Energy Optimization in Paper Machines: The Role of Regular Energy Audits

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EVERY kW SAVED TRULY MATTERS!

ENERGY EFFICIENCY AND SUSTAINABLE OPERATION

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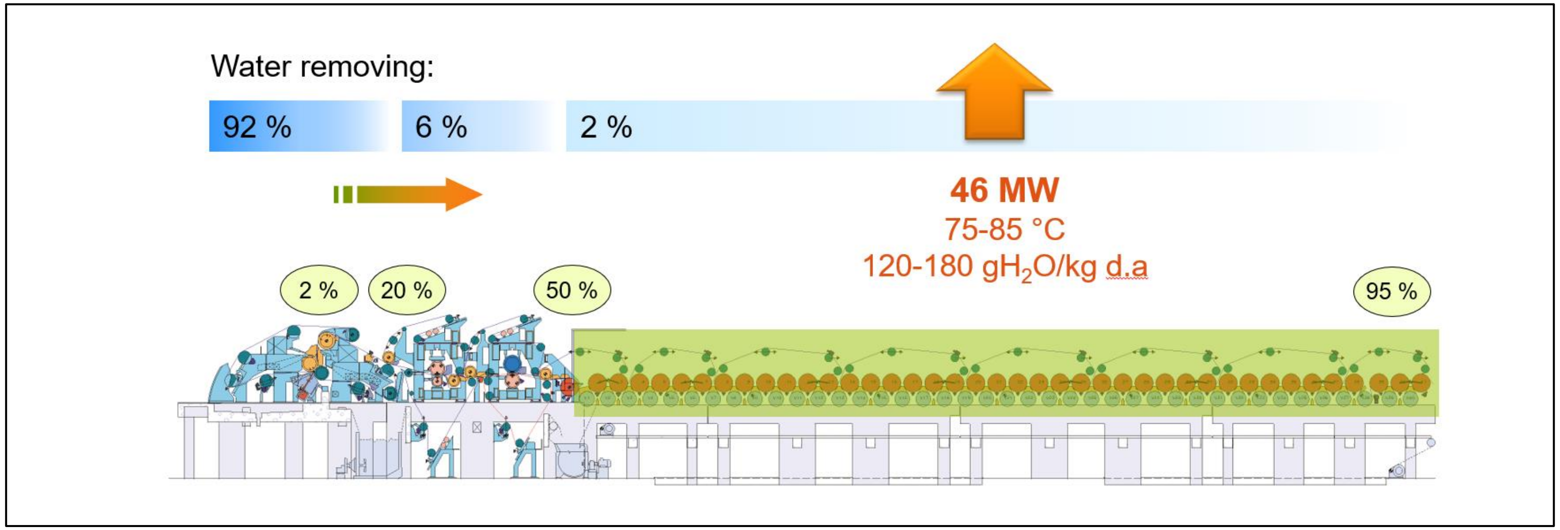

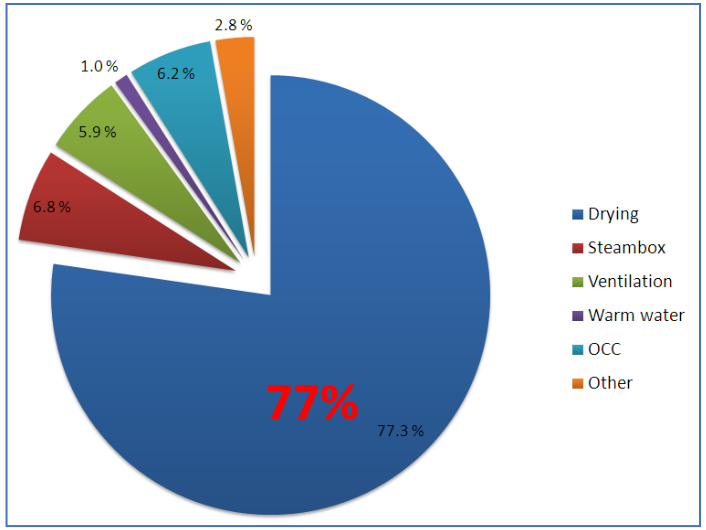

Energy intensive

Paper machines are highly energy-intensive, especially in the drying section.

Optimisation

Energy optimization is key to reducing costs and meeting sustainability goals.

Periodical audits

Periodical energy audits help identify inefficiencies and areas for improvement.

