ACHIEVING OPTIMAL RUNNABILITY AND COST EFFICIENCY IN PAPER MACHINES WITH PROPER MAINTENANCE OF RUNNABILITY COMPONENTS

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The efficiency of a paper machine can indeed be significantly impacted by the effectiveness of paper web transfer through the drying section. Single-tier drying sections, in particular, can present challenges due to the forces that hold the wet web on the cylinder, which can impede the smooth transition of paper from the cylinder to the bottom vacuum roll.

To address these runnability issues, it is important to maintain a certain level of underpressure in the dryer pocket. The underpressure is directly proportional to the forces that prevent smooth transient through the drying section. Runnability components are used to generate the necessary underpressure, which facilitates paper transfer from the press section to the drying section and stabilizes it on the fabric.

The choice of runnability components is crucial and may vary depending on the speed of the paper machine. These components are specially designed to ensure optimal runnability and cost-efficient production. Regular servicing and maintenance of runnability components are also necessary to ensure that they continue to function effectively and efficiently.

By maintaining the right level of underpressure in the dryer pocket and ensuring smooth paper transfer through the drying section, it is possible to improve the efficiency of the paper machine and reduce the risk of bottlenecks that can cause paper breaks and decrease paper production.

POSTIZANJE OPTIMALNE STABILNOSTI I EKONOMIČNOSTI U RADU PAPIRNOG STROJA KROZ PRIMJERENO ODRŽAVANJE STABILIZATORA PAPIRNE TRAKE

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Efikasnost papirnog stroja uvelike ovisi o efikasnosti prijenosa papirne trake kroz sušnu skupinu papirnog stroja. Međutim, u slalom skupini susnog dijela papirnog stroja, fizicke sile koje drže mokru papirnu traku na cilindru mogu stvoriti usko grlo koje ometa nesmetani prijelaz papira s cilindra na donji vakuumski valjak.

Da bi se riješili problema vodenja papirne trake kroz susnu skupinu, važno je održavati određeni negativni podtlak u susnom džepu, koji je izravno proporcionaln silama koje sprječavaju nesmetani prijelaz papirne trake kroz sušioni dio pairnog stroja. Upotreba specijalnih stabilizatora u susnim dzepovima omogucava generiranje potrebnog negativnog tlaka koji omogucava prijenos papirne trake iz partije presa u susnu skupinu i stabilizira papirnu traku na susnom situ.

Odabir pravilnih stabilizacijskih komponenata i redovito održavanje tih komponenti je kljucan za postizanje optimalnog i efikasnog rada papirnog stroja.

Održavanjem odgovarajuće razine negativnog tlaka u susnom džepu papirnog stroja i osiguranjem nesmetanog prijenosa papira kroz sušioni dio moguće je poboljšati efikasnost papirnog stroja i smanjiti rizik od uskih grla koja mogu uzrokovati prekide papira i smanjenje proizvodnje papira.

INTRODUCTION

Runnability issues within the press and dryer sections have long been a challenge for papermakers. Various problems, such as tail threading difficulties, edge fluttering, wrinkles, high draws, curling, and edge flutter, can arise due to airflow and boundary layer disturbances. Addressing these problems requires a comprehensive understanding of the forces affecting the paper in a single felted section (Leimu, J., (2012)). However, there is a prevailing misconception among customers that runnability devices are of minor importance in the papermaking process. This article aims to dispel this notion and emphasize the crucial role of runnability devices in achieving efficient production, energy savings, and high-quality paper.

FORCES THAT AFFECTING THE WEB IN SINGLE-FELTING GROUP

The efficiency of a paper machine relies heavily on the smooth transfer of the paper web through the drying section. In a single-tier drying section, the forces that keep the wet web attached to the cylinder and restrain the seamless transition of the paper from one cylinder to another act as bottlenecks for optimal runnability.

To achieve good runnability on a paper machine, it is essential to comprehend the forces affecting the web during the paper transfer in the drying section and proactively address them. After passing through the press section, the wet paper becomes attached to the cylinder and is pressed by the fabric. However, as the paper leaves the top cylinder (top open nip), it tends to remain attached to the cylinder instead of transferring smoothly onto the fabric and reaching the bottom roll (Figure 1).

Two dominant forces significantly influence the behavior of the web. The first is the adhesion force between the paper and the cylinder, which encourages the paper to stick to the cylinder's surface. The second force is the open nip force, which arises due to a two-component rotational air boundary layer between the cylinder and the fabric. These forces have a negative impact on the web's movement and runnability.

To mitigate the adverse effects of these forces, runnability boxes are installed in the dryer pocket. These boxes create an underpressure that counteracts the negative forces, promoting stability of the web on the fabric and facilitating smoother paper transfer.

