Improving Paper Mill Productivity Using Thermal Imagers

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ABSTRACT

Infra Red Thermal Imagers find extensive use in Condition monitoring. However, this can also be used in Paper manufacturing where there are wide variations of temperature of the Product exists.

By obtaining thermal image of paper in different stages along the cross direction like after each press section, Dryer, in-between dryer sections before calendar, the quality of paper can be analyzed before it reaches calendar. Also condition of dryer screen along the width can be monitored.

The IR thermography is a low cost novel technique for moisture profiling of the sheet especially for low speed, small, low grade paper machines where installing Scanners cannot be justified. Thermal Imager can be a substitute as well as complimentary to Scanners.Aim of this paper is to show how thermal imagers can improve the quality and productivity of paper mills.

Introduction

The paper market is becoming increasingly competitive, with customers demanding higher and higher quality specifications. The unique effectiveness of infrared inspection for predictive maintenance and process monitoring tasks in Paper mills have become a central factor in assuring uptime, maintaining productivity and product quality and preserving profits.

Infrared imaging allows for non-destructive and non-invasive monitoring of machines and processes. It also allows users to create new methods of examining operations, which greatly help in problem-solving.

The Paper Industry has numerous processes that can provide a thermal imprint. The papermaking process is based on water removal through drainage, mechanical pressing and, the application of heat.

The need to meet the increasing production volume as well as paper quality requirements puts significant pressure on fine tuning of the old paper machinery. There are numerous 15-30 years old paper machines that still have years of mechanical life time ahead but which should be modified to meet the increasing speed and efficiency requirements.

Infrared monitoring can play a vital role in maintaining paper quality and uniformity throughout the preproduction, forming, pressing, and drying stages of the papermaking process.

Some IR cameras can provide real-time infrared video imaging of temperature variations in the wet paper web, which indicate variations in moisture distribution, which in turn affect paper strength, printability, and convertibility. Infrared imaging can also detect barring in the sheet due to size press or press roll wear, wet streaks in the sheet caused by plugged areas in vacuum rolls or vacuum boxes, problems with steam box actuators, condensate flooding, scale and corrosion on dryer cans and dryer can imbalance, plugged, wrinkled, perforated or burned areas in press felts, roll cover delaminations, etc.

Paper quality variations in the machine direction can be reduced with greater ease when a fast real paper quality indicator is available. It is easier to track the root cause of variations .Naturally, this leads to better paper uniformity. The potential to save energy and increased production is remarkable and the uniformity of paper quality can improve noticeably.

The paper takes a look at problems on a paper machine that can cost thousands to millions of rupees annually in off-quality production and customer dis satisfaction.

The paper highlights the applications and presents infrared thermography as a novel technique to deal with several requirements, which are difficult to perform with other techniques.

Using the IR camera, we are able to “see” things, which are not visible to the eye.

Literature Review - Paper Machine Problems

The paper machine is a complex system with both the addition of water and removal of water through numerous concurrent processes including chemical, mechanical, heat and mass transfer components for the paper. Steam and water cleaning systems are also used in papermaking. This combination of processes makes it extremely difficult to troubleshoot at times.

Forming Stage

Most of the paper machines have scanning measurement and control of basis weight and moisture. The problem with these systems is that they can find and correct stable cross direction variation and long-term variation in the machine direction. The most problematic range for these controls is from 10 to 100 s. If paper machine speed is 20m/s this is from 200m to 2000m in the length of paper.

In the basis weight, only variations before press section can be seen. On the contrary, variations in pressing, drying, surface sizing and calendaring can not be seen.
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Pressing Stage

The complexity of paper machine and process makes it difficult to find the root cause of the problems that affect press section. The increased use of recycle furnish along with increased water recycling provides new challenges in maximizing efficiency and performance.

Large no of variables effect run-ability and efficiency of press section such as permeability, surface condition and void volume of press fabric. Good clothing condition has positive effect on dewatering efficiency and thus energy use, profile surface finish, bulk and a myriad of factors as well as operating expense such as fabric life.

Contaminants, poor showering, press loading, mechanical cleaning of felts, recycle fiber usage, water closure, machine operating temperature, pitch fines, fillers and specific wet additives all contribute to felt filling, compaction and felt wear.