Data base

Audits provide **data-driven insights** for better decision-making and system upgrades.

Benefits

Regular audits support **lower energy consumption, CO_2 reduction,** and **enhanced machine performance.**

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Courtesy of Valmet, N. Milosavljevic, Introduction to a Course in “Process Design & Energy Utilization in the Paper Industry

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ROOT CAUSE ANALYSIS (RCA) OVER QUICK FIXES

“At PM , the most difficult part isn’t fixing the problems — it’s identifying the root cause."

🛠️ **Problem**: The customer noticed an increase in steam consumption and an imbalance in the air hood system

→ 5 Whys Approach – Air Systems Functionality at in Paper Machine

→ 1. Why? – The air system is not providing adequate airflow.

→ 2. Why? – The ducts are partially blocked with dust and fibers.

→ 3. Why? – Regular air systems audits hasn’t been performed.

→ 4. Why? – Maintenance schedules were skipped.

→ 5. Why? – There is no monitoring system to flag airflow reduction or missed tasks.

→ ✅ **Root Cause**: Can be found in working <u>together with customer</u>, and applying systematic, comprehensive audit on the PM.

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PAPER MACHINE DRYING SECTION AIR SYSTEMS

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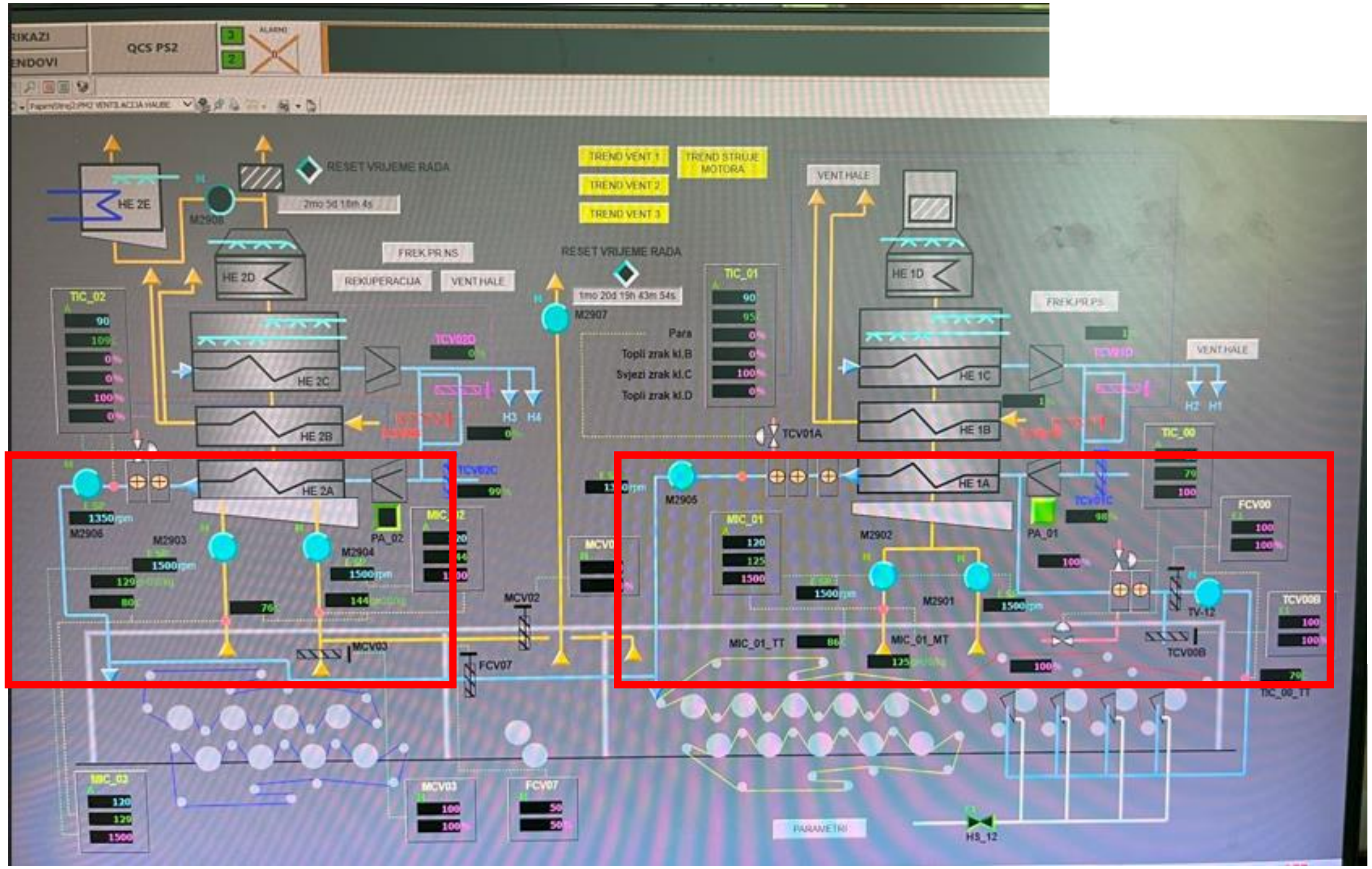
Drying section with associated heat recovery



