CAR RUBBER PROFILES: NEW DEVELOPMENT IN FLOCKING AUTOMATION

INTRODUCTION

Flock techniques have been used on rubber, plastic, metal, etc. materials for industries such as automotive, packaging and other commercial fields.

Among the various flocking machines on the markets are lines for flocking automotive rubber components. Over the years, these machines have benefited from progressive technical and technological evolution.

From the positive results of this development, the need to operate flocking lines automatically and with systems to manage the data collected by the electronic instrumentation used on the lines is becoming more and more important.

Flocking lines for automotive profiles is one area where interesting developments were possible. In short, **this new development involves dedicated flocking lines for corners of extruded rubber profiles (EPDM, TPE and TPV) previously jointed by special injection moulding machines.**

Thus, automated flocking lines equipped with robotized systems together with dedicated automation devices and sensors have been engineered in order to achieve:

- **increase of productivity thanks to automation useful to reduce defects and maximise the control of the parameters of the various technical functions used in the plants;**
- **ergonomics** to improve operators' working conditions. In particular, a special profile positioning system was developed to improve the loading and unloading of parts in the line: a hightech lifting system the profile supports in order to make loading/unloading easier;
- higher **productivity** with less operators involved in the process;
- **versatility** to quickly change the profile type;
- possibility of **collecting process data** through appropriate **sensors** and the use of advanced **communication** systems to use and process the collected parameters remotely.

These new characteristics allow the use of innovative products with particular reference to automation and process data management applied mainly (but not only) to the automotive sector, which is also one of the fastest growing markets globally (in addition to the automotive sector, the other sectors of applicability are, for example, the aeronautical, naval, railway and construction sectors).

THE STATE OF THE ART AND DEVELOPMENTS

In the area of flocking rubber profiles in recovery, there are applications that require semi-industrial, if not in some cases still artisanal, processes. Aigle itself has developed and installed several flocking lines of this type over the decades. However, these are plants on which it is now considered possible and useful to install robotic systems to automate various stages and above all to manage the process data collection in an appropriate manner.

Furthermore, as far as production automation is concerned, nowadays the pre-treatment part of the profiles and the glue application part are, in most cases, still carried out manually and sometimes off-line.

These experiences led to the need to develop new automated flocking production models for these phases of the flocking process.

The research area was developed in an innovative industrial project with the aim of creating a substantially different model from those currently in existence, including the use of sensors, connectivity and data analytics (production data analysis):

In summary, with regard to this type of equipment, currently on the markets, the first two operations (a, b) of the five on these machines are carried out manually:

a. **Pre-treatment (in the world currently performed off-line or by hand)**

b. **Glue application (in the world currently done by hand by an operator)**

c. **Flock application**

d. **Glue drying**

e. **Final Cleaning**

The innovation was to automate them with the use of robots and specific tools such as plasma guns and precision glue dispensers, but in doing so the entire plant necessarily underwent a deep electronic evolution in all its phases. In fact, it is essential that the rubber components to be processed are automatically recognised and that all phases are automatically managed and monitored in an integrated manner.

It was thus necessary that the data recorded by the sensors and cameras were not only collected but processed during production and then, **of course,** continuously **reprocessed** to control and increase the efficiency of the entire production system (productivity, waste reduction, etc.).

As the five working stages are very different from each other, each requires special instruments for reading, handling and collecting data (e.g. pyrometers in the ovens, high tension control in the flocking area, self-regulating pressure valves in the glue area, thermometers and hygrometers for the flock distribution area, etc.).

So the innovation is not just the simple automation of the first two phases, but the study of an **integrated system** that collects very different data from different sensors, data that is then analysed and managed continuously.

Aigle thus developed some prototype line parts to implement an automatic and process system. The aim was to validate and demonstrate the technologies used in the industrial environment first at prototype level and then at real operational level, up to the qualification of the system and the demonstration of its applicability in the rubber profile production area.

Finally, an attempt was made to combine the specific raw materials (chemicals and flock) with the special requirements of the control system, which was then developed in such a way that profiles with the desired technical characteristics could be treated on the surface.

THE FLOCKED RUBBER PROFILE: TOWARDS TOTAL QUALITY

Specifically on automotive sector (and not only), the rubber profiles require various treatments to assure thermal insulation characteristics and resistance to weathering and abrasion. The application of these treatments makes it possible to:

- limiting **vibrations** (anti-rumble effect)

- facilitate mechanical **sliding**

- extend product life by limiting **mechanical wear** and **tear** and aggression of **atmospheric components**.

There are, however, several difficulties faced in automating the production process and managing the data and achieving this at the process and control level.

The research presented took in consideration the following aspects:

- automation and process control

- changing the shape of the rubber during processing (which obviously hampers product quality and repeatability)

- flockability of **profile sections that are difficult to** reach by flock fibres (presence of undercut areas).