Contaminants can be affected by heat, chemicals and kinetic energy.

Usually fabric temperatures are kept as close to sheet or system temperatures to avoid negative impacts on dewatering or other adverse sheet interaction.

Moisture Streaks in Felts

Paper makers can diagnose the problem of wet felts in following order: Felt wear out, Crushing at press nips. Press vibration, plugged felt conditioning shower, Unevenfelt filling, uneven moisture profile, and Blocked suction holes for press rolls. Poor sheet dewatering, misaligned press rolls, Uneven roll cambering, Uneven loading at edges, conditioning systems. Oscillating Shower performance. Uneven moisture profile of the parent roll. Uneven and damaged press rolls cover.

The presence of contaminants and fabric water retention can be easily diagnosed using IR thermal camera.

Drying Stage

Contaminants of Dryer Fabric

High speed machines are particularly sensitive to loss of dryer fabric permeability and the resulting effects on sheet handling. Build-ups on dryer fabrics can also become dislodged during paper manufacturing, resulting in defects and breaks.

Contamination can negate many of the important properties, making the dryer fabric little more than transporter of the sheet. In the worst case, this can lead to sheet defects, poor moisture profile and ultimately end user dissatisfaction. Dryer fabric performance contributes greatly to the paper machine running efficiently, producing high quality paper and operating at the lowest possible cost.

No dryer fabric alone can run contaminant free. All fabric structures require cleaning mechanisms to remove and dislodge contaminants.
Paper machines that use recycled fiber are more susceptible to these issues, but this situation can also occur in virgin furnishes from pitch, starch and coating materials such as latex. For removal of paper machine contaminants when the deposit load exceeds the system's capacity to purge on its own, the application of mechanical action (e.g., high-pressure showering), high temperature water and the correct chemical cleaning agent will yield the optimum result, especially when these factors are combined. Thus, fabric properties and performance can be maintained over the clothing lifetime. This integrated approach effectively prevents and removes contaminants from the fabrics and paper machine surfaces in a safe and effective manner during production.

According to market assessment, about 50% of the paper and paper board machines installed are having drying limitations. This prevents many paper producers from increasing production on existing machines. The reality is that drying section requires 60-70% of the total power required by paper machines. Improvement in dryer section ensures considerable saving in energy and also increases productivity.

Adoption of improved cleaning methods is one such improvement. But how often this can be done can be determined by taking IR images.

Poor Heat Transfer

The wet fiber sheet is conveyed to the dryers through dryer felts. The primary function of a dryer fabric is to keep the sheet in contact with the dryer cylinders to provide maximum heat transfer from the cylinder to the sheet. If a wet object is placed against a heat source, the water on the surface will heat up. In the case of paper, the evaporation of the heated water creates a positive pressure that ends to lift the sheet off the dryer. This reduction or loss of contact with the dryer will result in poor heat transfer and poor drying efficiency.

Poor ventilation

The other associated problems in the paper dryer SECTION are inadequate ventilation due to clogging of the wires with contaminants and poor ventilation conditions. With better ventilation, it is possible to improve evaporation and even the pocket/sheet moisture profile. It also affects steam consumption of the cylinder and therefore saves energy costs.

Methodology of the Case Study

The data has been collected from Seven old paper machines (25 -30 years) manufacturing various grades of product like News print, WPP, Kraft and Board at different locations.The images obtained in machines having online scanners were excellent . Problem areas were found only in machines without scanner

and one which uses recycled fiber and producing Kraft paper. The Thermal imager used was low cost 100x100 pixels.

