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Installation of High Voltage Electronic Cards on Electrical Panels of Electrofilters

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Abstract

The project "INSTALLATION OF HIGH VOLTAGE ELECTRONIC BOARDS ON ELECTRICAL PANELS OF ELECTROFILTERS" by the Company RTP RIFINZIONE TESSILE PRATESE SRL, developed in 2015, is placed in an extremely innovative context; in fact, both for the specific structure and corporate philosophy of the Company, linked to innovation, a new innovative product has been created in accordance with the criteria set out in the Oslo and Frascati manuals. As can be seen from the experimentation, the elements of innovation are linked to different components that have determined a series of preliminary studies and tests for their operation. The innovative elements are enclosed in different specific components that are listed below as an example:

- Process flow.
- Creation and study of specific for the realization of the project.
- Evaluation of the technical-humanistic methodology also in function of the scientific literature.
- Specific analysis of tests and experimental trials.

The machines used in textile finishing (stenters, attics, dryers) use a large amount of thermal energy which is then dispersed almost entirely in the exhaust fumes. These fumes contain (in addition to heat) the residues of oils and sizings released by the fabrics during heat setting. The purification system by means of electrofiltration condensation reduces the pollutants present in the fumes (within the limits imposed by

current regional legislation) and, by recovering the heat content, achieves significant energy savings. Particulate matter and odors are eliminated and the recovered heat can be reintroduced (in part) into the stenters and/or used directly as hot water (in the dyeing room, for heating rooms or for other services). The introduction of pre-heated air into the stenters and dryers (in adequate quantities and temperatures) stabilizes their operation, reducing fuel consumption by over 15%.

In the case of the Company, we have foreseen two alternatives for using the recovered heat:
1. As hot water for the various production services (all year round)
2. As preheated air to be reintroduced into the copper (all year round) and, in winter, for room heating (using a fan heater that in summer will function as a disposer of any excess heat).

THE HRS PURIFICATION SYSTEM USING ELECTROFILTERS:
The purification of fumes by condensation-electrofiltration is carried out in four phases:
1. mechanical filtration: to capture suspended particulate matter in the fumes
2. cooling / condensation of pollutants with air-water exchangers
3. ionization and reduction of pollutants by means of plate electrofilters
4. collection / separation of condensates:
- oils (to be sent to the waste oil disposer)
- condensate (to be sent to the water purifier).

Keywords: Sustainability, Electronic aspects, Energy save, Voltage

1. Introduction

The Company's project involved the creation of a team selected with rigor and attention to the skills needed to tackle an advanced experimentation process in the Company's reference sector. The company chose its personnel with a precise assessment of their operational and theoretical skills, favoring people with decision-making ability and in-depth knowledge of company dynamics. The team was formed following a logic aimed at maximizing the contribution of know-how, transferring consolidated experience in relevant sectors into the experimentation and contributing to the achievement of objectives through a structured and methodological approach. The team was configured to ensure an ideal balance between theoretical knowledge and practical skills, creating a flexible and dynamic work environment, where the contribution of each member is valued and oriented towards solving experimental challenges. In selecting the group, particular attention was paid to the ability of individuals to tackle and solve complex

problems and to their inclination to manage changing situations, with a rapid decision-making approach based on technical data and specialist knowledge. This has allowed us to build a versatile and resilient team, capable of responding adequately to the specific needs of each phase of the experimentation, maintaining a high level of quality and ensuring constant progress towards the objectives. The company has also favored a team structure that integrates diversified skills, including people with various professional and personal backgrounds, an element that has enriched the experimentation process and has allowed us to tackle problems with multiple approaches, offering different perspectives and helping to strengthen the effectiveness of the proposed solutions. One of the fundamental objectives in defining the team was to promote a culture of collaboration, where the continuous exchange of knowledge represents a strategic added value. Each member is encouraged to express and share their technical contribution and to support colleagues, making the team a context in which learning is constant and adaptive. The company has placed emphasis on the inclusion of individuals with a strong predisposition for continuous updating, thus ensuring that the team is always in line with the most recent technical and scientific developments in the reference sector. In addition, the project was developed in collaboration with other entities, both to broaden the field of available knowledge and to ensure that the technologies and methodologies adopted in the experimentation were fully capable of meeting the standards required in the reference sector.
This synergy with other entities has further strengthened the team's capabilities, allowing it to develop solutions that integrate best practices and that stand out for their effectiveness and sustainability in production processes.
The dissemination and transfer of the results obtained were conducted in line with the guidelines of the Frascati Manual, ensuring that all sensitive information and know-how developed during the research and testing phases were carefully protected and only partially shared to safeguard the company's competitive advantage. Throughout the project life cycle, the Company rigorously and methodically documented each phase of the technological development processes, collecting evidence in the field through detailed reports and technical sheets, which were integrated into a comprehensive document attached to the final report.

