Improved Oil Lubrication Systems for Paper Machines

Hannu Harkonen

ABSTRACT

During last decades there has been significant development in the paper making technology. The speed of the machines is higher, machines are wider and the automation level is quite different as 20 years ago.
However the lubrication of the paper machines has not followed this development. Basically the lubrication systems are operating very similar way, as they have done always, although the lubrication related problem, like water in oil and huge oil costs are getting worse.
Finnish lubrication system manufacturer Safematic, now part of SKF Group, started few years ago a research project, where the target was to develop more efficient lubrication system, specially for paper machine circumstances.
Based on this project the new Flowline lubrication system was presented. Now after few years experiences, this new type of lubrication system has shown that the lubrication really can be done more effective and simultaneously the typical water and air problems can be avoided.

INTRODUCTION

The paper machines are increasingly utilising the oil circulation lubrication in the drying sections and other heavy loaded and hot parts of the machines. This is primarily due to increased operation speeds and higher operation temperatures. Instead of previous oil lubricated cylinder bearings, most of the machines today have also the oil lubrication for the felt rolls and gear reducers of the drying sections as well as for the wire and press section rolls.

Although the lubrication requirements of the machines have become more demanding, the basic construction of the lubrication systems has remained the same. The main development has been made in oil filtration, which has been improved tremendously during the last few years. However, today there are other even more serious problems in the oil lubrication systems, which have yet to have an effective technical solution.

- The higher operation temperatures of the drying sections and the oil lubrication of the wire and press sections have created many water and humidity problems in modern paper machines.

- The increased oil flows through the bearings develop turbulence thus increasing the air bubbles in the oil and thus decreasing the efficiency of the lubrication and the life time of the oil.

Asia Pacific Oy SKF Ab, P.O.Box 80, 40951 Muurame, Finland

- The efficiency of the lubrication and cooling requires much higher oil flows and pumping capacities, which in turn, increases the sizes of the oil tanks. This results in higher operation costs, raises the risk of inflammable liquids and increases environmental problems.

To solve these problems, a Finnish company, Safematic, started a project with the Technical University of Tampere, where the real characteristics of oil flow in lubrication systems were studied and simulated. The results of this project have completely changed the construction of oil circulation systems and are discussed in this artice

GOALS OF THE STUDY

The main goal of the study was to develop a lubrication system in which the main problems of the existing lubrication systems could be solved.

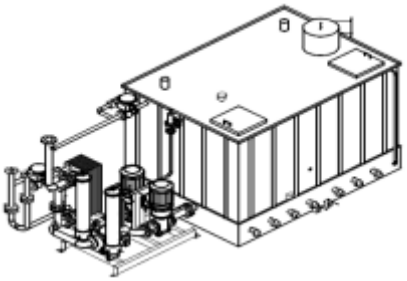
These goals were listed as follows:

- more efficient usage of the oil
- water removal from the oil
- foam and air removal from the oil
- lower energy and cooling water consumption

The study was designed to first determine how existing, traditional oil tanks operate and secondly to develop more efficient constructions to improve these features.

MORE EFFICIENT USAGE OF OIL

Dimensioning of the traditional cubic oil tanks has been based on a 30 minute retention time. It has been assumed that the oil is moving smoothly from the return inlet into the suction of the pump, when the flow is controlled by intermediate walls of the tank.