PREDRYING SECTION	
V2901 (exhaust fan) V2902 (exhaust fan)	Exhaust air from drying hood (predrying section) Exhaust air from drying hood (predrying section)
V2905 (supply fan)	Supply air to drying hood
HE1A (Air/Air)	Prehating of the supply air to drying hood
HE1B (Air/Air)	False Ceiling
HE1C (Air/Air)	Hall velntilation
HE1D (Air/Water)	Fresh water heating
AFTERDRYING SECTION	
V2903 (exhaust fan) V2904 (exhaust fan)	Exhaust air from drying hood (predrying section) Exhaust air from drying hood (predrying section)
V2906 (supply fan)	Supply air to drying hood
HE2A (Air/Air)	Prehating of the supply air to drying hood
HE2B (Air/Air)	False Ceiling
HE2C (Air/Air)	Hall velntilation
HE1D (Air/Water)	White water heating

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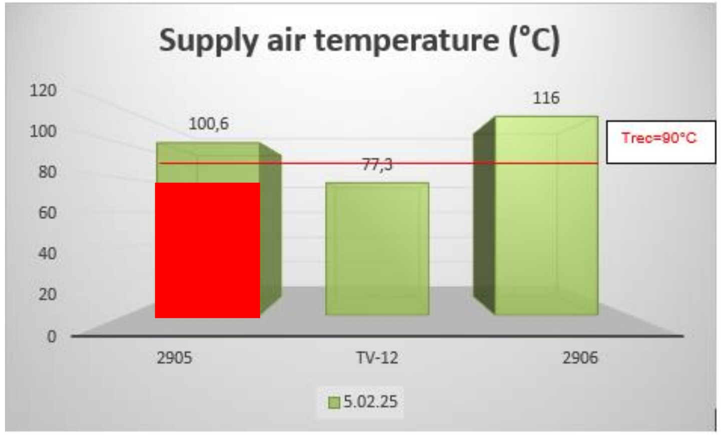
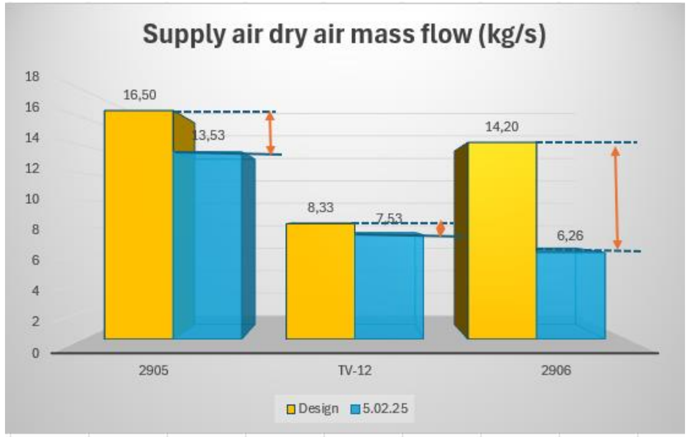
Measurement Results (Problem identifications)