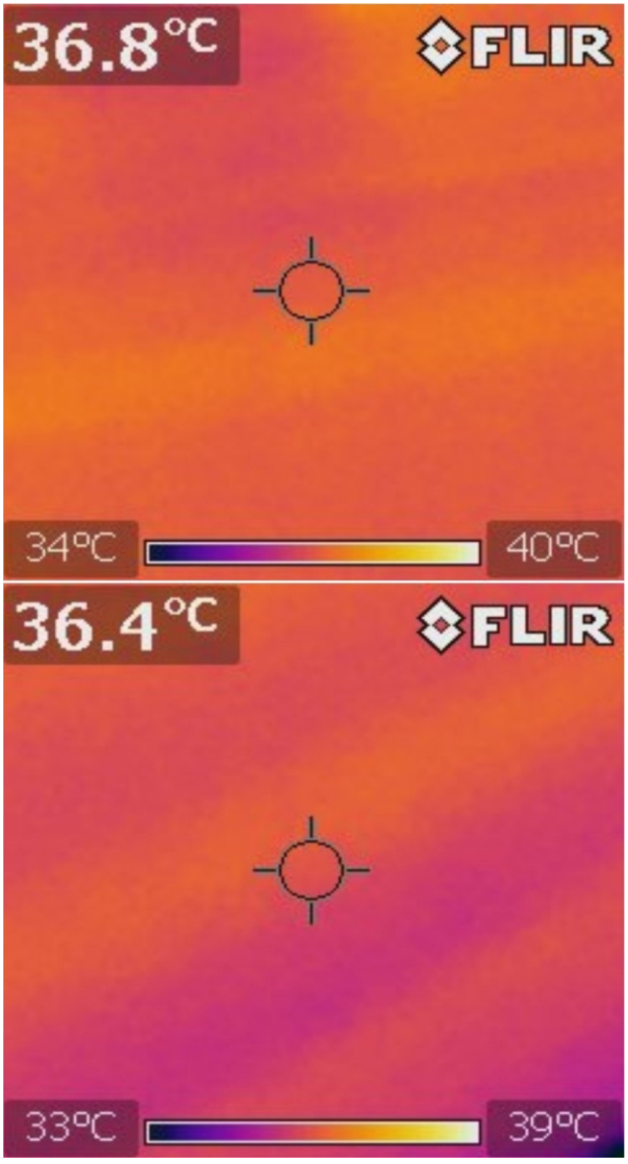
To get image of full width, images are joined together horizontally or vertically depending on the location. In high-end models, Image Builder software automatically "stitches" individual thermographs of adjacent views into one fully thermal collage.

For high resolution defect images, the web is typically illuminated with a light beam. LED's are used like stroboscopic lights; the LED's are switched on for 5-10 Microseconds depending on application. This short exposure time allows a smear free and crystal clear image of the web. This also allows good penetration through heaviest board and pulp sheets.

Results and Discussion

Press section fabrics use high-pressure showers to keep them clean. Sometimes the shower flow-pattern is transferred to the paper web as illustrated in **Fig 1.**

Fig 1 .Web after 2nd press. Purple streak shown by arrow is transferred from the felt.



This condition can cause problems in the dryer section, such as rusting of return rolls which in turn leads to premature wear of the dryer fabric. In this analysis, the shower nozzles turned out to be worn and were putting more water into the press fabric than could be taken out, thus transferring wet streaks to the paper. Paper containing moisture streaks can adversely influence quality and performance of the paper in a subsequent converting and printing processes.

Fig 2 & **Fig 3** shows the shower pattern on the Press section fabric.

Fig 2 : Image of 2nd Press felt after pressing shows Moisture retention. Dark Band is due to concentration of shower jet at one point.