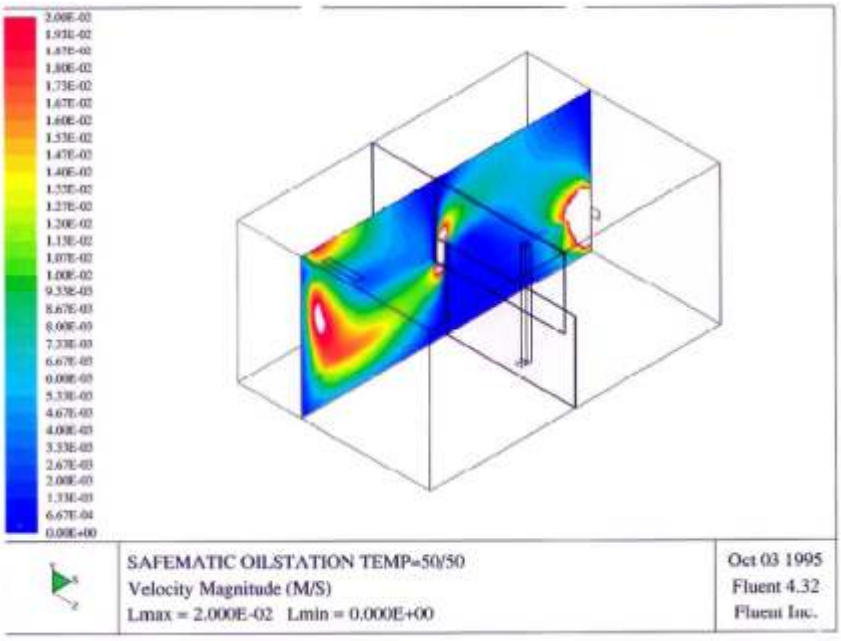


TRADITIONAL OIL TANK

This survey shows clearly, that only 30 - 50 % of the oil is circulating in such traditional tank and the rest of the oil is just remaining in there.

He real oil flow study was made by a computer simulation based on the particle vectors (Fluent 3D) and tested by practical measurements.

This simulation shows clearly that only a small part of the oil is flowing through the tank, while the majority of the oil is moving very slowly or not at all. In the picture below the return inlet is in the left end of the tank and the light colour indicates a high speed under it. A certain amount of oil is flowing directly at high speed between the control walls to the suction side of the tank and then direct to the suction outlet in the right end of the tank.



Oil speed inside tank

This picture shows only one cross section in the middle of the tank. If we look at the other cross sections towards the sides of the tank, there will be more and more dark space indicating lower and lower oil flow speeds.

These results mean that the efficiency of the oil circulation in the traditional oil tank is very poor and actually only a small percentage of the oil is circulating. This also means that the actual retention time of the oil is only from 5 to 10 minutes instead of supposed 30 minutes.

WATER IN LUBRICATION OIL

Most of the water problems of existing paper machines are caused by water condensing in return lines or leakage in the steam joints of the cylinders. According to the bearing manufacturers, the recommended maximum water content of the oil is 200 ppm (0.02 %). However, it is common for the real percentage to be several times higher, and in some cases much more. In modern, high speed machines, the water problems have increased because of greater temperature changes in return lines and because of oil lubrication on the wire and press sections.

The water, microscopic drops or dissolved water, will reduce the efficiency of the lubrication dramatically by breaking the lubricant film between the rolling elements of the bearing. The higher the bearing loads, the more critical it is for the oil not to contain water.

Especially at high temperatures, water reduces the life time of the oil by changing the chemical properties of the oil additives, such as corrosive resistant and EP-additives.

AIR AND FOAM IN OIL

Foam and air in the oil will always cause problems in lubrication. The microscopic air bubbles break the oil film between the bearing elements, which may shorten the life of the bearing. At the same time, the air will increase the oxidation of the oil, which deteriorates the chemical and the physical properties. The lifetime of the oil will decrease.

Particularly, air problems in oil circulation systems will increase greatly if a tight or incorrect return filter type is used.

ENERGY CONSUMPTION

In traditional pumping units, pressure regulation has been controlled by a separate pressure regulating valve. This valve requires a certain overflow of the oil to maintain a steady pressure in the piping system. Therefore, usually 15 - 25% of the pumping capacity is used only for maintaining system pressure.

