Central ventilation and local exhaust in wood industrial facilities

The development of wood industry and legislative requirements on the quality of the working environment results in increased demands on HVAC equipment, which should be definitely a part of every newly constructed premise. Greater emphasize is put on the clean working environment, energy savings and heat recovery, but maximum attention must be paid to safety requirements, economic efficiency, operational reliability and service life of machinery.

Keywords: ventilation, local exhaust, HVAC in wood industry, filtering and separating equipment of exhaust air, heat recovery system.

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Based on above mentioned requirements, HVAC have become an integral part of technology equipment, particularly in relation to the nature of wood processing operations. A large production of wood waste is typical for this type of operation, beginning from very fine dust to chips and fragments with a size of a few cm. Waste exhaust facilities are designed to capture the waste at the place of production, thus avoiding the unwanted spread and deposition in the area of operation. Afterwards, the waste is transported to the separation and filtration equipment, where it is sorted and stored for further use. That is why the air-conditioning equipment plays a crucial role in the protection and creation of a better working environment. [1], [7]

Introduction

The aim of the HVAC designer's work is to design functional and energy efficient ventilation and exhaust systems with the help of a suitable HVAC configuration. The following example shows one of the appropriate technical solutions of central ventilation and local extraction in a carpentry workshop where final wood works intended for the window frames are carried out. From the layout point of view, it is a one-nave hall building with some office and warehouse space [6]. Work progress of the designer could be briefly summarized in the following points:

- Defining the requirements for the parameters of the indoor environment in a human's working area – a dusty industrial hall type of operation.
- Calculation of emerging pollutants in wood working process.
- Proposal of distribution network of the central ventilation.
- Design of local extraction, filtering and separating equipment of exhaust air.
- HVAC heat recovery system design.
- Implementation of the drawing part of the project documentation.
- Technical report and specifications of piping elements and their components. [4], [5]

Indoor environment requirements

The parameters of the indoor environment in wood industrial facilities (see **Figure 1**) are defined according to the requirements and values defined in Decree no. 259/2008 Coll [8]. To relevant qualitative indicators of indoor environment suitable for humans belong: heat-humidity microclimate, complex heat, humidity and air flow activity and determination of the amount of solids suspended in the air.

Thermal-hygrometry microclimate

People's clothing and total body heat production (according to the classes of actions listed in **Table 1**) are the main factors in determining the optimal and acceptable conditions of thermal-hygrometry microclimate. Thermal production of the body is equal to its energy expenditure. In terms of activity type, the operation in a wood processing industry belongs – within the meaning of the decree – to the class 1c.

Figure 1. Wood industrial facility hall. [12]

In the areas intended for long-term stay, the optimum conditions of thermal-hygrometry microclimate are to be secured during the warm as well as the cold season of the year. The structural design of the building is a prerequisite for optimal climatic conditions. Where the structural design does not enable it, these conditions must be secured by technical equipment. The optimal and allowable operational temperature for specific clothing or activity may be more accurately determined (see **Table 2** and **Table 3**).

Air-change rate

All areas of long-term and short-term stay must be ventilated. Ventilation of buildings is either natural or forced. Ventilation capacity is determined by the number of persons, type of activity (see **Table 4**), the thermal load and the extent of air pollution in order to meet the requirements for the amount of air to breathe and the indoor air cleanliness. Natural ventilation is used for air exchange in areas without sources of pollutants and heat. The method of ventilation, the position and size of air intake and exhaust openings will be determined by calculation. In other cases, the exchange must be secured by forced mechanical ventilation. When replacing the air – the air balance must be respected. In our case, we choose the balanced ventilation system because the air exchange between the ventilated space and other spaces is not foreseen. The quality of supply and exhaust air will be consid-

Table 2. Conditions of thermal-hygrometry microclimate for warm season [11]

Class	Operative temperature θ_o (°C)		Airflow speed v_a (m/s)	Air humidity φ (%)
	Optimal	Allowable	Allowable	Allowable
1c	20–24	17–26	≤ 0,3	30–70

Table 3. Conditions of thermal-hygrometry microclimate for cold season. [11]

Class	Operative temperature θ_o (°C)		Airflow speed v_a (m/s)	Air humidity φ (%)
	Optimal	Allowable	Allowable	Allowable
1c	15–20	12–22	≤ 0,3	30–70

Table 4. Minimum amount of outdoor air supply. [11]

Class	Type of human activity	Minimum amount of outdoor air V_e (m³/h)
1c	Work predominantly in sitting position	50
	Work mostly standing and walking	70
	Heavy physical work	90

Note: At the warm air ventilation and air conditioning may not fall the proportion of outdoor air below 15% of the total supply air into the room; at the same time must be observed a requirement for the supply of outdoor air per person.