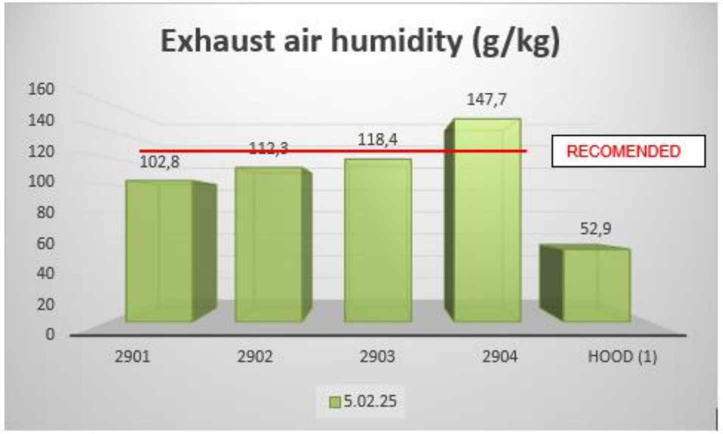
The graphical presentation of the measurement results



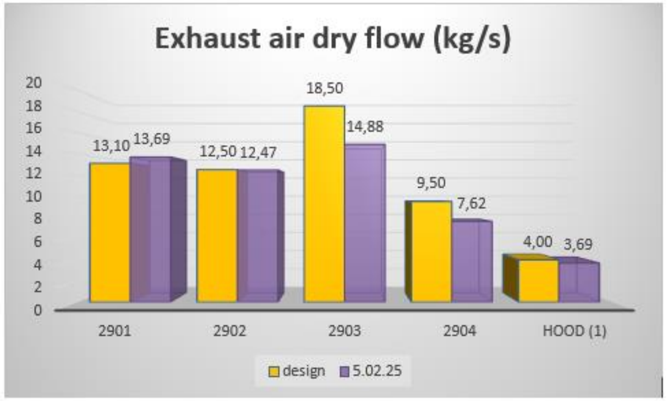
Q extra (2905) =136 kW equivalent to 0,05 t steam/h



Q extra (2906) =481 kW equivalent to 0,61 t/h



Exhaust air absolute moisture



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DRYING HOOD BALANCE

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To better understand the behaviour of the airflows in the drying section, it was conducted separate air balance calculations for the pre-drying and after-drying sections.

PREDRYING SECTION	$m_{d.a}$ [kg d.a./s]	m_{H_2O} [kgH2O/s]	x [gH2O/kg d.a.]	t [°C]	Ratio (%)
2901 – Exhaust 1, wet end	13,69	1,41	102,8	79,6	-
2902 – Exhaust 2, wet end	12,47	1,4	112,3	77,8	-
Hood (1) – Exhaust for runnability boxes	3,69	0,23	62,9	76,5	
EXHAUST	**29,85**	**3,04**			
2905 – Supply air	13,53	0,22	16,6	100,6	
TV-12 – Runnability boxes	7,53	0,33	43,17	77,3	
SUPPLY	**21,06**	**0,55**			70
Evaporation	According to air-balance	**2,49** kgH2O/s			

AFTERDRYING SEC	$m_{d.a.}$ [kg d.a./s]	m_{H_2O} [kgH2O/s]	x [gH2O/kg d.a.]	t [°C]	Ratio %
2903 – Exhaust air	14,88	1,76	118,4	79,2	
2904 – Exhaust air	7,62	1,13	**147,7**	77,4	
EXHAUST	**22,5**	**2,89**			
2906 – Supply air	**6,26**	0,05	7,7	116	
SUPPLY	**6,26**	**0,05**			**27,8**
Evaporation	According to air-balance	**2,84** kgH2O/s			

TOTAL HOOD BALANCE	$m_{d.a.}$ [kg d.a./s]	m_{H_2O} [kgH2O/s]	x [gH2O/kg d.a.]	t [°C]	Ratio %
2901 – Exhaust 1, wet end	13,69	1,41	102,8	79,6	
2902 – Exhaust 2, wet end	12,47	1,4	112,3	77,8	
2903 – Exhaust air	14,88	1,76	118,4	79,2	
2904 – Exhaust air	7,62	1,13	**147,7**	77,4	
Hood (1) – Exhaust for runnability boxes	3,69	0,23	62,9	76,5	
EXHAUST	**52,3**	**5,93**			
2905 – Supply air	13,53	0,22	16,6	100,6	
2906 – Supply air	**6,26**	0,05	7,7	116	
TV-12 (runnability boxes)	7,53	0,33	43,17	77,3	
SUPPLY	**27,3**	**0,6**			**52**
Evaporation	According to air-balance	**5,33** kgH2O/s			