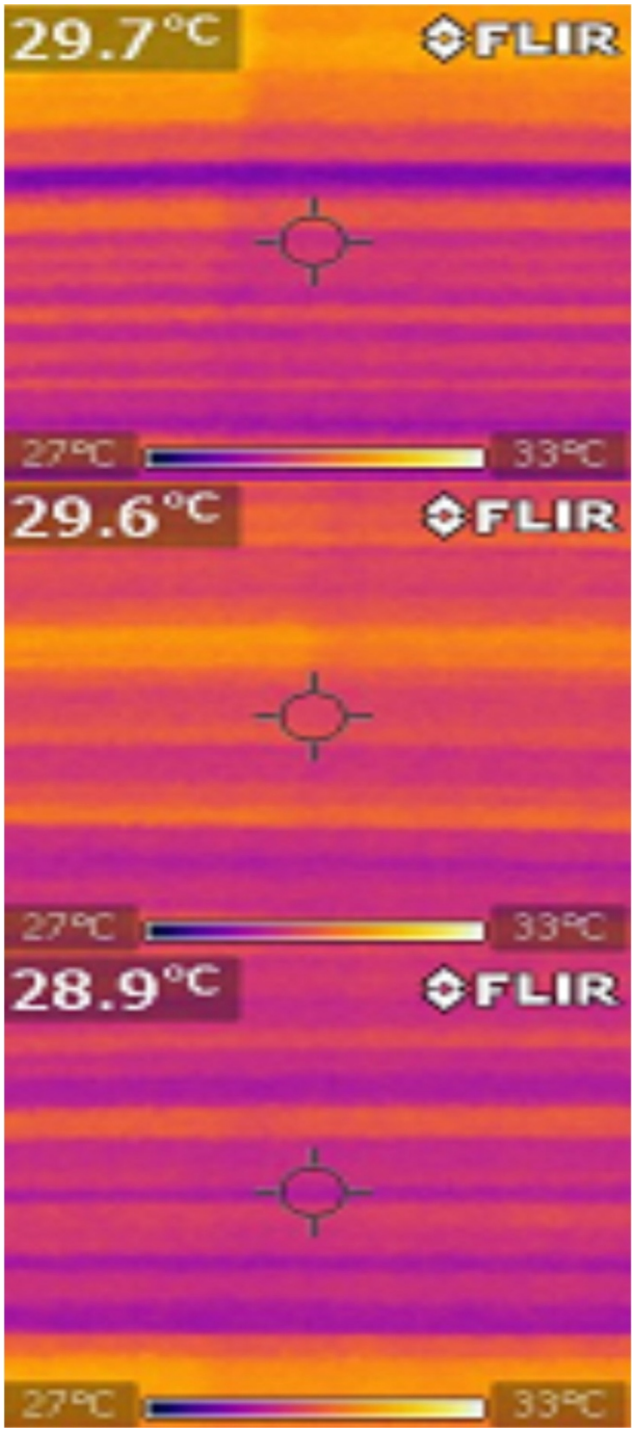
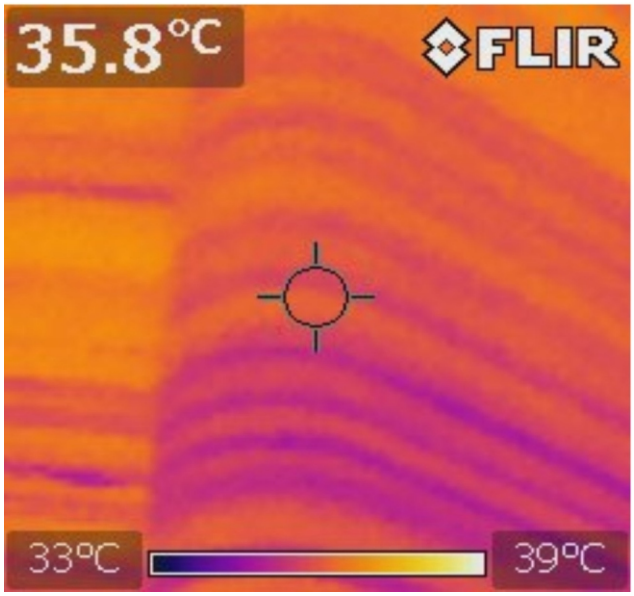
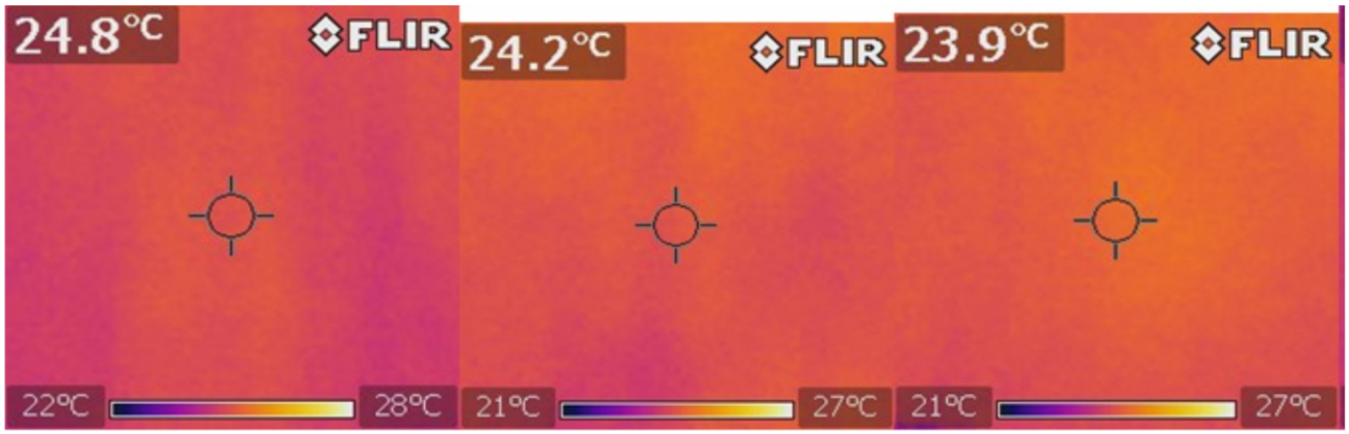


