actions are faster, because the parts are easy to handle. Thus no shutdowns longer than one day are needed for maintenance. Bearing change is required once in about two years, depending on the application. Here again, the light weight of high speed equipment makes life easier. The maintenance actions can be done on site, without any cranes necessary. Due to modular structure, the bearing change can be done in regular one-day maintenance shutdown.

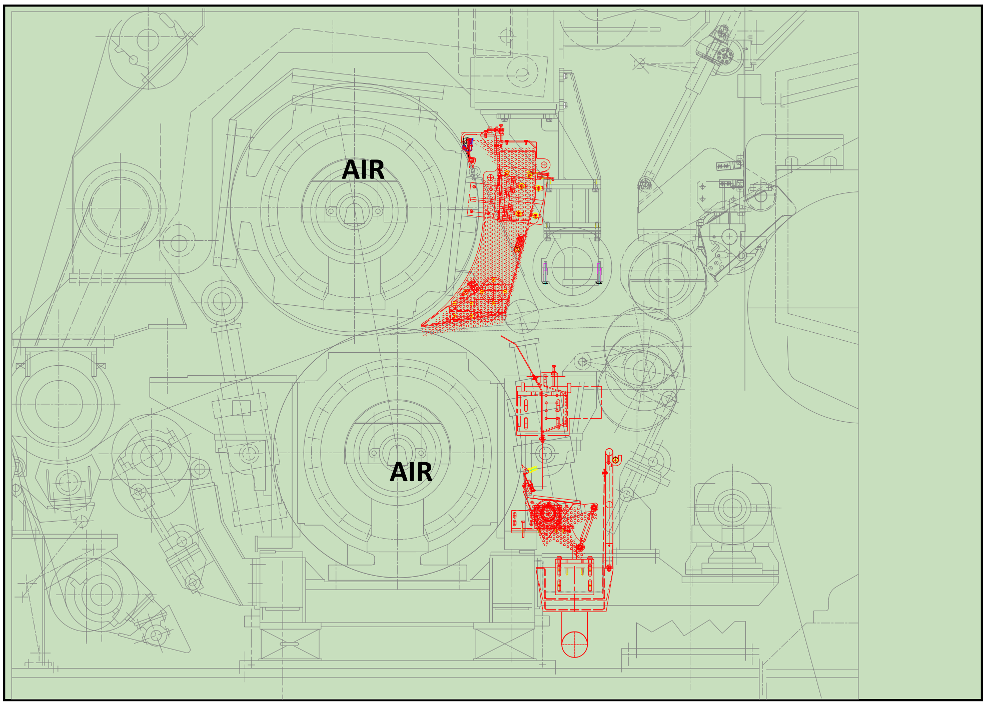
Variable speed drives are nowadays standard technology in the mills. Utilizing them in vacuum system is a natural step in improving energy efficiency. With this solution specially developed to economical pumping performance, this great potential can be utilized.

Nip Dewatering

Besides vacuum sources, improved nip dewatering is an essential thing when designing vacuum system rebuild. The vacuums can only be reduced to some certain level, after which there is too much water in the nip. Good energy saving opportunities are available even before this point, but further benefits in machine performance and energy efficiency can be reached with good water removal system, which is called RunPress concept. Besides vacuum, it consists of

- optimal nip roll doctoring, often with AitBlade, a doctoring concept where sharp air knife removes water not only from outer roll surface, but also from grooves and holes.





Figures 4-6. Air blade doctoring removes the water from roll surface, holes and grooves

And how to proceed?

A good way to proceed in this energy and water saving investment planning is a procedure consisting of three steps:

1) Light survey
2) Full process survey and project plan
3) System rebuild

Light survey

A light survey is a procedure to evaluate the potential for efficiency improvement. The work goes as follows. A system expert visits the mill for one day. During this day he collects the basic data on the system: production tonnage, grade etc on one hand, power consumption on the other hand. With this data, the benchmark numbers can be calculated. This step can easily be done by the mill personnel, but sometimes the data is not readily available or it is not reliable. If this first round suggests that there is good potential for improvement, the further steps are to be taken.

