Degreasing aluminium foil using corona treatment

Plasma method replaces lengthy annealing process in chamber furnaces

Rolls of aluminium foil commonly used in households have already been in the oven for up to one hundred hours before coming into contact with food. The heat causes the separating agent needed during production to evaporate. Without the grease, the foil cannot be rolled so thinly, and the consumption of aluminium, which requires a considerable amount of energy, would be greater. The aim is to replace the costly degreasing procedure with a corona treatment. During this procedure, high-energy electrons come into contact with the foil. The method can be integrated inline, in other words directly, into the production flow.

Aluminium which is almost completely airtight is used in households in order to keep food fresh and warm. The material is also widely used for industrial purposes. For example, it is added to the packaging used for drink cartons. A foil thickness of less than 0.007 millimetres – even thinner than a human hair – already offers sufficient barrier properties.

In order to achieve this degree of thinness, the aluminium foil is rolled in two layers. During this process, an inner matt side and a shiny outer side are created. In order to ensure that the two sides aren’t glued together, they are moistened with a separating agent which is not suitable for consumption. During the standard production procedure, the aluminium foil is then heated in a chamber furnace for up to 100 hours so that the separating agent diffuses out.

As an alternative to this annealing process, which requires a great deal of time and energy, a corona treatment approach has been forwarded since the 1970s. The mechanical engineering company Kampf from Wiehl, North Rhine-Westphalia,
has now successfully developed a prototype. This enables the inline degreasing of the aluminium foil following the rolling process.

Prototype for inline degreasing put to the test
Thanks to the continuous degreasing during running production, the lengthy annealing process is no longer required. The developers are also hoping to make energy savings. The chamber furnaces consume around 1.3 kWh per kilogram of aluminium foil during degreasing. As a result, this process uses up to ten per cent of the entire energy consumed during production. This lies between 12.9 and 17.7 kWh per kilogram of aluminium foil. In the chamber furnaces, the rolled aluminium foil is subjected to temperatures of between 250 °C and 400 °C. The temperature can only be increased slowly, since the rolls, which are up to one metre thick, will otherwise crack. It takes up to five days to diffuse out the separating agent.

By contrast, the corona method can be incorporated inline into the production process. After the double foil has been separated, it runs through the corona station in the Sepamat (cover image).

Plasma method functions under atmospheric pressure
The aluminium foil is degreased by an atmospheric air plasma. It runs over an earthed roller above which are high-voltage electrodes. The plasma is generated by a voltage in a range of up to around 20 kV. Ions from the plasma come into contact with the foil with a high level of energy. This causes the separating grease to oxidise. By-products of this process include ozone, nitrogen oxide and carbon dioxide. The gases are suctioned out. The cold plasma method functions under atmospheric pressure.

The degreasing depends on several parameters of the corona. Staff at the University of Applied Sciences and Arts (HAWK) in Göttingen have researched the optimum settings. In this way, the power density, and therefore the energy which acts on the surface of the foil, can be controlled.

Here, the aim is to achieve the highest possible degree of degreasing without damaging the foil. In practice, the foil does not always lie completely flat on the roller. It could get snagged and tear.

At higher speeds, the lower residence time of the foil under the electrodes must be compensated. For this purpose, a larger number of electrode rods can be used, for example.

Degreasing 800 metres per minute
Initially, the developers showed on a rotating roller (Fig. 1) that degreasing aluminium foil using corona treatment does indeed work. They then constructed a pilot system.

The corona station consists of the corona roller, the supply device, the suction device and the high-voltage transmitter. The system comprises two rollers, each with six electrode rods. They are arranged around the rollers in six units. Each electrode rod has a capacity of around 2 W/mm. The two rollers ensure that both foil sides are degreased.

The degreasing system is 4.30 m long, 2.40 m wide and 2.30 m high. Without the switch cabinet, it weighs around 3,400 kg. The degreasing system is surrounded by protective cladding.