By strategically employing runnability boxes and utilizing the underpressure they generate, papermakers can effectively enhance runnability in the drying section, optimizing paper machine efficiency and minimizing disruptions caused by inadequate web transfer.

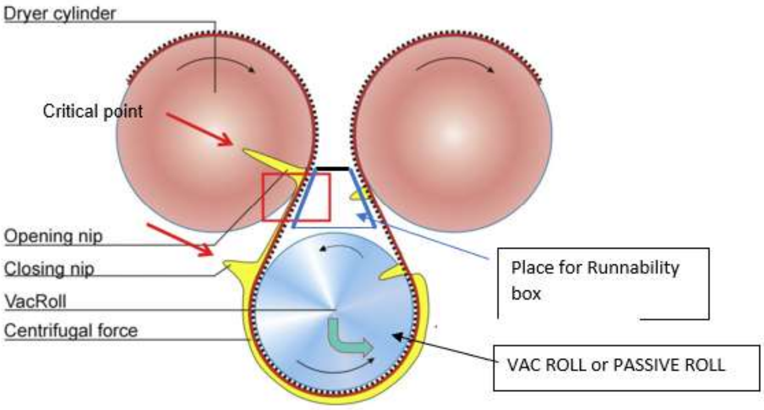


Figure 1. The forces that affecting the web (source: Milosavljevic, N., (2008)).

There are two main principles commonly used to create underpressure in the drying section and maintain the paper on the fabric, thereby ensuring good runnability on a paper machine.

The first principle (Air blowing principle -Coanda effect)

Many suppliers choose runnability boxes based on the air-blowing principle, specifically utilizing the Coanda effect, to generate a vacuum within the pockets and ensure favorable runnability of the paper web.

The air-blowing principle, relying on the Coanda effect, offers several benefits. It eliminates the need for physical sealing between the runnability boxes and the fabric, making it a reliable solution. The basic idea behind the Coanda effect is to direct air along curved surfaces, creating a negative pressure zone. This negative pressure effectively holds the paper web onto the fabric, preventing it from detaching or deviating from its desired path.

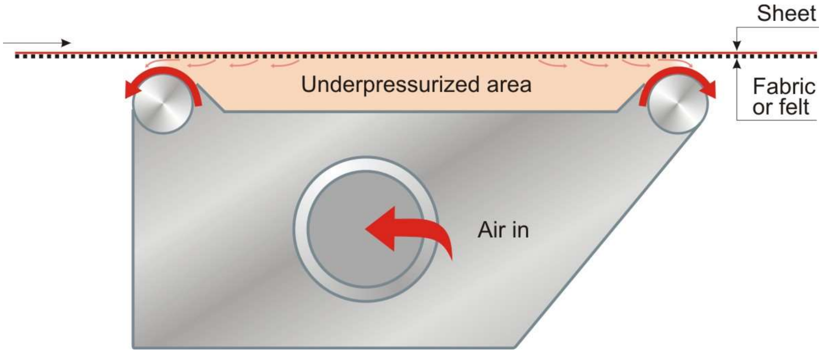


Figure 2. The principle of creating underpressure using air blowing around curved surfaces-Coanda effect (Courtesy of Valmet, Milosavljevic, N., (2014)).

The second principle (Direct air sucking – Vacuum cleaner effect)

Other suppliers of runnability boxes utilize direct sucking or the "vacuum cleaner effect" to generate underpressure and maintain the paper web on the fabric during paper transfer.

Direct air sucking requires less air and energy to create the desired underpressure and stabilize the web. However, it is important to note that this method is effective only under controlled conditions, such as proper physical sealing to the fabric without any air leakages.

Damages to the sealing can lead to uneven distribution of underpressure, fabric bending, and potential web breaks. When the sealing is compromised, particularly during periods of uncontrolled fabric tension, it becomes challenging to maintain precise control over the process.

It is crucial for papermakers to be aware of these considerations and assess the trade-offs between different runnability box options. Each approach has its advantages and limitations, and careful evaluation of the specific requirements and operating conditions is necessary to determine the most suitable solution for achieving optimal runnability while managing energy consumption and minimizing potential risks.

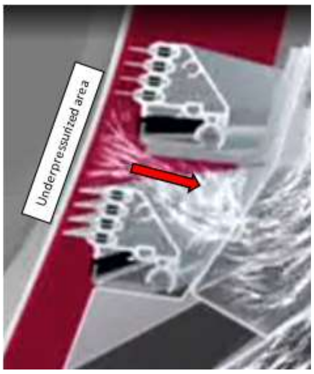


Figure 3. The principle of creating underpressure using direct air sucking -Vacuum cleaner effect (source: Internet).

