Concerns about environmental pollution, particularly in cities, is making the installation of cabin filters to control the indoor air of vehicles ever more popular. However, differences in filter geometries and materials mean that cabin air filter production lines have to be extremely flexible. In the following article, Ernst Reinhardt and Dr.-Ing. Michael Sperling, Karl Rabofsky GmbH, describe a highly automated production line for cabin air filter that is designed to easily accommodate a host of filter design requirements.

Ensuring the flexibility of cabin air filter production

As public concern grows over the pollution of the environment, particularly in our cities, more and more attention is being paid to ensuring the quality of the air inside the cabin of vehicles. If the air conditioning system of a vehicle does not include a dedicated filter system, polluting particles, such as soot and dust particles and fumes in the outside air can flow into the cabin without any restriction. Soot particles are of particular concern, since it is known that they can penetrate deep into the lungs of humans and greatly increase the risk of developing cancer. Other particles of concern include pollen, which can initiate spontaneous allergic reactions, and therefore affect the concentration of the driver.

To eliminate these problems more and more vehicles are being equipped with cabin air filters, so the demand for such filters. The most important parameters of these filters are dependent on the raw material; the dynamic flow properties at optimal efficiency and the geometric dimensions. The last one is often determined by the location of the filter because in most vehicles only limited space is available. In many cases, each vehicle has its own filter geometry, which complicates the manufacturing process. Thus, the requirements on filter production lines of such filters are high, especially concerning the ability to accommodate product changes and reproduction of manufacturing quality. In the following article an approach that can cope with these requirements is described.

Cabin filter production line

Cabin air filters can vary in height, width and length, depending on the application and type of vehicle. Furthermore the variation may also occur in material and pitch (pleat spacing). Because of this variety, all necessary adjustments on the production line must be made in the shortest possible time. Also the required number of operators must be kept to a minimum.

For these reasons, the main design objective of a cabin air filter production line is to provide functional units with the highest degree of automation. However, the complete automation of all functions is still not possible, so in some parts of the line manual handling is still required. The concept of the system is modular, with each module carrying out a specific function. This approach reduces the complexity and provides the necessary flexibility for the adjustments and future modifications for new applications. The basic system consists of the following modules:

(i) Twin unwind station

The twin unwind station consists of two cantilevered axles in a linear arrangement. The unwind station can be loaded with two medium rolls. Every roll can have a maximum diameter of 1200 mm, a maximum width of 350 mm and a maximum weight of 150 kg. Only one rolls is active at any one time. During the splicing operation the pleating machine is fed out of the integrated material buffer containing approximately 20 m of material. When the active layer becomes empty, the operator is informed by a visual and an audible alarm.

(ii) Electronic rotary pleating machine

An electronic rotary pleating machine can be of the type RE2000 and equipped with modern servo-drives and electronic controls. The machine is designed for a working width of up to 350 mm.

The machine is designed to pleat both single layer or laminated materials. The scoring and erecting rollers of the machine are able to produce pleat heights ranging between 15 mm and 50 mm, with a maximum linear speed of 60 m/min. A set of scoring rollers, consisting of a top and a bottom roller, each have blades set to the required pleat height range and media requirements. The scoring rollers are integrated in a special magazine, which allow quick change-over times.

Two sets of scoring rollers are available, each with specially designed blades for scoring either combined filter or particle filter materials. The scoring method allows an electronic pleat height variation over a range of 40%.

The pleating machine is also equipped with an infrared post-heating zone and a special active cooling unit, which help to produce the required stabilization of the pleats.

(vi) Pitching unit

The pitching unit arranges the pleats with a given pitch. The unit is equipped with pitching tools, which catch the pleated material at each single pleat and guides it until side sealing with glued side strips takes place. The pitch is determined by the shape of the pitching tools, so to change the pleat pitch it is necessary to change the pitching tools. The pitching tools have a certain length to keep the pitch of the pleats during the sealing process with side strips.

The pitching unit offers a working width ranging from 100 mm to 350 mm. To adjust the unit to the different widths of the filter inserts, the positioning of the tools can be manually changed in horizontal direction. The position is displayed on a scale. To adapt it to a certain pleat height, the position of the pitching tools can be

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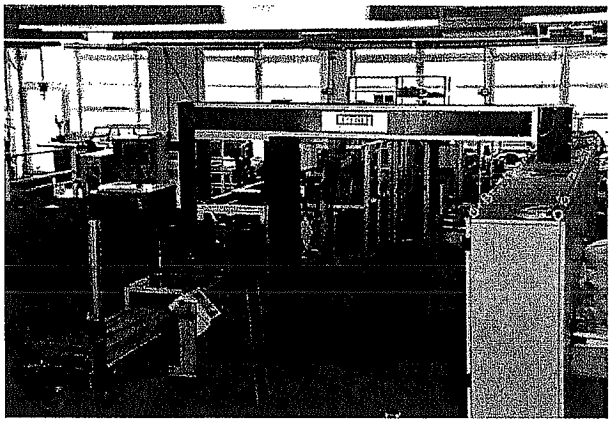

changed in the same manner in the vertical direction. The pleats are pitched by a "worm system" with parallel screws. For each requested pleat distance an appropriate worm system has to be used.