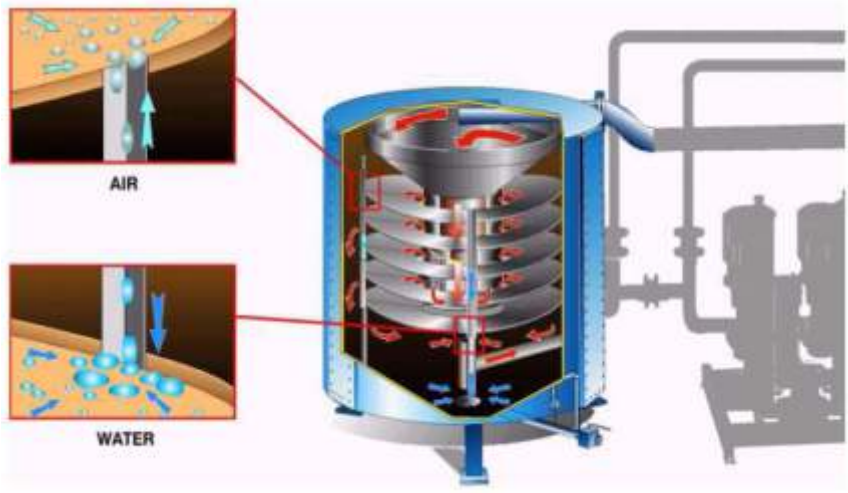
This is ineffective energy consumption, which is being lost 24 hours a day. Moreover, all the other components of the system must be dimensioned according to this maximum oil flow. For example, cooling of the 15 - 25 % additional oil volume will use a tremendous amount of water in a year.

IMPROVED TANK DESIGN

Based on the findings in the study of traditional oil tanks, more effective tank construction for oil circulation has been developed. In this new tank, more than 90 % of the oil circulates in the lubrication system. At the same time, the retention properties were improved inside the tank. Based on these solutions, the total amount of oil in the system can be reduced by 30 - 50 %.

This results in remarkable savings in oil costs. According to our experiences, the life time of the oil will remain at least the same, sometimes it will even increase compared to the traditional lubrication systems.

In this new tank and circulation systems, the water removal has been improved in two different ways:



Inside the round oil tank, there are several intermediate plates, between which the returning oil is flowing from the centre to the sides of the tank. Because the distance between the plates is very small, the small water drops in the oil have only a few centimetres to sink, before meeting the next plate. After that the water drops are collected slowly through the drain tube to the bottom of the tank.

By using this construction, only a few minutes retention time is required to separate the biggest part of non-dissolved water drops from the oil.

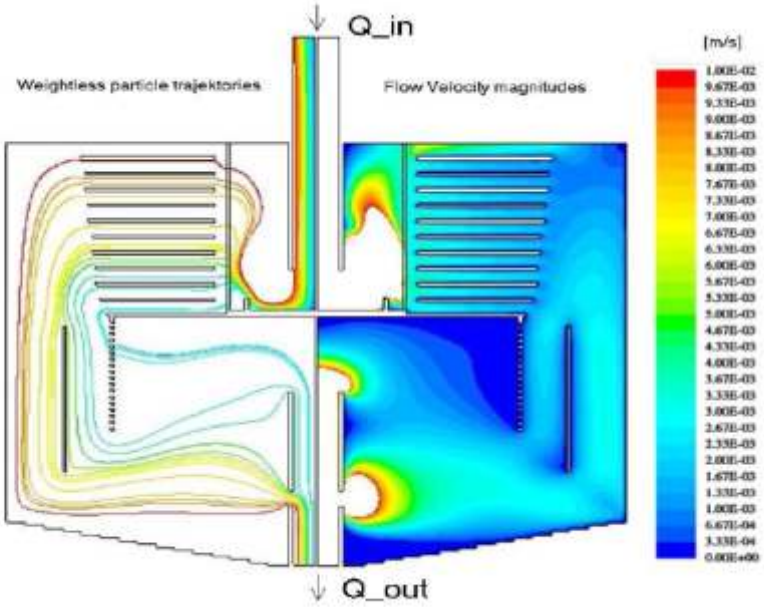
In quite the same way as the intermediate plates of the Flowline tank separate water downwards, these plates separate the air bubbles upwards.