Visually monitoring the runnability devices

The papermaking process is inherently messy, and even the most advanced runnability systems can quickly lose their efficiency if proper and regular maintenance and servicing are not carried out. Taking a hands-on approach and visually monitoring the runnability devices are crucial for their efficient operation.

The consequences of operating a paper machine with neglected runnability systems can be seen in the accompanying photos (Fig. 4, 5). Figure 4 illustrates the presence of plugged nozzles, which restrict and reduce the uniform distribution of air in the machine direction. Such conditions can lead to uneven drying and negatively impact the overall runnability and quality of the paper produced.

Figure 5 depicts the impact of destroyed physical sealings and formation of a single zone instead of two separate zones. This results in high underpressure within the entire zone, particularly in the bottom section. Consequently, this leads to considerable fabric bending and an increased risk of fabric breaks throughout the affected area.

Figure 4a. Blocked nozzle slots

Figure 4b. Impurities in blowing slots

Figure 5a. Damaged physical sealings

Figure 5b. Plugged suction openings

RUNNABILITY SYSTEMS AT PM2 and PM3 (DS Smith Croatia)

The runnability systems implemented on PM2 comprise four stabilization air boxes located in the slalom group (Figure 6). These boxes operate based on the well-known Coanda effect, which was introduced by Valmet in the 1980s. By introducing airflow around a curved surface, a negative pressure is created in the space between the box and the fabric.

Runnability systems on PM3 consists of two stabilization blow boxes between press and drying section and, two blow boxes in the first drying pocket and three single boxes in the rest of the slalom group.

This generated pressure effectively keeps the paper web on the fabric, ensuring good runnability between the upper and lower cylinders. It is worth noting that these air boxes are relatively simple solutions and are typically used for smaller paper machine speeds.

However, a limitation of these solutions is that they only control one side of the drying section, leaving the other side unsupported. This can present challenges in maintaining control and stability. If the runnability solution lacks vacuum roles, such as a bottom cylinder in the slalom group, the problem becomes even more difficult to manage. In such cases, the bottom rolls typically consist of grooved, unheated cylinders, which are commonly used in lower-speed machines.

To address these challenges, it may be necessary to explore additional runnability solutions that provide support on both sides of the drying section and offer better control and stability for the paper web.

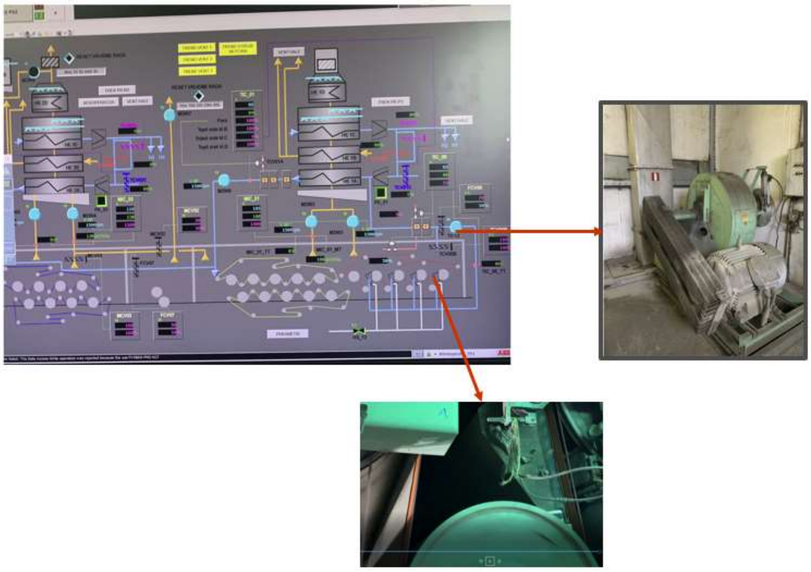


Figure 6. Runnability systems at DS Smith Croatia PM2

When the paper is not adequately controlled with runnability boxes, various issues can arise, such as the appearance of wrinkles, detachment from the fabric on both the front and backside, and the formation of air bubbles (Figure 7). These problems can lead to extended tail threading times, reduced efficiency, and loss of production time.

Figure 7. Detachment from the fabric and air trapped between fabric and paper

Indeed, problems in runnability and power consumption can escalate if the equipment is not regularly serviced and maintained in a timely manner. Even small modifications, adjustments, and balancing of air flows in heat recovery systems can yield significant improvements (Figure 8). It is unfortunate that runnability and power consumption issues often become apparent when they start disrupting production and causing increased energy consumption. However, these problems can be mitigated through proactive measures.