Air System Balancing for the Pre-Drying and Post-Drying Sections

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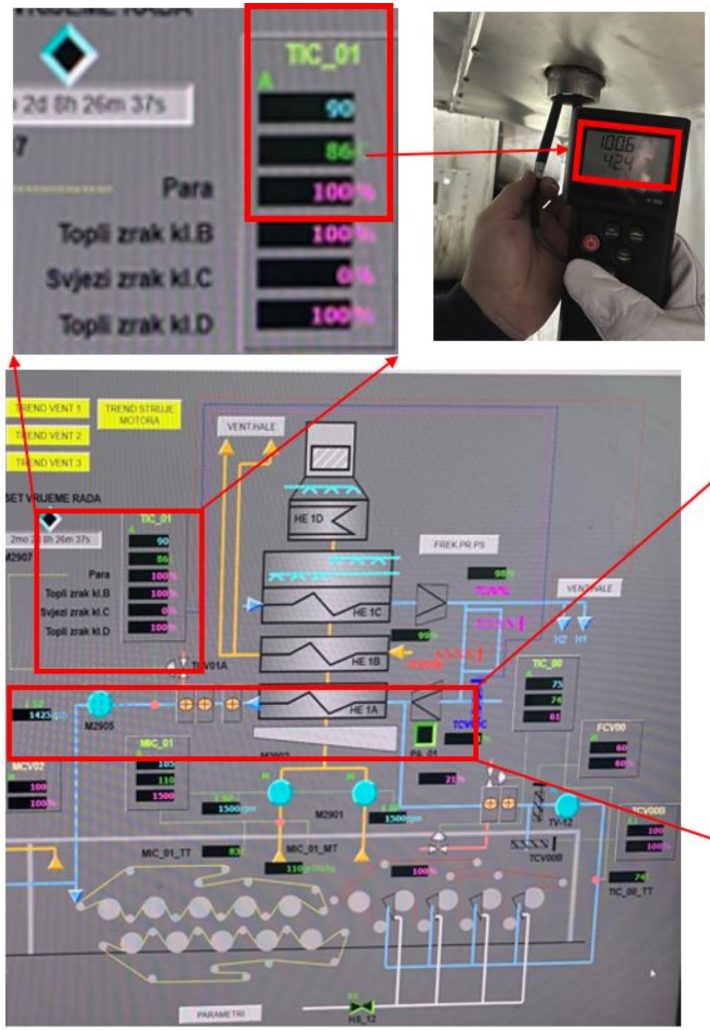
Identifying the Problem (Case No. 1)

Supply Air Temperature at Recuperator No. 1 Fails to Reach Setpoint of 90°C

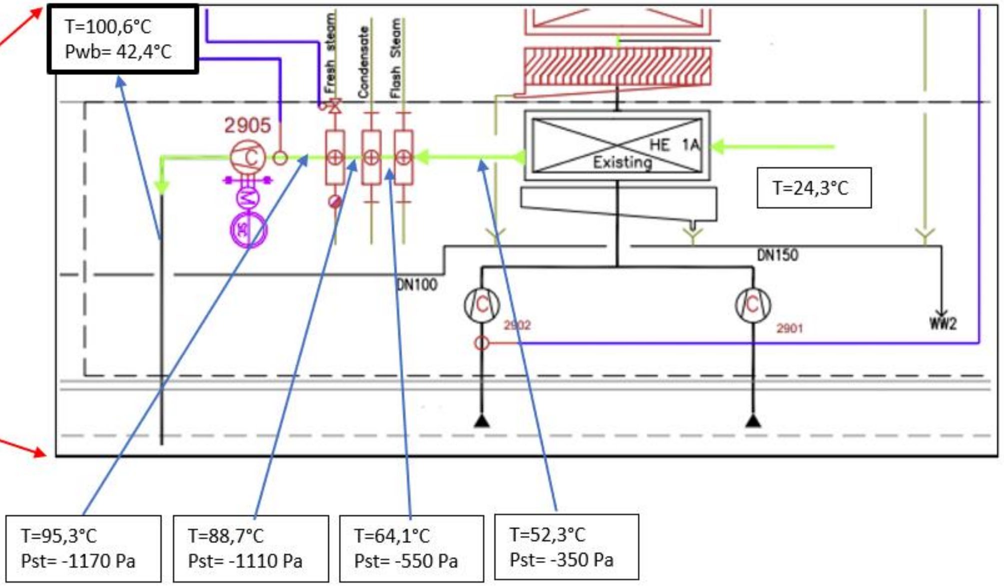


QCS – Hood ventilation

FINDING:
The temperature sensor TIC_01 was faulty and showed incorrect values.

