SurTec – a factory designed as a passive house

EnBau

This was an ambitious project. Alongside the deadlines and financial pressures that are usual in industrial building projects, further challenges and problems demanding creative solutions arise when constructing a prototype like this with high energy standards. This compact building, with three blocks, over 4,100 m² of area with energy requirement and a volume of 22,700 m³, houses the production area, a laboratory, a three-part high-bay warehouse with space for 2,000 pallets as well as offices, all under one roof. Even at an early planning stage, innovations were developed in partnership with various companies. Particularly noteworthy are the thermally insulated smoke vents on the warehouse roof, the well-insulated mullion-and-transom steel structure used for the atrium, the loading bay with vacuum panels for trucks, and the ventilation system. In designing the ventilation system, it was tried for the first time to find a system that fulfils the requirements of the chemical industry as well as those of a passive house. Despite the many innovations, the project was built in a short time and could be put into service quickly.

The SurTec GmbH building viewed from the south: the administration block is shown. Behind this is the atrium, which connects administration with the chemical laboratory.
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Building summary

Project status	
Location	SurTec-Str. 2, 64673 Zwingenberg, Hessen
Completion	2000
Inauguration	2000
Building owner	SurTec GmbH (+ Betreiber)
Occupant	SurTec Produkte und Systeme für die Oberflächenbehandlung GmbH
Gross floor area	4.860 m²
Heated net floor area	4.113 m²
Gross volume	22.700 m³
Work places	50
A/V ratio	0,25 m²/m³
Key aspects	Heat insulation, Atrium, Ventilation + heat recovery, Regenerative + passive cooling

Project description

This building is located on the northern fringes of the town of Zwingenberg in the state of Hesse, and has been the new headquarters of SurTec since 2000. The company develops, produces and markets products and processes for surface treatment, such as cleaning agents and galvanotechnical products. A total of 50 employees work in development, production and administration; in fact, around half of them work in administration. The production processes in the chemical industry result in special requirements for the airtightness and ventilation concept. The ventilation system must guarantee a legally stipulated level of air quality at the workplace (production/warehouse). The architect was able to convince the client that a high energy standard was achievable without adding to building costs.
To reduce ventilation and heat losses through the truck loading area, a special system for connecting the loading bay sealings to the building was developed, and the door leaves were fitted with insulating vacuum panels. The atrium was designed as a lounge area, and provides natural daylight to the production area. The upper area here also serves as an extraction zone. The glass structure was designed as a newly developed mullion-and-transom structure made of metal. The U value is around 0.8 W/m²K, meaning that the solar energy captured approximately matches the losses when averaged over the year. The company moved into the building in summer 2000. Measurements as part of the research project began soon after, meaning that the first interim results are already available.

Building concept

The range of rooms and areas in the building includes a high-bay warehouse (1,500 m²), laboratory and production rooms (1,600 m²), and office and conference rooms (600 m²). The site is a left-over piece of ground located between the main Frankfurt-Mannheim railway line and an important main road. The geometry of the site and the amount of noise present meant that a north-south orientation was decided upon for the building, with the high-bay warehouse positioned closer to the train tracks. The warehouse forms a continuation of the noise-blocking wall, and is partially sunk into the ground. The overall building consists of three blocks with differing designs, joined up by glazed structures: there is a narrow, naturally lit corridor between the warehouse and production area, and a main access atrium area connecting the offices and the production area.

The three-storey solid reinforced-concrete structure houses the office and storage areas, while the warehouse and atrium occupy the entire height of the building as a single storey. The warehouse and the production facilities have basements underneath. The building is the first factory which aims to fulfil the "passive-house" thermal standard; an annual heating requirement of 15 kWh/m² p.a. is projected. Central heating based on heating the supply air is used exclusively. Because of the very low heating requirement, no circulation of air is necessary. No local temperature control is provided in the individual areas. The particular challenges here include: an energy-efficient ventilation system that meets the requirements of a chemical factory; the presence of thermal zones in the building (warehouse/production/atrium/office); and the thermal optimisation of the building envelope.

The solid reinforced-concrete structure is thermally insulated, and largely free of thermal bridges. The connection between the blocks provided by the atrium and the absence of protruding structures leads to a very favourable surface-area-to-volume ratio of 0.25 1/m. The thermal insulation composite system used for the concrete exterior walls has a U value of 0.22 W/m²K. The windows in the perforated facades and the atrium structure have U values of 0.85 W/m²K thanks to the additional core insulation (polyurethane core) in the aluminium frames and the use of thermally insulating triple glazing. Large parts of the high-bay warehouse are buried underground, meaning that building components have less contact with the outdoor air. The foundation slab in the atrium and office areas has 16-cm-thick insulation made from pressure-resistant polystyrene; a 6-cm-thick layer of foam glass was used in the foundations for the warehouse and production area. The roof areas were planted to a large extent.