Full survey

If more precise list of actions and bill of material is requested, a full survey can be conducted before investment decision. Also, to get a precise estimate on the best possible future performance a full study serves the purpose. This means measuring each and every variable in vacuum system function onsite, with calibrated equipment. Quite often, the gauges and sensors, that are installed at the machine, are not giving exactly right values. They may be good enough for daily operation, but not good enough to reveal leaks and throttling, for example. By checking the readings with calibrated equipment, false assumptions can be avoided. Based on this measurement data, the real efficiency of the system is then calculated.

The energy efficiency of the system is defined by comparing the thermodynamic power or the air removed from the suction position to the electric power consumed at pumps. It is quite common for the water ring pump systems that some vacuum positions work with only 10-20% energy efficiency. Any efficiency level over 30% can be considered good result for this kind of pumps. For a turbo system, over 50% efficiency should be reached to be considered normal or good. However, a lot of power is often wasted in throttling, because a multistage turbo aggregate can not be adjusted to the capacity actually needed.

By eliminating excessive leaks and throttling, and reconnecting the piping more optimally, significant savings can often reached. The saving can be realized by simply shutting down excess pumps after reconnecting – or by changing the rotation speed, which requires investing in new geat set. For multistage turbo system, this optimization is often complicated, because shutting down one of the two (or alike) turbo aggregates represent such a big portion of total capacity.

Changing some or all of the pumps to speed controlled turbo provides good savings. This applies especially to low vac (<40kPa) positions, because here moving the air takes relatively little power vs. the power needed to rotate the water ring. Another good potential for saving are the variable vacuum (felt uhle boxes) positions. Sometimes the suction roll positions give good payback, too.

Rebuild

The survey report comes with a project plan. It provides:

- Schematic description on the modification suggested
- Layout plan
- Calculations on the energy savings
- Materials list (BOM)
- Cost estimate

The rebuild itself is backed with engineering support, installation supervision and commissioning. Further on, the new system will be optimized after new running patterns are established.

In the following cases, there are some examples from real life.

Reference Cases

Over 200 Runtech turbos are already in use.

Kotka Mills PM1

The longest operating experience is already over 17 years at a laminating base PM1 at Kotka Mills, Finland – and the mill people are quite happy with the system. It produces the vacuum needed, is easy to adapt to process changes and does not cause any trouble. The power cons is 40% less than with the earlier water ring pump system of 6 units. The PM makes 32tph (762tpd) laminating base for building material purpose. The main factor for choosing EP Turbos were eliminating the need for sealing water, and the possibility to install the equipment in very limited space in the basement.

Figure 7. The first variable speed turbo vacuum system is installed at Kotka Mills, Finland