Set Temperature = 90°C
TIC_01 =86°C
Fresh Steam HE = 100%
Measured Temperature =100,6 °C

Excess fresh steam consumption due to overheating = 240 kW or 0,3 t/h



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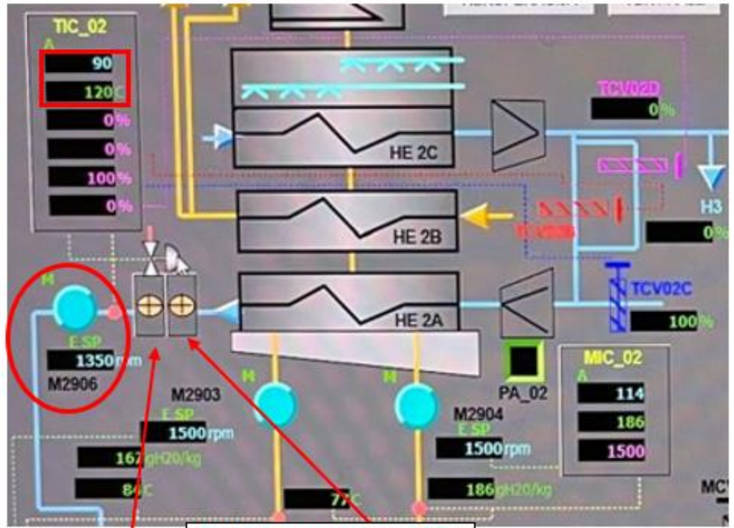
Identifying the Problem (Case No. 2)

Insufficient Supply Airflow at Recuperator No. 2

HEAT RECOVERY STAGE HE2A (Air/AIR HE)



FINDING:

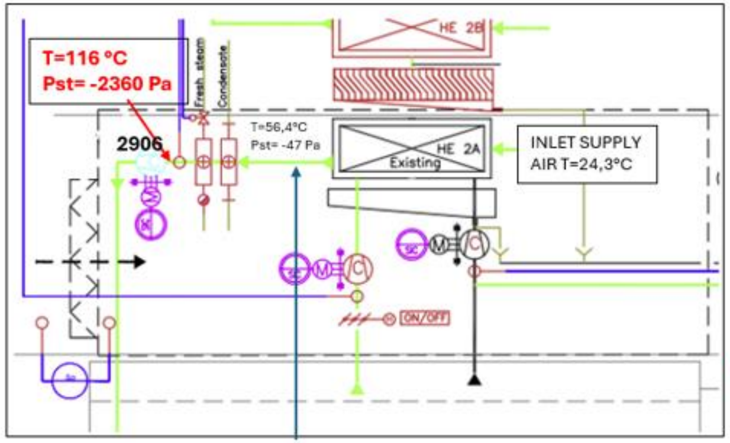
- Reduced supply air flow of fan 2906 due to plugged condensate and fresh steam HE

Design:	Measured:
V=14,2 m^3/s	V=6,26 m^3/s

- Too high supply air temperature (set 90°C/measured 120°C)

The energy required to heat the leakage air and balance the ventilation in the hood is 465 kW, which is equivalent to 0.61 t/h of fresh steam.

