# MASTERING A GRADIENT OF 1°C OVER 15m OF HEIGHT

In the Nantes factory where the big pieces of composit carbon are going to be made for the Airbus A350 Xwb, the workplace environment in the different production units has to be perfectly homogeneous.

Used to fabric ducts, the manager has also installed some “Pulsion” ducts. The thermal equipments have been reduced and the gradient will be controlled more effectively.

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The carbon’s manufacturing’s site volume – 114m long, 64m wide and 15m high under the ceiling – is treated by four AHU treatment plants, one of which is for incoming air only.

Just three “Pulsion” ducts, 1400mm diameter and 53m long, treat a volume of 150000 $m^3/h$ and the calories to keep a temperature of 19°C during the winter and not above 26°C during summertime. The gradient is reduced from 5°C to 0,8°C.

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Switching from aluminum technology to carbon fiber technology, the aeronautical industry is also radically changing their means of production. From the manufacturing of the metallic pieces, there has been a change in trade towards the use of the skills derived from the textile and plastic materials industry.

These changes involve essential precautions in order to guarantee the manufacturing quality of the elements and the control of the material, both for the constructing operations and the precision holing.

The use of large carbon pieces will entail some important restraints that need to be enforced in the production areas.

## PRECISE THERMAL TOLERANCES

In the new 19000$m^2$ area of the AIRBUS factory in Bouguenais, near Nantes, which will manufacture the central rings of the future A350 fuselage, the internal conditions must be very precise: a temperature during the winter time from 19°C and 20°C, a maximum temperature in summer of 26°C and a 50-55% humidity rate in both seasons.

To this, there will be added a gradient criteria of horizontal and vertical temperature of 5°C in the three nearby volume areas, which are from 14 to 16 meters high.

These conditions require a great production of hot and cold, consequently there is the need to evaluate some energy-saving solutions. In charge of the engineering part of this construction site, Spie Ouest-Centre suggested a classical offer: some powerful air treatment plants, and the diffusion through classic textile ducts.

Later on, the company got back to the engineers in charge with a more cost effective solution for what concerns the equipment: less powerful air treatment plants and a different air diffusion technology, with a much easier way of functioning and with a better control of the environment. Wanting to compare the differences between the two options, AIRBUS chose to install them both in the new plant.

## THE MIX-IND® DUCTS PUT IN MOTION THE ENTIRE AIR VOLUME.

Increasingly used in industrial and commercial premises, the technique of the pulsion ducts suggested by Sintra has always less and less difficulty to be chosen by contractors. This is thanks to the reduction in the energetic needs and to the diffusion of the aerodynamic knowledge in this product.

On a metallic or fabric duct base, this concept’s goal is to exploit the capability of induction around the diffuser, given by the air speed (from 6 to 30m/s), the choice of the dimensions for both the main and secondary holes which allow the pulsed air to mix with the room air, the distance between these holes, their angle compared to the vertical axe, the height at which the diffuser has been fixed, and the applied pressure.

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## DRAPAGE: THE CLASSIC TECHNOLOGY

90m long, 64m wide and 16m high, the first hall of this new factory is dedicated to the first stage of the production of the large carbon pieces: the tying together of the carbon or aluminum sheets, which will be then pressed before the thermal treatment in the autoclave. The environment's quality for this big volume is ensured by six AHUs:

- Four with a single capacity of 82000 $m^3/h$, 474 kW heating power and191 kW refrigerating power;
- Two for a single capacity of 30000 $m^3/h$ dedicated to the introduction of new air, and with a 964 kW heating power and 483 kW refrigerating power.

In order to supply an air quality like the one in the "white halls" or ISO 8 (class 100000), the four AHUs are provided with G4 incoming filters and F9 outgoing filters. In addition, in order to keep the humidity of the room, there is a Carel adiabatic sprinkling humidifier which atomizes water at 70 bar feeding it directly into the airflow. This humidifier is fed by a water softening and osmosis skid with a capacity of 1,5$m^3/h$.
Treated air is transported through a network of ATC textile ducts fixed on the roof at a height of 16 metres. There are also four non-spreading ducts with a diameter of 1250mm and 18m long, and each of them feeds four spreading ducts with a diameter of 900mm and 22m long.

This solution is suitable to deal with 4,5 to 5 volumes per hour and it fulfills the standards imposed by AIRBUS for these industrial premises: the temperature's gradient is at 2°C in any point of the volume. This classic solution uses the convection effect: in order to achieve such results, there is the need to limit the maximum $\Delta t$ at the blowing point to 5°C. This calls for a recovery to be made with a network of nozzles at ground level.
Basically this solution needed an equipment with an electrical power of about 340Kw, the installation of 18 recovery filters on the ground and 584 metres of ducts, 424 of which would have been textile ducts.

Was it possible to build simpler and lighter equipment and to keep it as effective? This is the question that Franck Babu, head of the climatic and fluid engineering department of Spie Ouest-Centre posed to Pascal Danthony, in charge of AIRBUS dealings for what concerns investments and means of production.