Energy concept

A central gas-fired condensing boiler is used to generate heat. Two 1-m³ buffer storage tanks provide process heat to the production equipment and also supply three central heat exchangers in the ventilation system. The energy required to heat up the daily goods turnover of around 12 tonnes and the additional ventilation losses through the loading bay had to be taken into account when designing the heating system for the warehouse and production areas. Sealings at the openings in the truck loading bay are provided to reduce the ventilation losses. The building has a sprinkler tank with a capacity of 220 m³ in the basement as part of the fire-safety system. This volume of water is used in summer as a cold reservoir for removing process heat.

The building is ventilated mechanically and only heated by heating supply air. Because of the different requirements of the office, production/laboratory and warehouse areas, separate heat exchangers are used to heat the supply air as needed. Common components include the central air intake via a 300 m-long earth-to-air heat exchanger, heat recovery, ventilators and the exhaust system. The central ventilation unit is located in the basement, underneath the laboratory area. All equipment is located within the building's thermal envelope.

In winter

The air intake through the earth-to-air heat exchanger heats the supply air to temperatures above –5 °C, meaning that there is no danger of ice forming on the exhaust-air side of the heat recovery unit. After heat recovery in two cross-flow heat exchangers connected in series, the supply air for the offices is subjected to further central heating (T_{max}=45 °C), as needed, and then fed into the rooms at a location close to the facade through a raised floor. Different temperature levels are not provided for. The atrium area is the exhaust zone for the offices, conference rooms and the canteen; air can flow through noise-proof flow ducts and the usual gaps around doors. Extraction at a number of points high up in the atrium feeds the exhaust air back to the heat recovery unit. The atrium, which is the central traffic area, is therefore heated indirectly. The production area and the warehouse each have their own air intake and extraction points and backup heat exchangers. For safety reasons, the production and laboratory areas are both subjected to slightly negative pressure (exhaust rate > supply rate). Some of the production and warehouse facilities have additional source extraction.

In summer

The earth-to-air heat exchanger is an important part of the summer cooling system. In addition, the smoke-and-heat-extraction flaps high up in the atrium can also be used to remove heat at night. The south-facing facade and the atrium roof have external shading.

Daylight and lighting

The side windows supply the 4.2-m-deep offices with sufficient daylight. A disadvantage of the east-facing facade is the sun's low position and the associated glare in the mornings. Facade planting provides protection from the sun; internally fitted blinds help prevent glare. The access area benefits from light entering through the roof and facade of the atrium, while the production and laboratory areas receive minimal daylight through the windows in the atrium and naturally lit corridor. The atrium roof has external blinds to provide sun protection in summer. The warehouse and production areas have simple fluorescent lamps without reflectors, while the offices have floor lamps with a rating of 10.8 W/m². Automatic control or adjustment of this power level is not provided. Users can manually switch between two brightness levels.

Performance

The staff are satisfied with the company building, and the elegant architecture plays an important role in this. When the heating was out of order for a few days during a spell of cold weather, most of the staff were won over by the building concept. Company management prepared a set of user instructions that informed staff about the effect of leaving doors, gates and windows open in winter, for example. Experience has shown that the comprehensive information and constant reminders are important in familiarising employees – especially in production and the warehouse – with the new building and encouraging them to play their part.

Optimisation measures and possibilities

In the area of logistics for incoming and outgoing goods, there were major problems in the beginning which, because of the importance of production, led to ad hoc solutions. For example, goods deliveries were taken in through a large opened window.

In the first year, some operating problems occurred with the ventilation system in the laboratory and production areas and with the heat supply. The air-change rate in production was set too low, meaning that uncomfortable indoor temperatures with high air humidity and a dust nuisance occurred in summer. In February 2001, it was noticed that the specially developed heat exchanger had been damaged by chemical and mechanical action, meaning that it had to be replaced.

In addition, other problems occurred that were rectified in time:

The average indoor air temperatures in winter were above the planned values

There were problems with heating regulation

The vacuum-insulated loading bay gate was damaged a number of times, which meant that this opening could only be closed off in a provisional manner for long periods

Construction costs and economic viability

The construction costs were very low at less than 1,000 euros per m². The low energy consumption leads to low operating costs.

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	
Heating energy demand	13,90
Measured energy consumption data (in kWh/m²a)	
Site energy for heating and domestic hot water (dhw)	28,70
Source energy for heating and domestic hot water (dhw)	31,60
Total source energy	169,20
Building physics - ventilation	42,60
Building physics - lighting	0,30
Building physics - heating	8,00

Implementation costs

Costs of implementation in €/m²	
Construction (KG 300)	777
Technical system (KG 400)	149

These figures represent calculated costs

Net construction costs (according to German DIN 276) relating to gross floor area (BGF, according to German DIN 277)