PLUGGED EXCHANGERS



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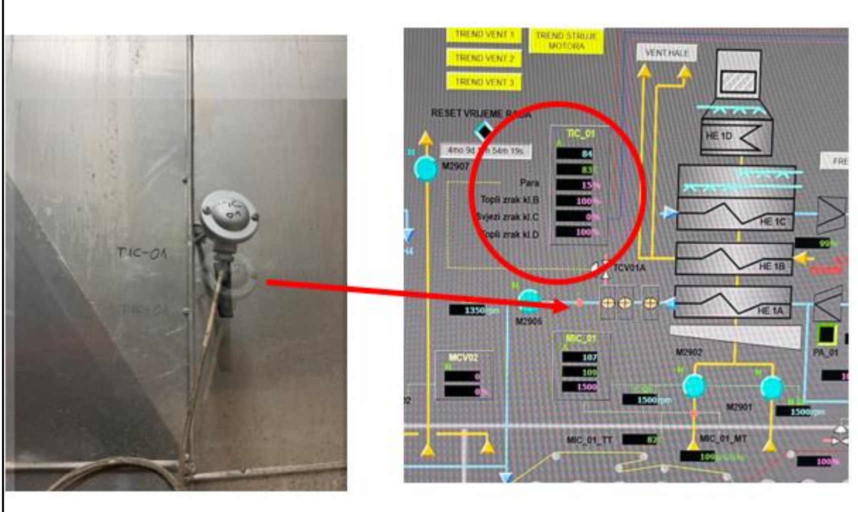
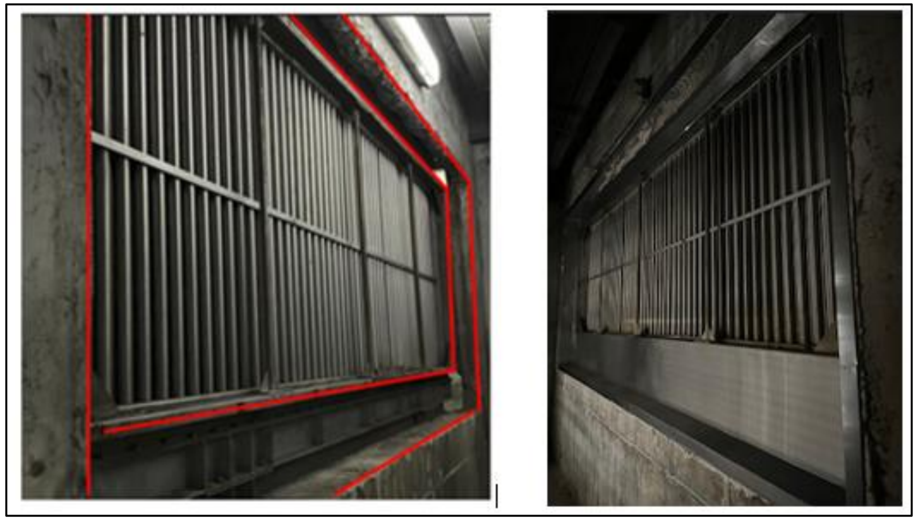
ROOT CAUSE ANALYSIS

The effect of the air system control parameters regulation



CASE1. Replacement of the failure temperature sensor for the supply air

CASE2. Improved air flow with cleaning of the plugged filter for the supply air V2906



CASE3. Insulation of the leakage at Heat exchanger (Problems of leakage air)

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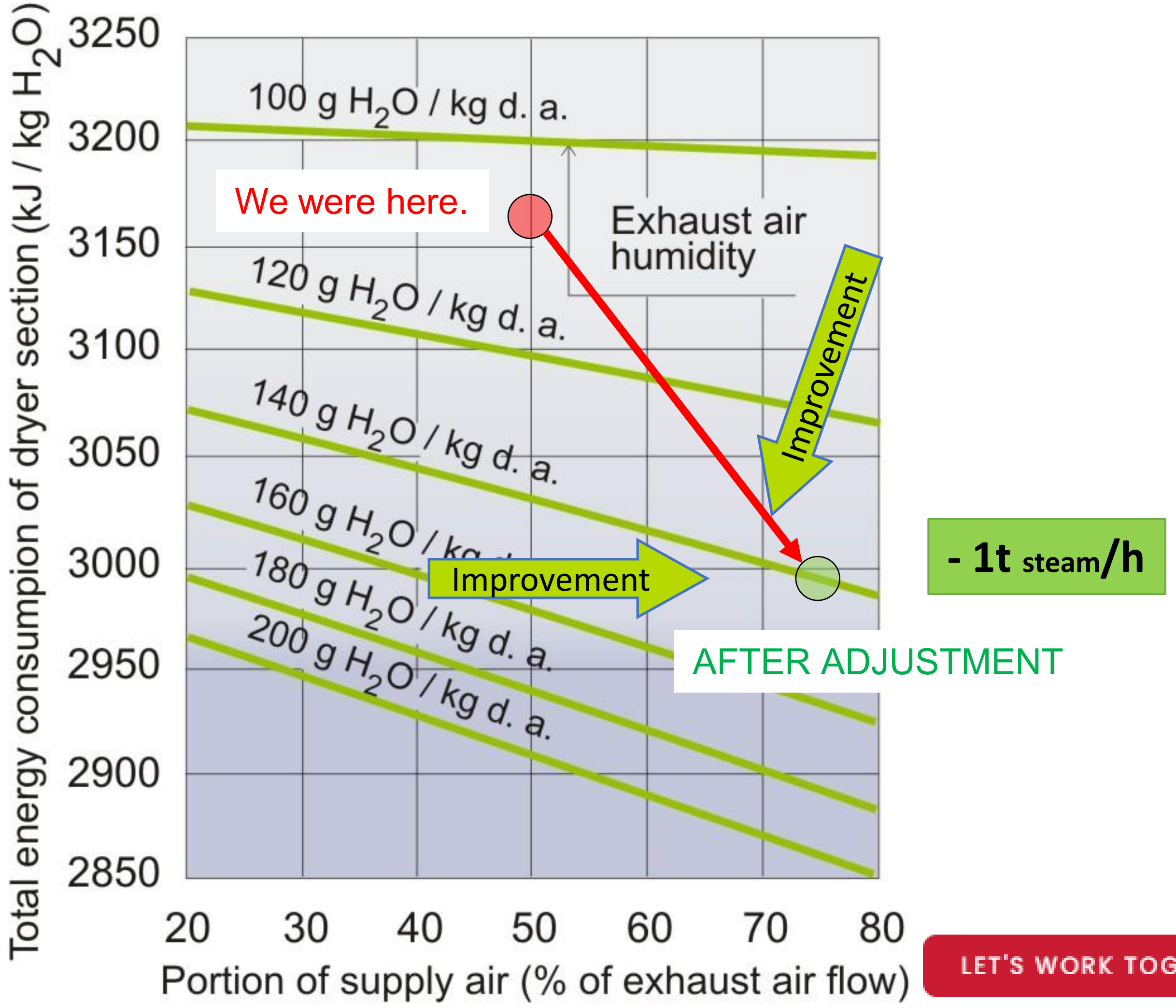
THE EFFECTS OF THE AIR SYSTEMS CONTROL PARAMETERS ADJUSTMENT