(v) Lateral sealing unit

The lateral sealing unit uses side strips, which are supplied on both sides of the unit from a twin unwind unit. The unwind units also contain a splicing table and a small material buffer. This allows a change between the empty active roll and the new stand-by roll (similar to the twin unwind unit for the basi cmaterial) without interrupting the process. The side strips are guided into the lateral sealing unit, which consists of a system with continuously circulating belts parallel on both sides of the pleated material web. These belts press the strips to the lateral sides of the pleated web after hot-melt is applied through slit-nozzles to the inner side of the strips. Along the belts, the glue is actively cooled down and solidified by a cooling unit. The lateral sealing unit can be adjusted to the required filter width. At the end of this unit the edge sealed filter packs run onto the conveyor belt.

(vi) Stabilizing unit

The stabilizing unit is an optional device, which is only required for filters that easily lose their shape. It consists of a hot-melt nozzle on the top and can be activated for applying a hot-melt bead on a rotating transfer belt, which transfers the glue in a flat shape (like a tape) on the pleat tips. This serves as an additional pack stabilization. Sometimes the hot-melt is applied on a slim fleece strip, which is pressed onto the pleat tips.

(vii) Automatic cross cutter

The automatic cross cutter is triggered by a high performance sensor system, which counts the pleats leaving the lateral sealing unit. Cutting is done from the bottom to the top edge of the dedicated pleat moving the blade in the line of the pleat tips. The cross cutter also tolerates lop-sided pleats within a certain range.

(viii) Cut edge sealing unit

The standard cut edge sealing unit consists of a hot-melt unit to melt and dispense hot-melt through a nozzle system. This unit is required to seal open cut edges of active carbon material to prevent the spread of the active carbon powder after the pleated material is cut. When filters, incorporating other media than active carbon materials are produced, this station is inactive and the material passes without sealing.

(ix) Front and rear sides sealing unit

This unit is only required for applications of rectangular shaped filters, which require an additional sealing of the front and rear sides. The sealing is made with strips of nonwoven material supplied by the twin unwinding station as explained for the lateral sealing unit. The strips are applied with hot-melt and pressed on the front and rear pleats of the filters. In addition to the twin unrolling units, the front and rear sides sealing unit consists of a hot-melt unit, a cutting unit for the strips and a outlet conveyor. After leaving the front and rear sides sealing unit the production process of a rectangular filter with a sealing on all four sides are finished.

Specific configurations

For producing alternatively combined filters consisting of separate layers of activated carbon (e. g. polycarbonate) and protective fleece it is helpful to use a pleating method that can handle multiple layers of more difficult and highly sensitive media, and at the same time offers sufficient flexibility and ease of operation.

Two examples of machines designed to produce filter packs of combined media for cabin air filters are Rabofsky's PC-controlled and fully electronical knife pleating E2000 machine and the high speed HE2002 pleater, with the latest direct drive technology. Both pleating machines can be used to convert sensitive media like activated carbon by freely programming not only the tilting angle of the pleating knives, but also by using a programmable "soft-touch" for the knife movements. Both of these features ensure less strain on the media because of reduced stroke and knife pressures, and thereby ensuring high pleat quality even at high-speed levels.

The HE2002 electronic knife pleater's maximum physical speed of more than 300 pleats/min and programming features for separately tuning the top and bottom knife movements to the media characteristics mean it is an ideal alternative to rotary machines for pleating more difficult and multi-layered materials within semi-automatic or fully automatic production lines for cabin air filters.

Programmable control

Each logical complex module of the production line has its own electronic control (PLC). The control units evaluate the measured values of the local sensors and control the dedicated actuators. By these means more than 20 independent drives are controlled in the complete system. The drives are mainly servomotors. In addition to the PLC each complex module contains a separate operator panel. On these panels specific fine adjustments on the modules can be made and messages and errors may be displayed. In addition to the controllers the production line contains a central operator terminal. This includes a PC with a graphical user interface, which saves the so-called "recipes" for the specific production process. This heirarchical control enables a smooth operation of the wwole production line.

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