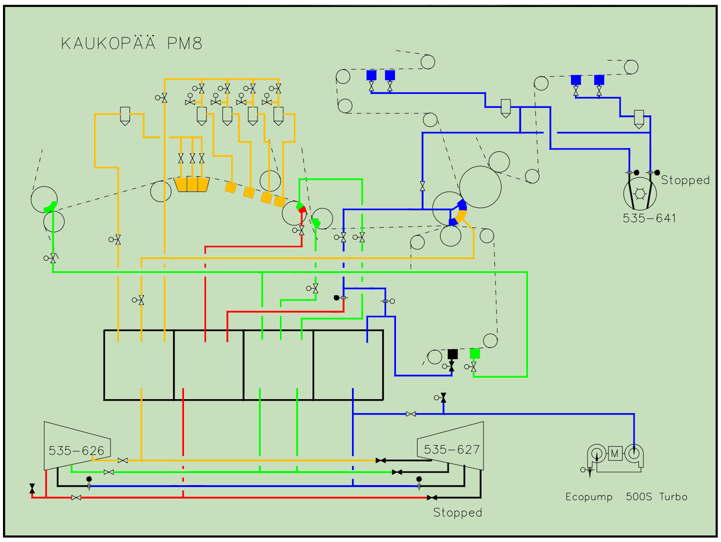
Stora Enso Kaukopää PM8

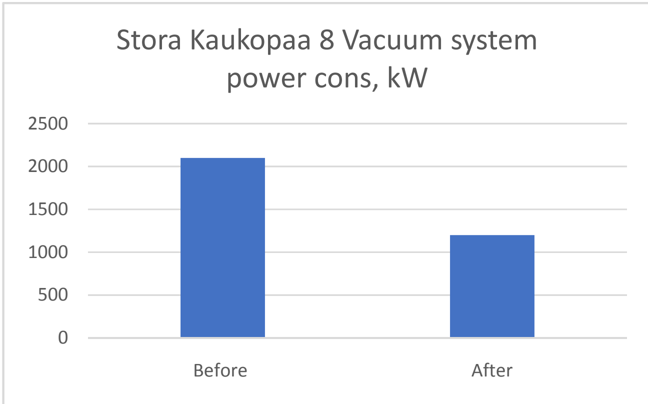
Here, the machine produces uncoated fine office papers about 30tph (720tpd). The old system consisting of two large multistage turbos presented a significant risk of unavailability. It did not allow possibilities to energy optimization, either. The vacuum system was rebuilt to concept of one multistage turbo and one variable speed turbo running. The saving realized was 900kW. at the same time, the system reliability was significantly improved, when the unit shut down was left as spare unit. (This backup was considered necessary, due to severe problems with the old multistage turbos.) The equipment required was :

- EP 500 Turbo with electric drive
- Modification of the existing water separator 1 ea
- 7 valves (5 automatic, 2 manual)
- Drain pump
- Some piping modifications

The results:

- Power consumption was cut by 900kW
- Water separation was improved, now does not cause problems anymore
- Backup capacity available

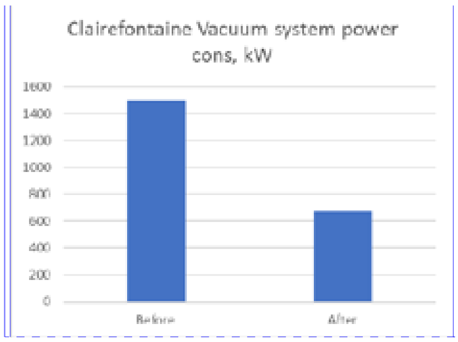


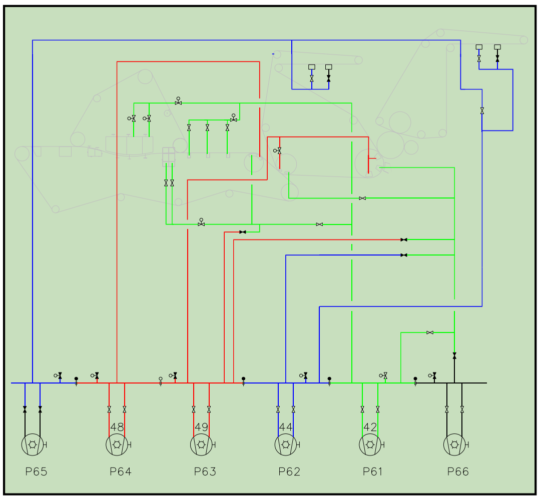


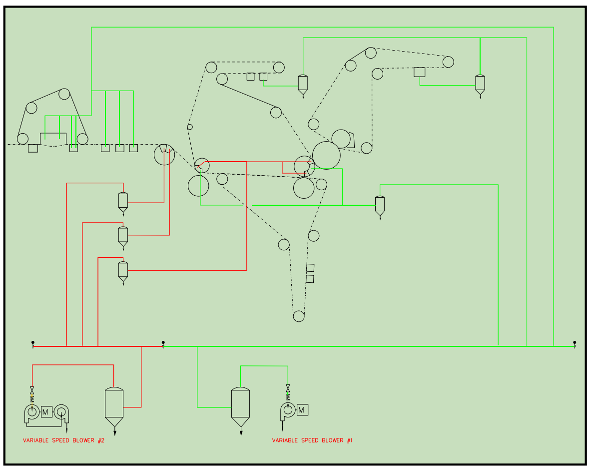
Figures 8,9: Vacuum rebuild at Stora Enso Kaukopaa; Energy saving results

Clairefontaine PM6, France

This machine makes 16 tph (380tpd) uncoated fine paper. Here, the main motivation for investment was energy saving. A vacuum system survey was conducted. Based on the survey, The old system of 6ea water ring pumps was replaced with two variable speed turbos. The power consumption was cut by 40%, from 1,.8MW to 1MW, and seal water savings about 2000m3/d However, according to machine operators, the biggest benefit comes from process controllability and easy use of the vacuum system.