LOWER ENERGY AND COOLING WATER CONSUMPTION

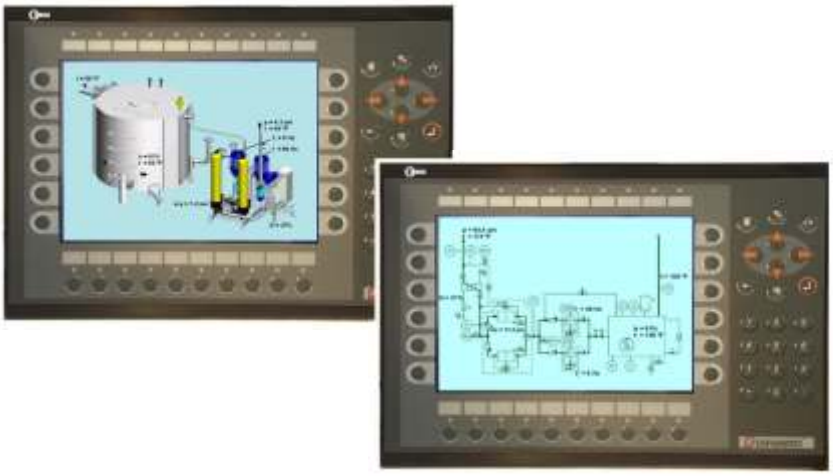
The energy consumption of the oil lubrication unit can be reduced by using components with a higher efficiency ratio. For example, screw pumps and plate type heat exchangers rather than gear pumps and tube shell coolers. However, the biggest savings can be achieved by reducing unnecessary pumping capacity.

If the oil pressure of the system is regulated by adjusting the rotation speed of pump with a frequency converter (variable speed AC-drive), the pumping unit is always operating with the optimum energy consumption. The pump is pumping exactly the amount of oil that is required by the lubrication points and no more.

The construction of this tank is shown in the following picture



Construction of Flowline tank



Lay-out display and PI Schema based display

ADVANCED SYSTEM CONTROL

Traditionally the control of oil circulation systems has been a mix of manual monitoring and few alarm based automatic operations. However while the size of the systems has increased, the optical monitoring with manual controls has became more and more complicated. Only such modern systems, which are connected to the control of the paper machine itself, have given the full range of monitoring and control including

- control and monitoring of system pressure
- control and monitoring of system temperature
- filter monitoring
- oil level monitoring
- oil flow monitoring to single lubrication points
- oil temperature monitoring in different parts of the machine

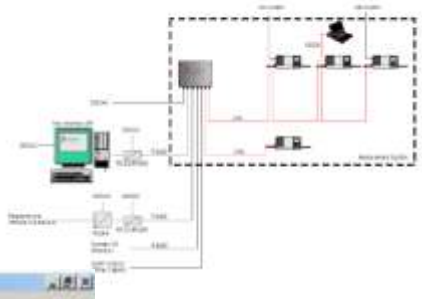
The new, PLC based control centre is utilising the modern display technology, and this will give to maintenance people the same versatile monitoring and control possibilities, which are normally used in the process control of the mill. However these control systems are independent systems and therefore it can be used in older paper machines as well, while rebuilding the lubrication system.

Advanced control system helps to identify the possible malfunctions quickly and efficient, but it will enable the full automatic start-up process of the oil lubrication system as well. Particularly in the bigger systems, the cold start-up of the lubrication will require lot of optical monitoring and manual adjustments, only to prevent the overflow of cold high viscosity oil through the bearing housings. By new Safematic control system together with automatic field control valves, the whole procedure can be done step by step.