Table 1. Class activities [11]

Class	Total energy expenditure		Examples of activities
	q_M (W/m²)	q_M (met)	
1c	106 – 130	1.82 – 2.23	Standing activity with permanent involvement of both hands, arms and legs together with carrying loads up to 10 kg (shop assistant's work at high frequency of customers, painting, welding, drilling machine, lathes and milling machines operators, light trucks pulling or pushing). Slow walking on the flat ground.

ered acceptable if its composition neither endanger nor worsen the living conditions of people in the areas of the building or its surroundings. [2]

Limit values of noxious factors in the indoor air

These values are determined as limit values of selected chemical, microbiological and biological pollutants and solids. The limit values of chemical substances and solids are shown in **Table 5**. According to the type of dust premise only values for the production of solids in the air are worth mentioning.

Wood waste

A significant production dust solid elements occur during the wood working process. This may be considered harmful when exhausted freely in the air either of indoor or outdoor environment. As for the wood waste, local exhaust is designed for every working station, where the production is intended. This waste is exhausted from its place of origin through the exhaust system into the filter system where it is captured, stored and shifted for further processing.

The amount of wood waste is directly proportional to the intensity of production, performance and character of machines. This amount is highly variable because the production is not continuous and even machine manufacturers do not specify this information. [3], [8]

Depending on the type of wood and the nature of the wood working process, we can define the properties of the solid waste and the method of filtration. A few examples are listed in **Table 6**.

Chemicals

Exposure to chemical substances in the premises of the project that can be exhausted into the atmosphere and cause pollution are not taken into account. Therefore it is not necessary to apply additional measurements.

Heat production

During the warm season the heat production is considered to be a thermal load, so measurements are to be taken in order to sustain the acceptable temperature. During winter, the production helps lower the energy demands for space heating to the desired temperature. In accordance with STN EN 15243:2008, the calculated total heat load Φ was of value 66,469 W.

Table 5. Limit values of chemical substances and solids in indoor air areas. [9]

Article Nº.	Pollutant	Index	The maximum allowable value (μg/m³)	Time (h)
2.	Solids	PM_{10}	50	24

Note: Dust elements whose predominant size is of a diameter of 10 μm and which can pass a special selective filter with a 50% efficiency.

Design of central ventilation and local exhaust system of Wood industrial facility hall

Located in a city of Zuberec in Slovak republic.

Parameters of outdoor and indoor air:

Outdoor calculation temperature of air in the winter — θ_e = –17°C

Indoor calculation temperature of air in the winter — θ_i = +16°C

Outdoor calculation temperature of air in the summer — θ_e = +30°C

Indoor calculation temperature of air in the summer — θ_i = +26°C

Calculating volumetric airflow [10]:

Central ventilation system — 4 176 m³/h

System of destratification units — 12 000 m³/h

Local exhaust system — 16 980 m³/h

Table 6. Basic wood working operations. [9]

Operation	Tool	Waste	Separation
Cutting	Frame saw	Coarse	Separation chamber
	Band saw		
	Circular saw		
	Cutting saw	Coarse – medium	Separation chamber Cyclone separator
	CNC saw		
Chipping	Wood chip flaker	Coarse	Separation chamber
Milling	Milling machine	Coarse – medium	Separation chamber Cyclone separator
Drilling	Wood drill	Coarse – fine	Cyclone separator Buckle filter
Planing	Planing machine	Coarse	Buckle filter
Grinding	Grinding machine	Fine – very fine	Buckle filter

Equipment No. 1 – Central ventilation of production area

The central ventilation system (see **Figure 2**) is secured by central modular HVAC, composed of two filter and fan chambers, heater and heat recovery exchanger. The unit is in the HVAC engine room. The exhaust is situated on the north-western facade. The outdoor air supply is located on the north-eastern wall of a building provided with a louvre against the rain. The exhaust pipe is situated on the north-western facade.

The air supply into the hall will be secured by large-scale industrial diffusers of cylindrical shape with thermal regulation of the air flow. The exhaust air is secured by the local exhaust devices (efferent grids) set directly into the cut out of a circular pipe (see **Figure1**).

Equipment No. 2 – De-stratification units

The system of de-stratification units is situated on the roof in the roof lights (see **Figure 2**, ref. 2.01_V = 4 000 m³/h). Its role is to ensure the exhaust of the overheated air in the summer in order to avoid the excessive overheating of the space. In winter, these units help improve the heating system by transporting the warmer air from the roof space into the working area.