Fig 3: Image of Felt after nip and shower.



This was found to be transferred the paper to the second bottom dryer section fabric, which is downstream in the paper manufacturing process. After replacing the high-pressure shower nozzles, the shower nozzle pattern can no longer be seen (**Fig 4**) in the dryer fabric.

Fig 4: After rectifying the showers



2nd Press Felt Taken From Bottom

Felt Moisture Profile

Felt moisture profile taken after the nip across the full width of the felt help in diagnosing the press and felt related problem, which are normally difficult to detect and are usually identified by scanpro moisture profiler.

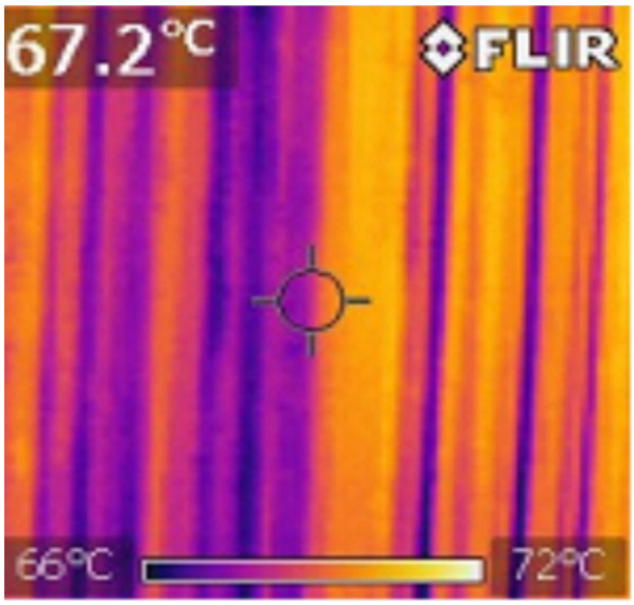
Thermal Imager of high resolution also can be used to take image of Felt moisture profile. For low cost, low resolution imagers, use of LED flash light gives considerably good image.

Limitation is the speed of the machine. In case of high speed machines, Thermographer can not find a vantage point due to water spray which may spoil the lens. In low speed machines, images can be taken from sides.

Drying Stage

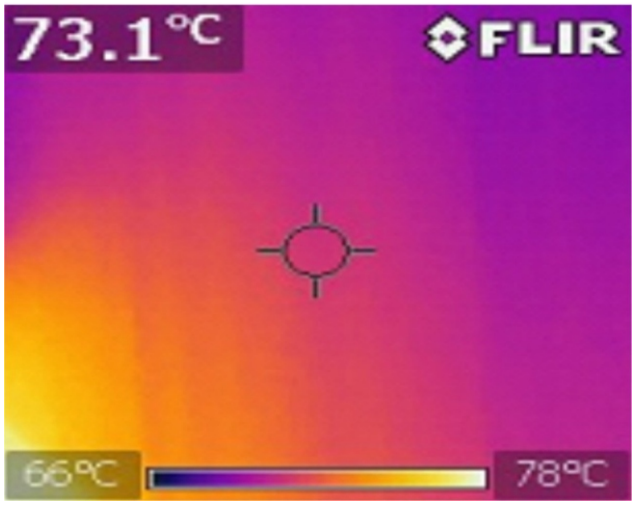
Fig 5 and **Fig 6** shows paper entering and leaving the dryer cylinder respectively. Heat transfer from the dryer surface to paper can easily be seen throughout the width.