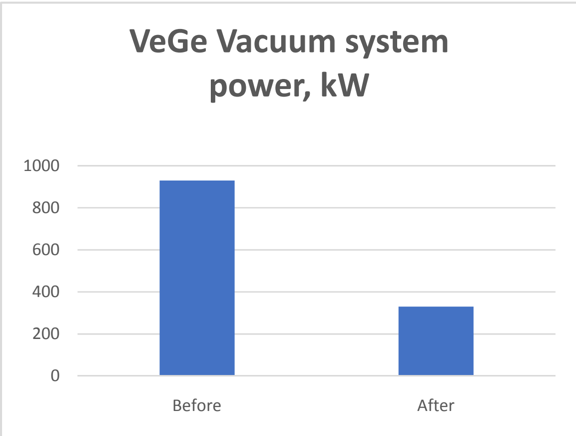
Figures 10,11,12: Clairefontaine PM6 old vacuum system, power consumption and new system

VeGe PM, Kemapasa Turkey

VeGe produces 10tph (240tpd) uncoated fine paper with its machine in Kemalpasa near Izmir, Turkey. In the vacuum rebuild, both energy and water savings were targeted. The system was studied and plan made for:

- Replacement of water ring pumps with 1 variable speed turbo unit
- Nip roll doctoring and water collecting saveall tray was replaced with better functional one

The power consumption went down from over 900kW to 330kW. The production rate was slightly (about 5%) increased. The break rate was reduced, which tells about improved dryness of the web. The mill is continuing the optimizing process and further 100kW saving is exoected.



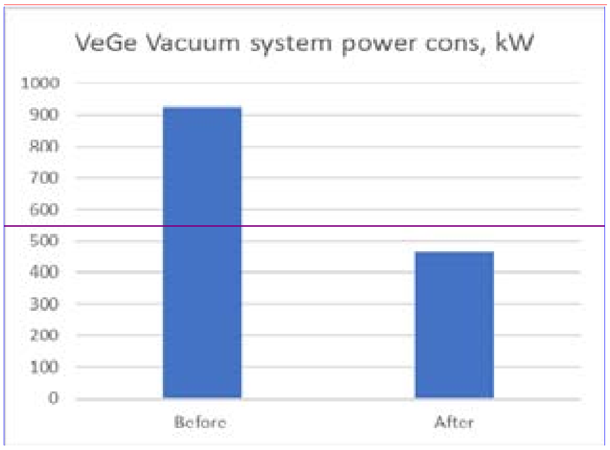


Figure 13. Power consumption before and after

Figure 14. The startup team of VeGe in front of the turbo unit

UPM GrandCouronne

PM3 is a newsprint machine producing 15tph (360tpd) improved newsprint. Here, the old system consisting of :

2 Multistage blowers and 3 water ring pumps was to be rebuilt. Building and piping work to be kept minimum.

BEFORE AFTER

A vacuum and dewatering survey was conducted and new system based on the process character.

- Old blowers and pumps were replaced with 3ea variable speed EP Turbo blowers, minimum pipe work.
- The press section was equipped with Ecoflow dewatering measurements
- The nip water collection was improved by designing new saveall trays equipped with air blade doctoring

Results:

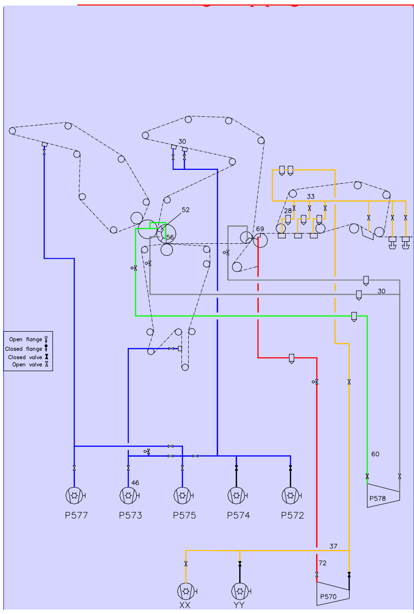
- Vacuum system power and steam consumption were reduced but machine speed was increased