## TRANSITION AND PRODUCTION ROOMS: ALL WITH PULSION DIFFUSERS

Having already equipped their customers with the pulsion linear diffusers (DLP) Mix-Ind from the Italian maker SINTRA, the Spie engineers came up with a variation which relies on less powerful generators and on a simpler installing process, both able to further reduce the gradient.

Pascal Danthony and Berbard Boudaud, Airbus managers in charge of the plant and energy maintenance for the site of AIRBUS Nantes, imposed: only the transition rooms for the manufactured pieces – the room called DNO (mould removal and cleaning of the equipment) where there is the 'cooking' autoclave for the composit carbon elements – and the manufacturing workshop will be equipped with this option.

This was a way for them to maintain a technique already tested in the drapage laboratory (the most sensitive at technical level) and to test a new solution in which they were already sure they were interested. "We noticed Sintra's method a few years ago through Interclima", admits Bernard Boudaud.

"The selected companies are always at the leading edge for innovative technical proposals" explains Pascal Danthony, "as long as they are sustainable and not just research and development. We have secured the thermal chain. That is to say: Optimization of the production of hot and cold water, constant of the working points AHUs and commitment of the supplier for the air distribution conduct. This solution could be applied in the future A320 carbon sites.

The massive 20m long and 100m wide building gathers the first three production workshops for the big elements of the fiture Airbus A350 XWB. On the right hand side, the warehouse for the wrapping of the rings has been handled in the traditional way: six AHUs with a capacity of roughly 390000 $m^3/h$ and a remarkable thermal power.

Air is spread through classic textile diffusers and is recovered in the lower part of the volume. The central area (autoclave) anc the manufacturing warehouse (on the left) have been planned out with an atmosphere treatment by pulsion linear diffusers.

The homogeneity of the mixed air mass allows to reduce the aerodynamic and thermal needs by half, yet guaranteeing a gradient of less than 1°C on a 15m height of the building.

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**REQUIREMENTS REDUCED FROM 40% TO 60%**

The transition hall is 45m wide, over 100m long and 15m high under the ceiling. The technical specifications initially indicated the installation of two air treatment centrals of 75000$m^3$/h each, which means an electric engine power of 150kW.

The air distribution must be ensured by 24 diffusers, 8 on the ground and 16 at a height of 3 meters. The variation suggested by Spie drops the power stored by the engines of 2 CTAs (55000$m^3$/h each, 137kW hot) at 90kW.

The air diffusion is ensured by two groups of Pulsion ducts: two diffusers of 1250mm diameter and a length of 57m each, and two with a diameter of 900mm and a length of 30m each. These kind of diffusers with specially fit holes have a 20m capability and ensure an air volume movement rate equal to 2.

Consequently the air recovery is ensured only by two wide openings positioned at a certain height next to the recovery of the central ones. The additional advantage is that the temperature gradient in the rooms is about 0,8°C.

**FROM 700m TO 150m OF DIFFUSERS**

About 114m long, 64m wide and 15m high, the manufacturing warehouse had to be fitted beforehand with an equipment similar to the one in the ring wrapping warehouse: four 85000 $m^3$/h CTAs, which means an electric power of 300kW, and a 10000 $m^3$/h new air plant, which means 5,5kW.
Here, 742m of ducts, among which 700m of textile ducts (32 sections of 22 meters each), were supposed to keep the required temperature for the production; the recovery of the completely moved air volume was carried out by 22 openings at 3,5m from the ground.

In this case the substitution in favor of Sintra's solution proposed by Spie seems obvious. From four times 85000 $m^3$/h the needs generated from the use of pulsion ducts are reduced to 3 AHU of 50000 $m^3$/h each. They provide 150kW heat and 242kW cool. The installed electrical power drops from 300kW to 90kW.

Only the initial new air plant (10000 $m^3$/h and 5,5kW , 142kW hot) resists to the new configuration. To spread the treated air, the ceiling of the huge workshop can count on three DLP of 1400mm diameter and 53m long each, situated 13m high and with holes on the sides: their unit capacity is 50000 $m^3$/h each.

The lateral capacity of the aerodynamic flux is 17,5m. The recovery is limited to three openings located at the level of the building's framework of the ceiling. The rate of the total air volume which has been moved calculated for each side of the diffusers is 1,9.
Also in this case the gradient of the temperature should be 0,8°C. For Spie Centre-Ouest, the presented solution leads to remarkable energy efficiency. The installed electrical power is of 522,5kW against 792,5kW forecasted at the initial CCTP.

The fitting of traditional ducts involves big expenses and a considerable amount of work. This type of diffusion must be considered in the calculation of the industrial building's structure.

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In the carbon wrapping workshop the AHU supply a volume of 82000 $m^3$/h. In order to supply air without any particles in an ISO 8 environment (white hall) the class C CTA covers support a 2000 Pa permeability.

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The new air centrals in the carbon sheets wrapping warehouse: these units of 30000 $m^3$/h are equipped with an adiabatic moistening system with small sprinklers that do not let the water stagnate.

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The DLP meet some particular specification of calculations: dimensions, perforations, fixing height, flow and air pressure applied.

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