Fig 5: Web before entering the dryer cylinder



Web before entering dryer cylinder

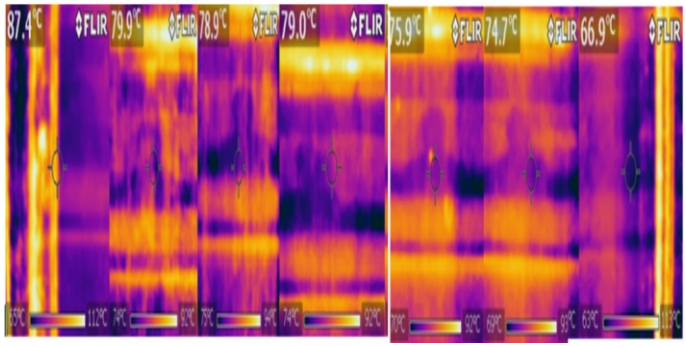
Fig 6: Web leaving the heated cylinder



After Leaving the heated cylinder

An infrared imaging inspection of paper coming off the mill can even reveal a failing dryer roller. **Fig**7 shows CD profile of a dryer cylinder.

Fig 7 .Image of Dryer cylinder. Vertical Band on either ends or bright portions is rust formation. Here temperature is high, indicating improper heat transfer.



Screen Contaminants

A mill was getting complaints from a printing customer where a wet spots on the paper was causing problems in processing some of the paper. The source of the problem was identified using an IR camera (Fig **8)** in the drying section screen contaminants.

Fig 8: Image of Dryer Screen shows lot of patches .White patch indicates blocking of pores of screen by stickies. Thick purple patches are holes.

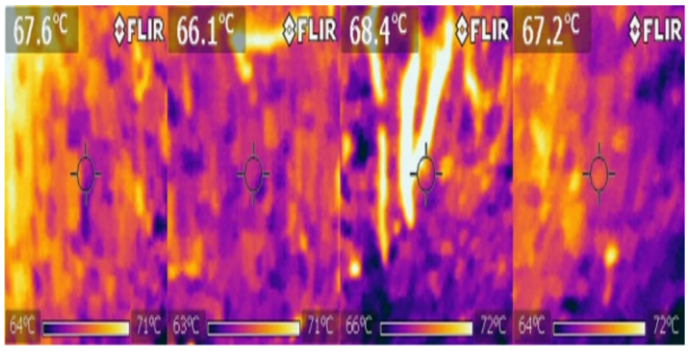
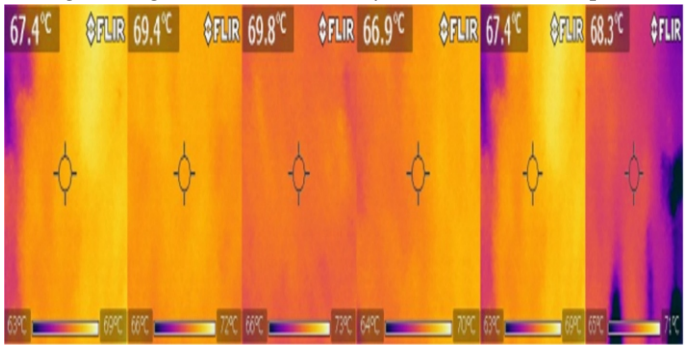


Fig 8 shows a very poor CMD profile. The problem in this case was identified to originate due to improper dryer-cleaning shower and non existent continuous cleaning system.

After cleaning the screens using high pressure shower pump the CMD profile shows much improvement. .The **Fig 9**] image

Fig 9: Image of Good bottom Dryer Screen after Size press.



shows a Unirun dryer section fabric shot from the basement looking up to the first dryer section which is a good Cross Machine Direction (CMD) profile.