LUBRICATION POINT OIL FLOW MONITORING

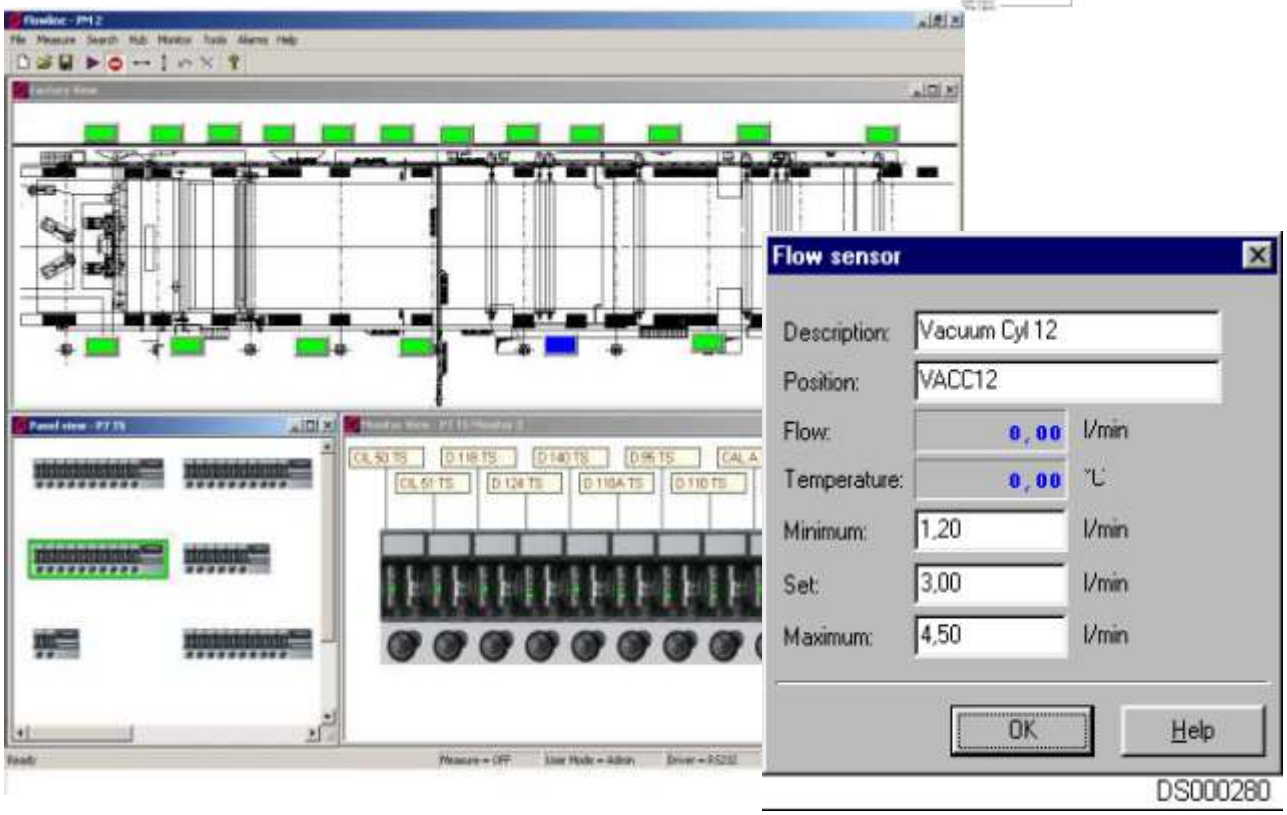
Oil flow monitoring has been done traditionally by different type of optical methods, like by sight glasses or oil rotameters. Particularly the rotameters have been developed during last ten years significantly and today they are easy operating reliable devices, specially if equipped with the electric low level alarm.

Complete turbine wheel monitoring unit, with flow display



Below the typical PC monitoring display

PC based monitoring



However the digital oil flow monitoring will give lot of advantages, by which the reliability and efficiency of the paper machine lubrication can be improved. It is also interesting to note that the price of digital monitoring has become very reasonable compared to the situation of few years ago.

The most typical digital flow meters are based on gear sensors or turbine wheel.

Although the digital oil flow monitoring is mainly done by a separate monitoring software, also the local field monitoring is absolutely required. This field monitoring is used for the oil flow adjustments, as well to solve the problem and alarm situations. The field monitoring can be done by a separate monitoring unit, which serve one or more sensor panels. However the longer distance it is from the sensors and adjusting valves to the field monitoring unit, the more complicated is the operation and adjusting of the oil flow. In this sense the complete monitoring units with the sensors and own local displays are ideal.

The monitoring software will be configured according to the system circumstances. It can be included in the paper machine condition monitoring software or it can be a separate PC based software.

The viscosity of the oil is one of the most important factor for the lubrication. Therefore the digital oil flow meters also measure the temperature of the oil supply to the bearing and if needed, automatically compensate the flow display based on viscosity changes.