

End-to-End: the state-of-the-art oxidation oven for the production of carbon fiber

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The production of carbon fiber is an everyday challenge that requires the best possible thermal treatment equipment. The state-of-the-art E2E Oxidation Oven offers many benefits which allow manufacturers of carbon fiber to run an efficient and reliable process that will make carbon fibers more affordable for large volume applications.

Like in many other markets, CF producers want to grow their business, reduce their cost and maintain or improve the quality of the product – often all at the same time. To make carbon fiber more affordable for large volume applications, improving the efficiency of the customers production equipment is a requirement. Short lead times and easy to install equipment are important factors allowing carbon fiber manufacturers to grow their business quickly and cost effectively. The oxidation process is the most



demanding step in a carbon fiber line. The equipment currently occupies the largest footprint and consumes the most energy in the carbon fiber line. The performance requirements for the oxidation ovens are the most challenging to achieve, but necessary to uniformly oxidize the product across the entire tow band width. All these aspects need to be considered when aiming for cost reduction.

Oxidation oven airflow systems

Currently there are two different types of proven oxidation oven systems used in today's market. These systems are differentiated by their airflow systems, either vertical or parallel flow.

The vertical down airflow pattern is mainly used on small tow applications (24K or smaller) while the Center-to-End (CTE) system provides airflow parallel to

the fiber and is used for all tow types. Hence Center-to-End ovens are the most popular oxidation oven system in the market today. The growing demand for industrial grade CF, which is typically heavy or large tow, will be the driver for the future demand for parallel flow systems. While CTE systems are established technology, they also have a disadvantage: In the middle of the process chamber of the CTE oven is a center plenum where the air is distri-

-buted to the oven chamber. This is an area where fiber can possibly contact the plenum, and the homogeneous supply of air is difficult to achieve which creates a risk of low airflow areas.

End-to-End oxidation oven

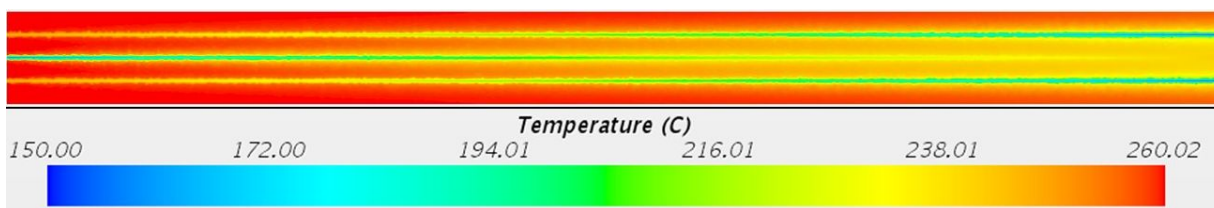
A new oven system that overcomes this disadvantage is the Eisenmann End-to-End (E2E) Oxidation Oven. The benefits of this parallel airflow system

have been demonstrated by Eisenmann Thermal Solutions. Eisenmann has manufactured a full-size production scale End-to-End oxidation oven complete with a 3000 mm tow band width, 13 m heated length and 11 passes. Comprehensive testing has also been performed to validate that the performance meets or exceeds industry requirements.

The End-to-End oxidation oven is the state-of-the-art technology that:

- eliminates the center plenum while providing uniform parallel airflow;
- eliminates any low airflow areas;
- provides for new access and improved maintenance;
- has the smallest footprint in the industry;
- has the lowest operating costs;
- requires less capital investment than CTE systems

A computational fluid dynamics (CFD) simulation was used to investigate the processing aspects of both parallel flow systems close to the fiber. After the validation of the simulation model, several simulation runs were conducted to investigate the impact of the oven zone temperature, the fiber inlet temperature, the fiber transportation speed and residence time, the amount of exothermic energy that is released from the fiber and the recirculation air speed.



In parallel airflow systems, a boundary layer builds up over the treatment length, which affects the heat transfer from the fiber to the recirculation air. As a result, the fiber temperature is increasing over the treatment length. It could be found that the fiber temperature in the CTE ovens is rising more than in the E2E system. The root cause for this was found in the areas of lower airflow in the center plenum of the CTE system. The

oxidation oven systems capability to provide uniform properties across the tow band is established by the measurement of airflow velocity uniformity throughout the entire process chamber. Since the performance of the latest CTE systems already provides exceptional properties for industrial and aerospace grade carbon fiber, the benchmark for the E2E system was to achieve a similar performance. The re-

sults show that End-to-End surpasses the Center-to-End airflow velocity uniformity performance by approx. 15% over the full process chamber. There are no areas of low airflow – especially not in the center – and the system is perfectly suitable to produce industrial grade and aerospace carbon fiber.

Summary: The state-of-the art E2E Oxidation Oven offers many benefits. The design is operator and maintenance friendly, has the smallest footprint, the lowest capital investment, and the industries best performance. This allows manufacturers of carbon fiber to run an efficient and reliable process that will make carbon fibers more affordable for large volume applications and more cost competitive compared to other materials