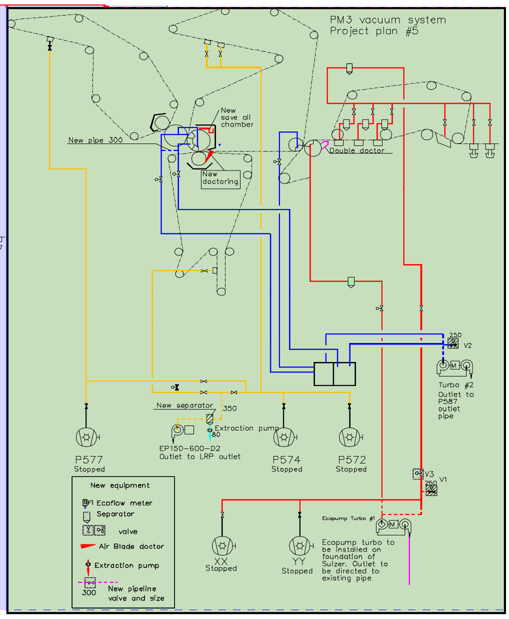
The turbos were installed on the foundations of old pumps. The concrete bed was leveled and anchor bolts attached. With careful layout and piping planning, the modifications in piping and civil were kept minimum. This reduced the overall installation cost. It also shortened the installation time so that the whole thing could be done in yearly maintenance shut.

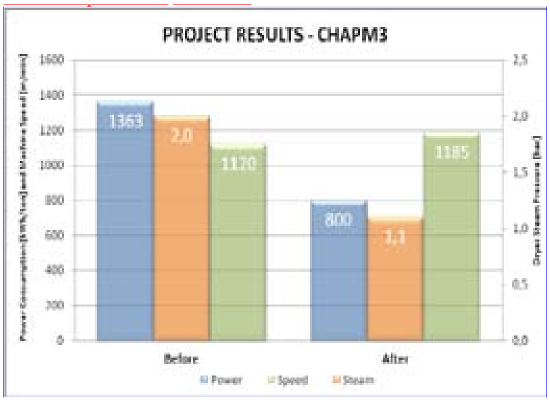
Metsa Board Tako

Here, the multiply board machine (FBB) had a rather old system consisting of 5 water ring pumps, consuming 700kW electric power. It was rebuilt by replacing 4 of the old pumps m with one Ecopump Turbo. The pump serving couch roll was kept, because the vacuum level of this position was significantly different from those other positions and the pump itself was in reasonably good ondition. The equipment is:

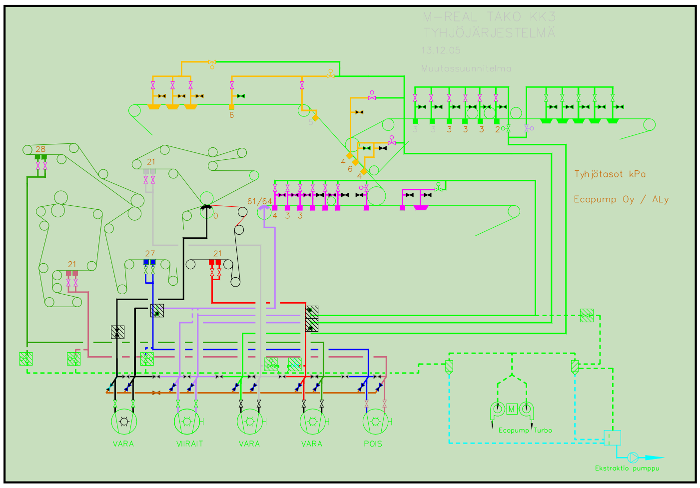
- EP 315 Turbo with electric drive
- Water separators 2ea
- 7 valves (5 automatic, 2 manual)
- Drain pump
- Some piping modifications







Figures 15-17: UPM Grand Couronne PM3 Old vacuum system, new vacuum system and results. Even though the speed has gone up, both vacuum system drive power and drying section steam consumption were reduced.



Figures 18,19. Vacuum system connection at Tako BM3, Turbo with a silencing hood. Piping is adapted tho the existing pipelines.

The results :

- Power consumption was cut from 700kW to 350kW, equalling to 45kWh/ton
- Seal Water consumption was cut by 80%, the reduction being 280000m3/annum