Equipment No. 3 – Equipment producing wood waste and its local exhaustion

The exhaust system (see **Figure 3**) ensure the transport of waste particles produced during the woodwork process. The pipe network consists of two parts. Each one can work independently and simultaneously as well. 100% interaction of all devices is considered within one branch. The system consists of a suction pipe network made of a circular pipe, transport radial fans, a filter and separator unit, and a piping network to return the filtered air back into the production space through large-scale textile diffusers. The exhausted devices are connected to the exhaust system using a flexible hosepipe designed especially for the wood industry. Filtration equipment and transport ventilators are located outdoors and are equipped with anti-explosion and fire system.

The pipes transferring the returned filtered air into the production area are equipped with the mixing chamber in the exterior space. Its role is to exhaust the air directly into the exterior during summer and into the interior in winter.

Discussion

Hygienically optimal thermal-hygrometry condition of the indoor environment is created all year round only in rare cases. Mostly (for economic reasons) are in the interior ventilated and air conditioned buildings maintained satisfactory conditions (acceptable, admissible). Requirements on air quality are always limits.

The only way to achieve these limits in the wood industrial facilities is to apply all three systems of ventilation and air conditioning, which in our example are listed as

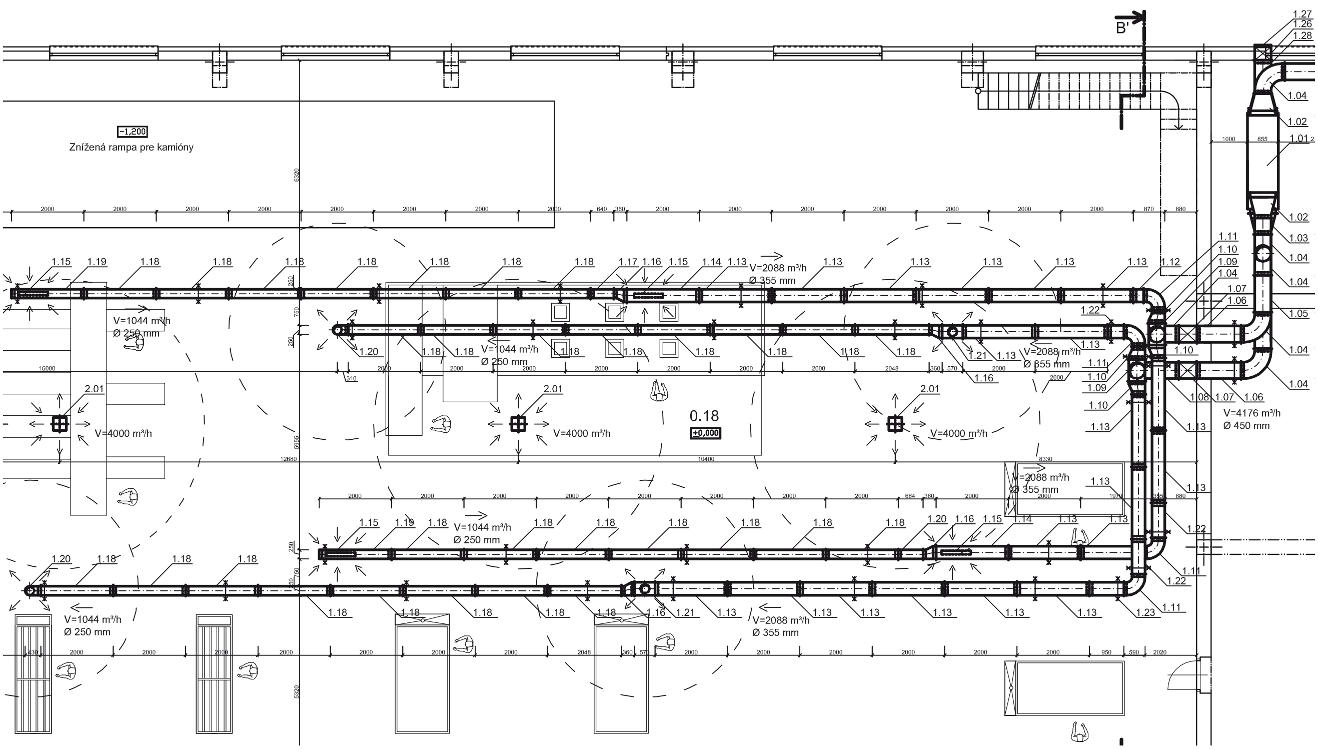

Figure 2. Central ventilation equipment – Plan of wood industrial facility hall. [13]