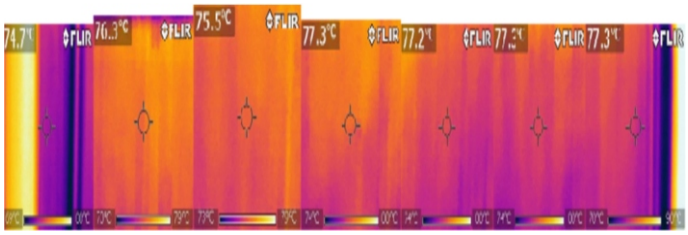
Water Logged Cylinders

Imaging of dryer cylinders reveals host of problems associated with them. One of the cylinders was operating at 84°C while other cylinders in group were showing higher temperature. Later it was found to be water logged.

Monitoring Of Performance Dryers

Problems such as excessive edge wear is shown in **Fig 10**, repetitive surface wear, out-of-round dryer, skipped crepes, excessive doctor blade loading, sheet plugging, uneven dryer coating, steam leaks and many more can be detected.

Fig 10: Image of bottom Dryer Screen .The dark streaks are due to edge wear out on either ends.



3rd DG bottom screen (Dark Streaks of Moisture seen)

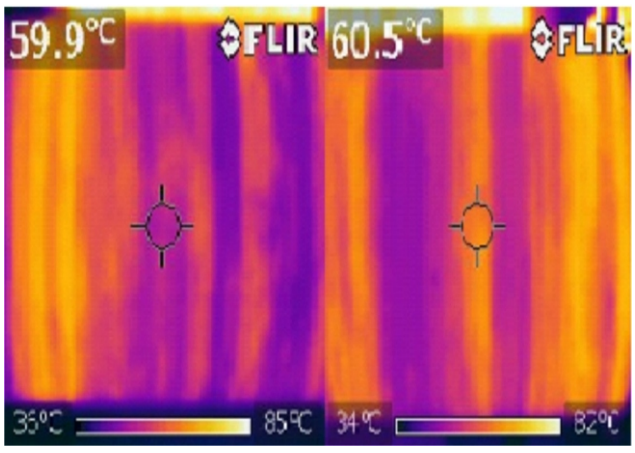
Detection of Stickies

Deposition of stickies can be found on the dryer screens due to different thermal conductivity, it is easy to identify based on the relative cooling that each achieves following a period of heating. This method showed promising results for pure stickies, But mill stickies are nearly always a mixture of several adhesives, are not clearly visible **Fig 8**

Paper Roll

Pope Reel thermal image shows lines of moisture, a critical paper quality factor, on a paper spooling roll. The purple bands indicate too much moisture in that area. **Fig 11**

Fig 11: Image of pope reel of Kraft machine from 10ft distance

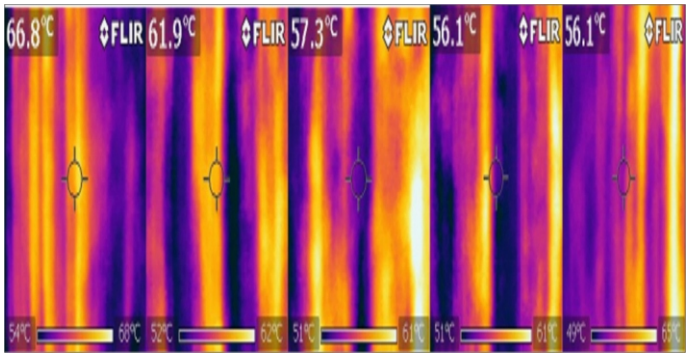


Pope Reel CD Moisture Profiling

The variations in the sheet moisture at the reel taken from Scanners are usually found to correlate with the temperature difference observed by the Thermal Imagers