Figure 8. Regular maintenance of runnability components (findings: depositions of dirty in blowing slots)

RUNNABILITY MEASUREMENT AT PM2 and PM3

In the slalom group of PM2, the drying section comprises drying cylinders positioned at the top, with unheated grooved rolls serving as the bottom cylinder (Figure 9). To stabilize the paper web, four blow boxes are installed in the dryer pockets.

However, upon opening the hood doors, issues with web stabilization and detachment of the paper from the fabric, as well as the formation of bubbles, become apparent.

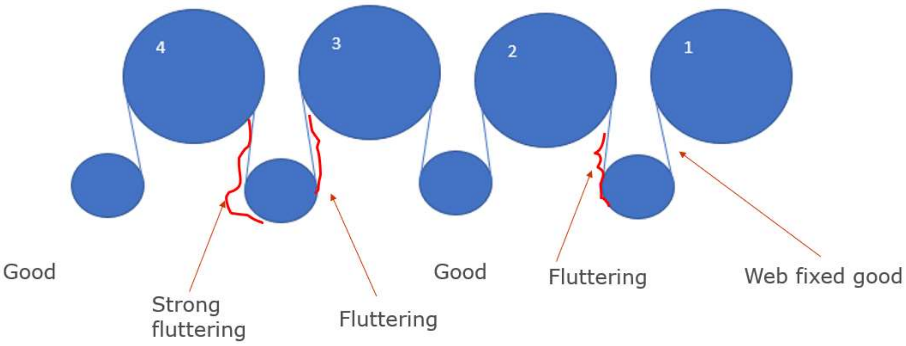


Figure 9. Web behaving in slalom group PM2

To assess the performance of the runnability devices in creating negative pressure, measurements were taken at two specific positions between the fabric and paper. The first measurement location was at the opening nip position, which is where the paper exits the top cylinder. The second measurement location was at the closing nip on the bottom cylinder (Figure 10).

By measuring the negative pressure at these specific positions, papermakers can evaluate the effectiveness of the runnability boxes in creating the desired vacuum level. This information is crucial for assessing the runnability performance of the paper machine and identifying any potential issues or areas for improvement.

Accurate and consistent measurement of the negative pressure generated by runnability devices provides valuable insights into their functionality and allows for adjustments or optimization if necessary. It helps ensure that the runnability systems are operating within the recommended range and facilitating proper web stabilization throughout the drying section.

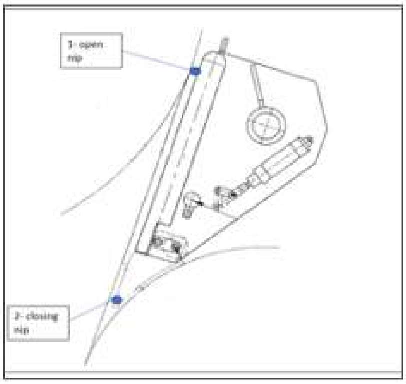


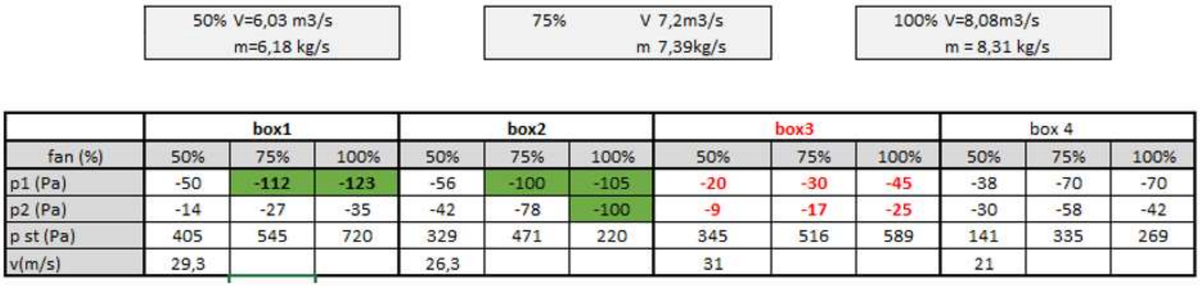
Figure 10. The measuring places at runnability box (source: Internet)

The measured values in Table 1 represent the negative pressure generated by the runnability boxes at different fan power at the PM2. The measurement variable was expressed as a percentage of the fan power, ranging from 50% to 100%.

At the opening nip position, the negative pressure increased progressively as the fan power percentage increased. The measured values ranged from -20 Pa at 50% fan power to the value of -123 Pa at 100% fan power.