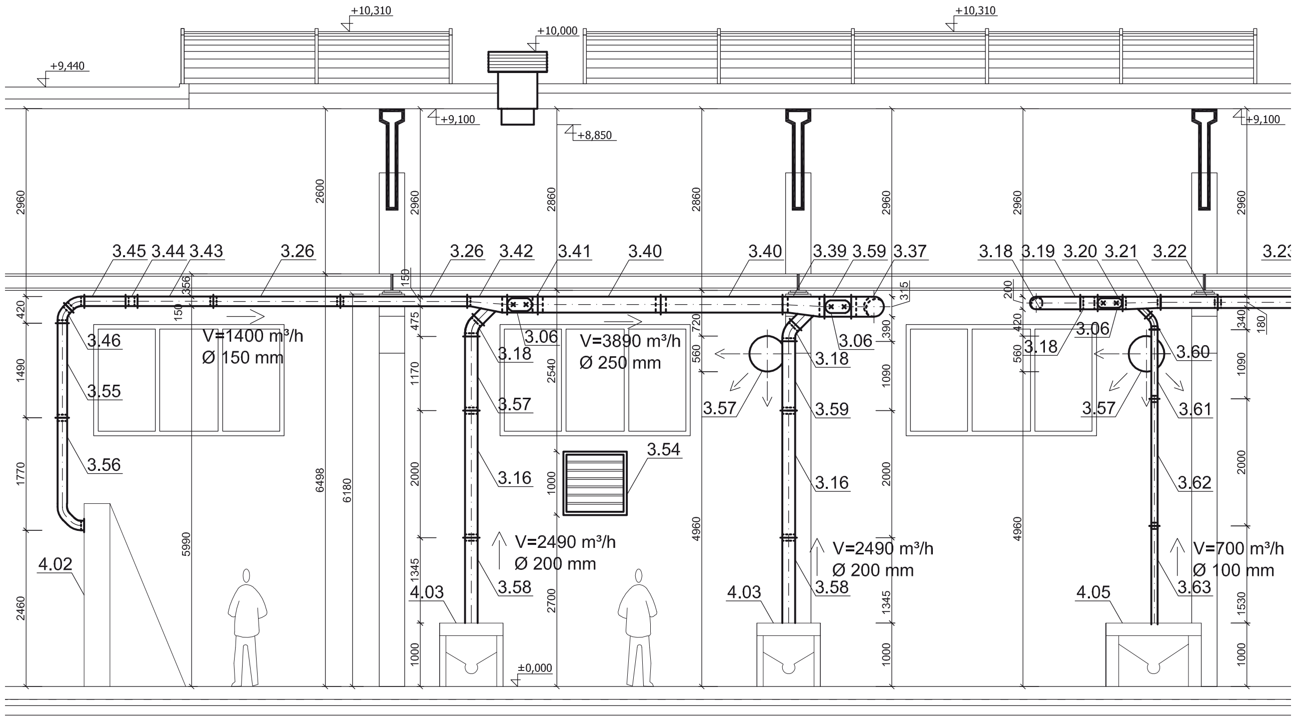

Figure 3. Local exhaust equipment – Cross section of wood industrial facility hall. [13]

equipments No. 1, 2 and 3. To propose only some of these systems would lead to under-ventilated space solution and thus also a threat to human health.

Conclusion

The role of the central ventilation system is to ensure the hygienic air exchange in the area of production, whereby the air is evenly distributed in the workshop. Energy requirements for air treatment are minimized and aimed only to reheat the air from exterior using a water heater. Placing a plate regenerative heat exchanger in HVAC unit can reduce the demand for heating air by up to 40%.

All systems are designed to ensure their seamless interaction with respect to the health conditions in the working environment, energy efficiency and to minimize the ecological burden on the environment.

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[10] STN EN 15243:2008 *Vetranie budov. Výpočet vnútorných teplôt, záťaže a energie pre budovy so systémami klimatizácie.* (Ventilation for buildings. Calculation of room temperatures and of load and energy for buildings with room conditioning systems).

[11] STN EN 15251:2012 *Vstupné údaje o vnútornom prostredí budov na navrhovanie a hodnotenie energetickej hospodárnosti budov – kvalita vzduchu, tepelný stav prostredia, osvetlenie a akustika.* (Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics)

[12] Wood industrial facility hall – photo from www.dimechanik.sk

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