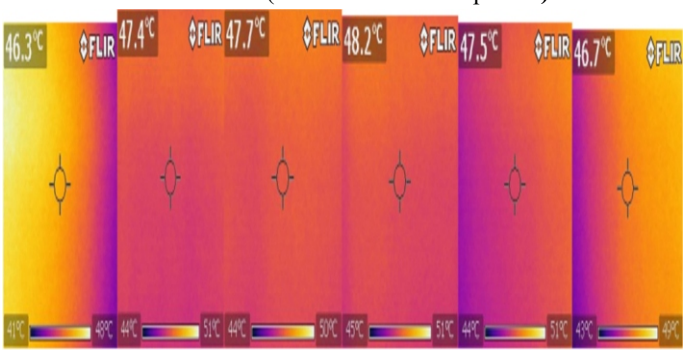
Paper with lower moisture content is warmer as compared to that at higher moisture content. **Fig 12 shows** a poor CD moisture profile of pope reel with thick stripes of moisture.

Fig 12: Image of pope reel of Kraft machine from 4ft distance (Poor CD moisture profile)



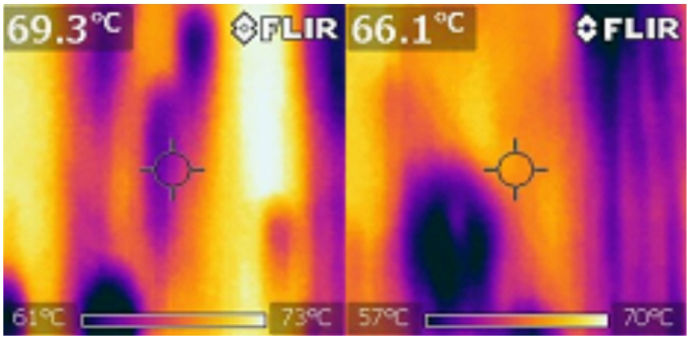
The images are taken at a distance of 10 Ft and 4 Ft respectively. **Fig 13** is good CD moisture profile of pope reel

Fig 13: Image of Pope Reel of WPP MACHINE at 4ft distance. (Good CD moisture profile**)**



If the paper has a wet spot, it could be invisible to the eye, but not to the, infrared digital camera **Fig 14** shows spots on the paper due to contaminants which were eliminated after cleaning of dryer screens.

FIG 14: Image of web after calendar showing spots due to contaminants in fabrics



Optimization Programs

It is suggested that the mills can perform an imaging of the Paper machines once in day starting from Press section, between dryers, Screens top and bottom in all the dryers, calendar rolls and pope reel etc.The complete imaging takes hardly one hour but it is worth its effort as host of problems can be identified before it turns in to a catastrophe.

Conclusion

Effective use of Thermography has potential to reduce web break losess by 25%.

The mills can realize a return on investment very quickly while benefiting from the other intangibles of infrared windows. Namely: The ability to inspect the previously un-inspectable equipment

The Thermographer has to know each process of the paper machine that can add or remove heat and change the image. A lot of valuable time can be wasted trying to correct a misdiagnosed problem.

Small Mills can adopt IR imaging methods to achieve significant increase in machine speeds, operating efficiency and reduced energy costs. Those who can not justify investing for an Online Scanner, use of IR camera can improve their quality significantly.

Some problems on the paper machine are very easy to analyze and solve. Some problems can take several months to track down the root cause. The infrared camera is a great tool to isolate the area of the problem by providing thermal images of heat differential not visible to the eye. This can save a lot of valuable time and money in maintenance costs, improved quality and customer satisfaction.

The IR thermal imager is a new power tool for papermakers to better monitor and control the paper quality and to maximize the sellable paper tonnage and production profitability.

It is quite impossible to tune the process or make decisions about paper quality with only laboratory measurements of moisture by taking samples from every machine reel in one to two hours interval.

A properly designed optimization program will help in the improvement of performance and productivity

Thermal Imager helps in diagnosing the problems of Press water removal, felt contaminants, Dryer screen contaminants, Dryer heat exchange etc. Taking proper action related to all the above can offer.

1. improved sheet quality due to more uniform pressing,
2. Increased production due to increased speed, reduced rejects caused by moisture variation vis a vis minimization of wet streaks.
3. Elimination of sheet spots holes, cracked edges, crushing etc.
4. reduction of steam consumption
5. Reductions in down times to batch wash fabrics.

Acknowledgements

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