The corona system is ventilated for cooling purposes. The developers have calculated that 100 m³ is needed for every kilowatt installed. A high air throughput is important to maintain the temperature resistance of the electrodes. However, it also reduces process efficiency. In addition, it helps create ozone production. In the pilot system, ventilation with 4,000 m³/h was installed for a corona output of 60 kW.
One of the challenges in developing the method for inline degreasing is the high speed of production. In practice, the winding processes involved while separating the double foil run at 800 to 1,200 metres per minute.

With the prototype, degreasing of up to 800 metres per minute was achieved.

What is corona treatment?
Corona treatment is a plasma method under atmospheric pressure. Essentially, the physical plasma is an ionised gas mixture.

In nature, it occurs in lightning, for example. In industry, plasma which is generated under controlled conditions is used as a pollutant-free alternative to chemical methods. It is suitable for modifying, cleaning and disinfecting surfaces.

The types of plasma used include glow discharging like that used in fluorescent lamp bulbs. The method requires a low pressure environment. Another option, known as barrier discharging or dielectrically impeded discharging or silent discharging, is similar to glow discharging. It has the advantage that it can also ignite under atmospheric pressure.

The term corona discharging is used to describe directly applied discharging in foil surface processing.

Until now, corona treatment has been used above all for processing synthetic materials. Yoghurt pots and other products made of plastic have a water-resistant, electrically insulated and non-polar surface. However, corona treatment is helpful in enabling them to be glued or printed. For example, it is used upstream in offset printing machines. The method increases the tension in the surface and in so doing, improves moisture penetration.

The corona treatment is also used with other synthetic, metal and paper surfaces to ensure that the products bond better with the dye, adhesive and coatings.

The degree of purity required determines the energy requirement
The energy required by the method depends on the degree of purity required for the surface. Measuring grease residues on the foil directly after the corona treatment would help. In this way, aluminium producers could react quickly to batches with differing grease levels. This would reduce the energy required by the process.

The degree of degreasing is currently determined using test ink. In the same way as when spraying a water drop onto a surface, a check is made to see whether the fluid runs. If the drop remains intact, this is a sign that there is still grease on the foil. In order to test whether the separating agent has been fully removed, the carbon content on the foil surface is measured.

Research on inline measuring procedures is needed
Staff at the University of Applied Sciences and Arts attempted to develop an inline compatible measuring procedure. They tested six different measuring procedures. However, these proved unsuitable.

An inline measuring procedure must work with contact-free analytics. Visual systems have until now failed to cope with the reflective surface of the aluminium foils. The challenge to be overcome is the speed at which the foil is wound. Also, the layer of grease is much thinner than assumed by the scientists before they began their tests. The thickness of the grease layer is less than the roughness of the surface of the aluminium. The layer of grease is therefore not smooth and sealed. Further research is needed on the development of an inline measuring procedure.
Energy balance of aluminium foil

In Germany, around 180,000 tonnes of aluminium foil with a double foil layer are rolled every year. The corona method can reduce the energy required for the degreasing process. Until now, this process, which is conducted in chamber furnaces, accounts for up to ten per cent of the entire amount of energy used in production.

At the same time, the energy consumed in the production of aluminium foil is currently the focus of criticism. In Germany, according to figures from the head association for the aluminium industry (GDA), around 432,500 tonnes of aluminium were produced in 2011 using melt flow electrolysis. The figure is further increased by 634,000 tonnes of recycled aluminium. The raw material requires a great deal of energy to produce – between 13 and 16 kWh per kg. With recycled aluminium, the energy consumption is up to 95 per cent lower.

The re-use of aluminium foil is managed in Germany using the Green Dot system. Packaging which contains aluminium foil is collected in yellow recycling bins. This waste is sorted and separated. The aluminium packaging is shredded and other materials are removed. The aluminium is finally melted down and returned to the industrial cycle as a raw material.

Across the world, recycling meets around a third of the increasing demand for aluminium, according to the association for the aluminium industry.

Project participants

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Links and literature (in German)

- www.kampf.de | www.tigres.de | www.hawk-hhg.de
- www.tigres.de/de/publikationen/messung-der-entfettungswirkung-an-gereinigten-bauteilen.html

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