- By optimizing process parameters, it is possible to influence energy consumption at a paper machine
- The specific energy consumption decreases at higher exhaust air humidity levels.
- Less supply air requires steam heating at a specified leakage ratio, as shown in this diagram
- Increased exhaust air humidity makes the heat recovery more effective through increased condensation on the heat surfaces.



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Advantages of Conducting Periodic Audits

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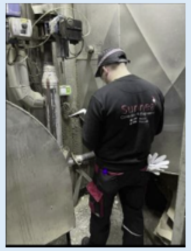
📈 Summary: 1 t/h of potential steam savings means:

Technical metrics like “steam per hour,” “kWh,” and “tons of CO_2 saved” are commonly used to express energy performance, but their economic effect is often undercover and underestimated.



Audit findings:

Possible savings 1t/h fresh steam

Equivalent to

- **EU ETS (European Union Emissions Trading System)**: As of early 2025, the price for CO_2 allowances under the EU ETS typically ranges between €70 and €100 per ton of CO_2.

Annual CO_2 reduction of 1 **000 tons**.

€ 70 000 per year

€ 240 000 per year.

Annual steam cost savings **8 000 tons**

- The **cost of producing 1 ton of fresh steam per hour** at **4,5 bar** using natural gas and assuming typical operational costs is approximately **€30 per hour**.

Total

- By recovering **1 ton of steam per hour** at **4,5 bar**, the **total yearly savings** could be approximately **€310 000**. This includes **fuel cost savings** and **carbon emission savings** .

€ 310 000 per year.

- The results may vary depending on the regional steam and CO_2 prices!

Savings achieved with systematic energy audit at PM2

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Conclusions

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The expression **"Every kilowatt-hour saved truly matters"** emphasizes the **dual importance** of energy conservation, highlighting **both environmental and economic benefits**:

1. Environmental Savings:

- **Reduced Emissions**: Saving one kilowatt-hour (kWh) means less energy production is needed, often reducing the burning of fossil fuels. This directly cuts down on greenhouse gas emissions (like CO_2) and air pollutants.
- **Lower Resource Use**: Energy production consumes natural resources—coal, gas, water. Saving energy reduces strain on these resources.

2. Economic/Financial Savings

- **Reduced Energy Costs**: Using less energy directly translates to lower costs for Paper Mills and businesses.
- **Operational Efficiency**: Businesses that use less energy often operate more efficiently and profitably.

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Small energy savings make a big difference—for our environment today and our economy tomorrow.

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