Furthermore, the internal dissemination plan of the project was oriented to maximize the appropriation of the skills developed by the technical team and management resources, enabling a continuous application and optimization of innovative technologies for an environmentally sustainable process. This strategy made the company more competitive, capable of quickly responding to the challenges of the sector and fully exploiting the technical innovations acquired.
The “rameuse” uses a large amount of thermal energy, and consequently for some years R.T.P. S.r.l. has equipped itself with smoke purification and heat recovery systems in order to meet the emission limits imposed by current legislation and at the same time recover part of the thermal energy used by the “rameuse”.

One of the phases of the smoke purification system consists of the ionization and reduction of pollutants by means of plate electrofilters. Over the years, the maintenance of these electrofilters has proven to be particularly difficult and expensive, as there have been frequent problems with worn components inside the electrofilter cells, with significant and in the long run unsustainable maintenance costs.

R.T.P., supported by the company that had previously supplied and installed the fume purification and energy recovery systems, therefore designed, tested and implemented in 2015 an intervention on the electrical panels for the management of the electrofilters containing traditional Duplicators and Transformers, replacing them with electrical panels equipped with electronic cards for the generation of high voltage, in order to limit the costs and maintenance times of the electrofilters. The high voltage cards installed generate voltages of 5,000 and 10,000 V, allowing greater continuity of the electrical power supply, thus increasing the efficiency of the system as a technology.

2. Materials and methods

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This part includes an aluminum roller to accompany the fabric, a towing drum to pull the fabric from the roll, and an adjustable curved spreader (banana) that has the function of "stretching" and thus removing any creases from the introduced fabric. The fabric is brought onto the "carpet" on which it is subjected to UV treatment by means of two towing cylinders: one motorized at the exit and one "idle" at the entrance (the movement is managed by PLC like the entire line).

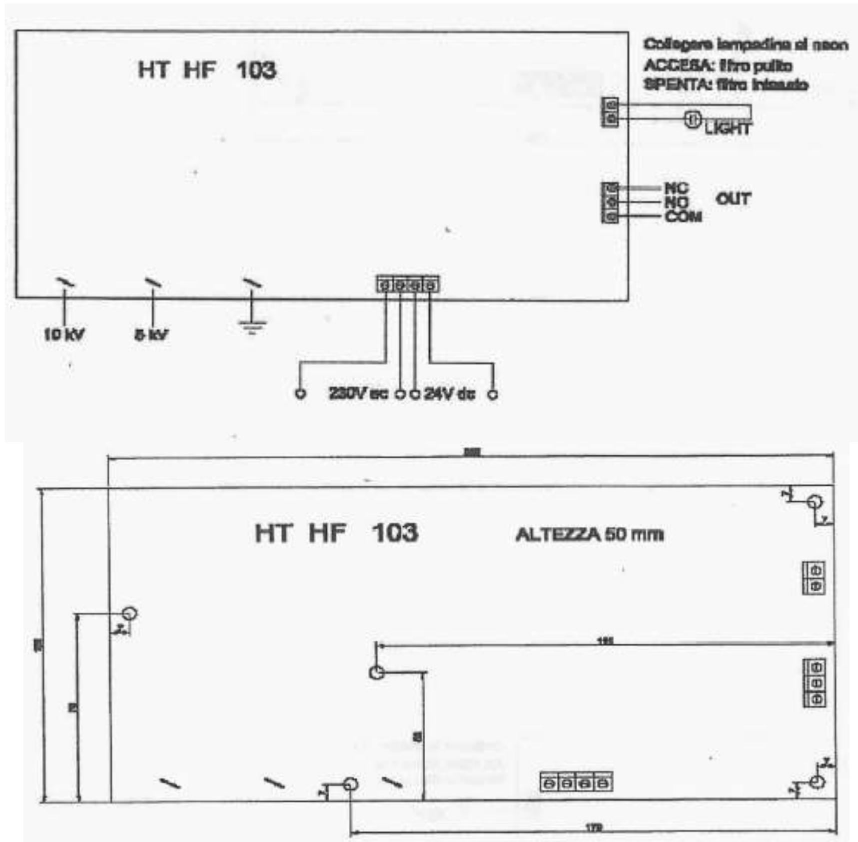

Figure 1. Description of the card

SUN WASH unit: it consists of a steel structure essentially made up of:

• SUN WASH lamps: there are 3 medium pressure air-cooled mercury vapor arc lamps (lasting approximately 1090 hours). The power of each lamp is 120 W/cm. The body of the lamp is made of a tube that is 90% transparent to UV rays and resistant to normal operating conditions (the surface temperature of a lamp in operating conditions is between 600 and 800 °C);

• SUN WASH housing: lamp holder in extruded aluminum with heat sink and equipped with a shutter suitable for lamps, aluminum sheet cover. There are 2 holes for connecting the cooling fan and ozone removal:

- lamp power supplies: each lamp is equipped with a 400V/50Hz power supply;
- single-phase, variable power output, 50% stand-by mode, regulation of
- AC/DC power, variable impedance, power factor correction capacitors, self-resetting thermal protector, input and output terminal blocks;
- heat dispersion box: around and under the housings there is a containment box with the dual function of protecting from the escape of light (which could be dangerous for

the eyes) and collecting and - via a connection to the ventilation system - disposing of it outside.

After having inserted the electrical panels with the new high voltage electronic boards in place of those equipped with duplicators and transformers that were previously present, and having carried out the software modification necessary for the operation of the aforementioned boards, the greater continuity of the electrical power supply that resulted has given consistent and evident improvements with regard to the maintenance of the electrofilters that are part of the purification system of the fumes discharged by R.T.P. S.r.l.

As can be seen from the literature, the project will in turn be a source of technical literature since for the first time they have been designed with a new logic and not currently available on the market in reference to the year 2015. The structure of the project INSTALLATION OF HIGH VOLTAGE ELECTRONIC BOARDS ON ELECTRICAL PANELS OF ELECTROFILTERS includes a phase of experimentation and validation of the products in real situations.

3. Results

During the execution of the project, significant critical issues emerged, especially in the development and testing phase of the experimental tests and trials that required targeted and scientifically structured interventions to ensure the compliance of the results with the sustainability and operational quality objectives set. One of the main difficulties encountered was related to the effective identification of an innovative experimental protocol for the creation of new types of boards for the electrical panels of the electrofiltration systems. The uncertainty analysis highlighted that the operating conditions could indirectly influence the machines and the recovery of thermal energy from the fumes produced during the production process, thus requiring a prolonged and specific testing phase to evaluate the behavior of the boards. Overall, these critical issues highlighted the importance of a rigorous scientific approach. The management of the critical issues was therefore conducted through a process of empirical verification and scientific validation of the operating parameters, ensuring a systematic and adaptive response to the problems encountered.

DIMENSIONING OF A RECOVERY UNIT - PURIFIER MOD. HR/K-W 32: The purification plant suitable for treating the emissions of your new 5-field stenter will reduce the polluting content of the fumes (including oil mists) within the legal limit using a HR/K-W 32 unit that will have the following performances:

LATO FUMI		PARAMETRI	LATO ACQUA	
10.161	Nm^3/h	portata max. normalizzata	4.710	l/h
130	°C	temp.media fumi entrata	20	°C
35	°C	temperatura uscita	85	°C

- **Calore recuperato dai fumi : 306.140** [kcal/h]
- **Concentrazione in uscita (totale) : ≤ 10** [mg/Nm^3]

RICOLLOCATORE RC 6

LATO ARIA		PARAMETRI	LATO ACQUA	
6.000	m^3/h	portata totale	4.710	l/h
5	°C	temperatura entrata	85	°C
63	°C	temperatura uscita	63	°C

- **Calorie reimmesse in rame : 104.400** [kCal/h]

TERMOVENTILATORE TV 15

LATO ARIA		PARAMETRI	LATO ACQUA	
15.000	m^3/h	portata totale	4.710	l/h
42	°C	temp.immessa	63	°C
5	°C	temp.esterna	27	°C

Calorie immesse in ambiente : 166.500 [kCal/h]