Similarly, at the closing nip position, the negative pressure showed a similar pattern of increase with increasing fan power percentage. The measured values ranged from -9 Pa at 50% fan power to -100 Pa at 100% fan power.

Table 1. Measuring results of runnability components at PM2



50% V=6,03 m3/s
m=6,18 kg/s

75% V 7,2m3/s
m 7,39kg/s

100% V=8,08m3/s
m = 8,31 kg/s

	box1			box2			box3			box 4		
fan (%)	50%	75%	100%	50%	75%	100%	50%	75%	100%	50%	75%	100%
p1 (Pa)	-50	**-112**	**-123**	-56	-100	-105	**-20**	**-30**	**-45**	-38	-70	-70
p2 (Pa)	-14	-27	-35	-42	-78	-100	**-9**	**-17**	**-25**	-30	-58	-42
p st (Pa)	405	545	720	329	471	220	345	516	589	141	335	269
v(m/s)	29,3			26,3			31			21		

The obtained results indicating very low negative pressure values across all runnability boxes, even at maximum fan power, are concerning. The problem appears to be most prominent at the position of Runnability Box 3, where the negative pressure values are extremely low regardless of the fan power.

After the service of the box no.3, the underpressure of the runnability device improved (leading to better web control and enhanced overall performance of the paper machine.

Table 2. Performance of the runnabilty box no.3 before and after the maintenance at PM2

Underpressure (Pa)	Before cleaning (15.01.2022)	After cleaning (2.03.2022)	Improvements %
P1	-45	-104	131
P2	-25	-78	212

Following the service and optimal adjustment of the runnability boxes at the PM3, a substantial improvement in their performance has been observed, with their efficiency nearly doubling. Figure 11 shows improvement of the underpressure after detail box maintenance at PM3 and the positive impact of maintenance and adjustment of runnability components at PM3 (Figure 12). The improved performance of the runnability boxes leads to better web control, minimized web breaks, and reduced downtime.

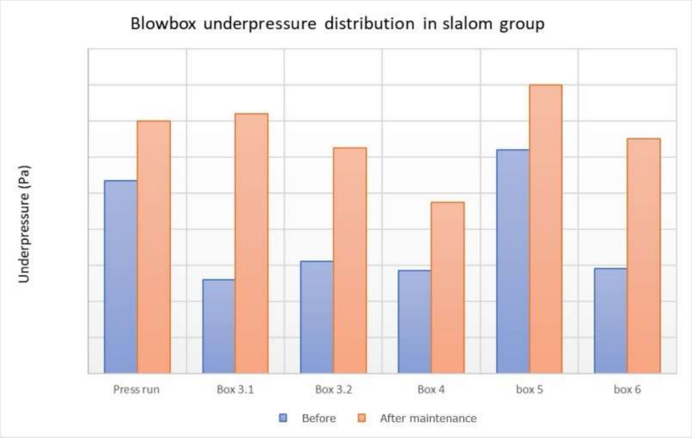


Figure 11. Improvement of the underpressure after detail box maintenance at PM3 (blue-underpressure in boxes before cleaning, red – after cleaning)

Figure 12. Lost time for breaks and no. of breaks per day at PM3

The benefits from the service performed on the runnability boxes at PM3 include increased underpressure at runnability boxes by 30-100%, a reduction in lost time for breaks from 25.3 hours per month to 13.7 hours per month, and improved tail threading. The number of breaks per day has also decreased from 2.7 to 1.5.

CONCLUSIONS

The enhanced runnability and web control resulting from the maintenance activities have facilitated smoother and more efficient tail threading operations at PM2 and PM3. As a result of these improvements, the overall efficiency of the paper machine has increased. The reduction in web breaks and improved tail threading process have contributed to a more seamless production flow, minimizing downtime, and maximizing the machine's output.

To ensure effective web stabilization, runnability boxes should be capable of generating sufficient vacuum to keep the paper firmly fixed to the fabric. Ideally, this type of runnability component should be able to create a negative pressure of at least -200 Pa. However, a recommended value for good runnability is typically considered to be higher than -100 Pa.

In terms of paper production, at the PM3, the 12-hour reduction in lost time for breaks translates to approximately 150 tons of paper per month or 1,800 tons per year. This improvement represents a significant increase in productivity and cost savings for the paper mill.

It is important to educate the paper machine crew about the significance of keeping the runnability devices clean and properly adjusted. Additionally, selecting appropriate fabric permeabilities and keeping them clean is vital. When the fabric becomes clogged or plugged, it significantly reduces the efficiency of the runnability devices.

Suppliers should also focus on developing efficient cleaning systems to ensure that runnability devices can operate under optimal conditions.

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