Figure 2. Main results

4. Conclusion

The project has a high degree of applicability, transferability and reproducibility, thanks to the systematic and scientific approach adopted in the development phase and the creation of an operational model that can be extended to different industrial contexts. The applicability of the developed solutions lies in their ability to respond to concrete needs for efficient management of resources with the use of innovative cards, offering a production model that can be adapted to both the company and other similar and industrial companies. The project does not limit itself to introducing an isolated product or service but represents a system based on in-depth knowledge and their characteristics. This advanced knowledge is easily transferable, as the approaches and techniques used can be implemented and replicated in other industrial contexts, thus extending the use of the solutions to different areas. Transferability is realized in the possibility of applying the methodologies and technical parameters of the project to other production sectors, facilitating the transfer of new skills to other researchers or industrial operators who wish to implement similar solutions to improve the environmental quality and efficiency of their production processes. Furthermore, the know-how acquired through the use of advanced techniques can be used as a basis for further research and development activities in the field of industrial sustainability, providing a reproducible model for those who intend to adopt surface management practices based on advanced products and integrated solutions. The reproducibility of the project is guaranteed by the scientific soundness of the processes used and the standardization of the procedures, which makes it possible to replicate the results in different operating contexts, regardless of the specific conditions of the application environment. This element ensures that the benefits deriving from the technologies and methodologies used can be extended, contributing to a general increase in know-how in the Company's reference sector. Through the systematization of the knowledge acquired, in the project, it allows to build a technical-scientific heritage that is transferable and usable also in similar sectors, promoting sustainable and responsible management of resources within complex production processes. In this sense, the project is configured as a reference for production practices for the Company's reference sector, consolidating knowledge and expanding the potential for using the technologies developed, and allowing other players in the sector to benefit from the new skills, thus increasing the impact of sustainability and efficiency in the long term.

References

[1] Ma, N., Aviv, D., Guo, H., Braham, W.W., Measuring the Right Factors: A Review of Variables and Models for Thermal Comfort and Indoor Air Quality, *Renewable and Sustainable Energy Reviews*, **135** (2021), 110436. https://doi.org/10.1016/j.rser.2020.110436

[2] Sadrizadeh, S., Yao, R., Yuan, F., Awbi, H., Bahnfleth, W., Bi, Y., Cao, G., Croitoru, C., de Dear, R., Haghighat, F., et al., Indoor Air Quality and Health in Schools: A Critical Review for Developing the Roadmap for the Future School Environment, *Journal of Building Engineering*, **57** (2022), 104908. https://doi.org/10.1016/j.jobe.2022.104908.

[3] Brink, H.W., Lechner, S.C.M., Loomans, M.G.L.C., Mobach, M.P., Kort, H.S.M., Understanding How Indoor Environmental Classroom Conditions Influence Academic Performance in Higher Education, *Facilities*, **42** (2024), 185-200. https://doi.org/10.1108/F-12-2022-0164

[4] Deng, S., Lau, J., Seasonal Variations of Indoor Air Quality and Thermal Conditions and Their Correlations in 220 Classrooms in the Midwestern United States, *Build Environ.*, **157** (2019), 79-88. https://doi.org/10.1016/j.buildenv.2019.04.038

[5] Zhang, S., Chen, Y., Li, Y., Yi, X., Wu, J., Study on Air Quality and Its Annual Fluctuation in China Based on Cluster Analysis, *Int J Environ Res Public Health*, **19** (2022), 4524. https://doi.org/10.3390/ijerph19084524

[6] Guo, M., Yu, W., Sun, Y., Wang, L., Zhou, H., Zhang, Y., Effects of Increasing Indoor Negative Air Ions on Cognitive Performance and Health of High Pure CO2 Level-Exposed College Students, *Indoor Air*, **2023** (2023), 1-11. https://doi.org/10.1155/2023/8298339

[7] Cao, X., Li, P., Zhang, J., Pang, L., Associations of Human Cognitive Abilities with Elevated Carbon Dioxide Concentrations in an Enclosed Chamber, *Atmosphere* (Basel), **13** (2022), 891. https://doi.org/10.3390/atmos13060891

[8] Haverinen-Shaughnessy, U., Shaughnessy, R.J., Cole, E.C., Toyinbo, O., Moschandreas, D.J., An Assessment of Indoor Environmental Quality in Schools and Its Association with Health and Performance, *Build Environ*, **93** (2015), 35-40. https://doi.org/10.1016/j.buildenv.2015.03.006

[9] Zhang, X., Wargocki, P., Lian, Z., Human Responses to Carbon Dioxide, a Follow-up Study at Recommended Exposure Limits in Non-Industrial Environments, *Build Environ*, **100** (2016), 162-171. https://doi.org/10.1016/j.buildenv.2016.02.014

[10] Hui, P.S., Wong, L.T., Mui, K.W., Using Carbon Dioxide Concentration to Assess Indoor Air Quality in Offices, *Indoor and Built Environment*, **17** (2008), 213-219. https://doi.org/10.1177/1420326X08091773

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