Today, the growing need for automation of various mechanical parts of the automobile, first and foremost hatches, bonnets, and other non-automotive related areas, sees the use of flocked profiles on the rise. The increase in demand, however, requires rationalisation of production criteria and their control, and an **increase in productivity**.

At the same time, constantly rising quality standards require manufacturers of these components to make an effort to achieve total quality and thus production systems that are able to increase productivity while maintaining high quality control of the semi-finished product.

The reasons why there were currently no particularly advanced automated plants for the above-mentioned are mainly due to the following factors:

- rubber parts sometime are not maintaining a **constant shape and position** along the production line. This makes the use of robots difficult.

- the profile should be flocked not completely **but only in some parts**. Therefore, the application of spray glue would have to involve the use of masks; this would make the process expensive and more difficult (but anyway possible) to automate.

- The difficulty of flocking on rubber lies in combining a special pre-treatment (plasma) and finding chemicals (glues and its additives) compatible with precision dispensers. In order to be flocked, the profiles need the glues to create a wet layer of about 0.2 mm on the surface of the rubber product. This can only be achieved with spray techniques. Glues have also been found that cure at relatively low temperatures (in case of PTE profiles), but still allow them to adhere well to the rubber. Pre-treatment, quantity and quality of glue distribution, flock flow control, electrostatic fields and drying temperature control are the **parameters** that this research has collected and managed with the aid of advanced measurement systems, automation and communication protocols that have made the process data easily accessible to the production control staff.

For profiles, the difficulties of flockability are multiplied by the fact that it is complex to reach the fibres evenly across the entire **section of** the profile. For this reason, it was decided to use the technique of electropneumatic flocking, which, by precisely mixing air and flock, allows the fibres to reach areas that are difficult to flock.

Moreover, the profiles do not always have a constant shape and position. We studied a solution using **a cameras installed on the robots to correct the trajectories just before the process is started** for limiting the problem. For these reasons, up to now the operators have always been obliged to operate manually and the need to automate the process has already been clearly expressed.

There are currently no alternative systems to flock that can guarantee the same performance on rubber profiles. A 'textile' type product that precisely follows the surface of rubber objects is not available on the market. Furthermore, flock fibres can be selected for:

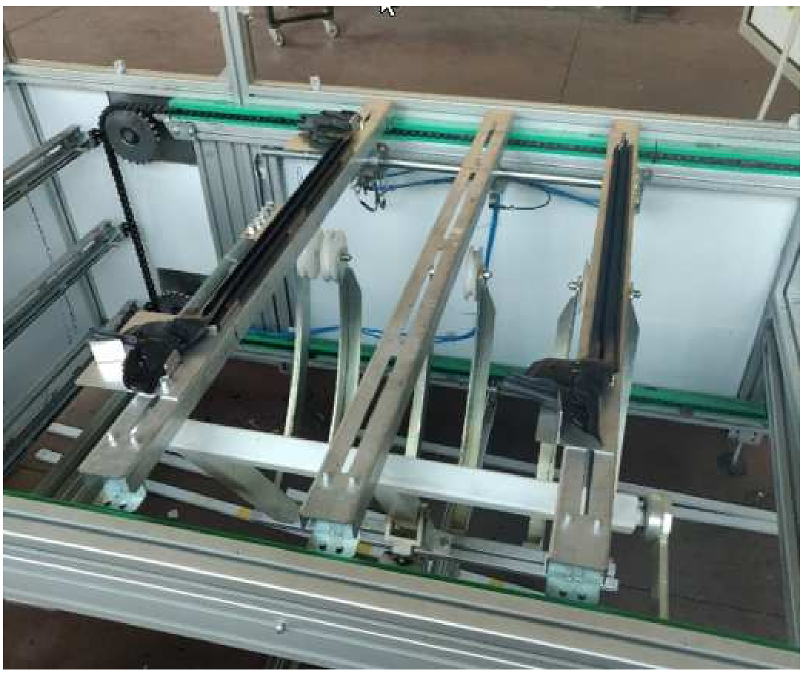
- diameter
- length
- colour

For rubber, polyester or polyamide flock is preferred as they are more resistant. However, the possibility of choosing the type of fibre and thus its mechanical performance can also allow for very varied uses.

THE FLOCKING LINE: INNOVATIONS

Several elements have therefore been adopted on the new flocking lines:

- The **pieces are supported** by a system of supports or pallets that move with a step-by-step movement. Compatibility with the support transport or carousel pallet systems used on these previously constructed flocking lines was studied in terms of mechanical, operating speed and product geometric compatibility. The supports, for example, are raised towards the operator by a system of automatic levers (controlled by sensors) that allow easy loading of the profiles onto the line. In this way, better ergonomics of the operator is assured during profile loading/unloading operations.



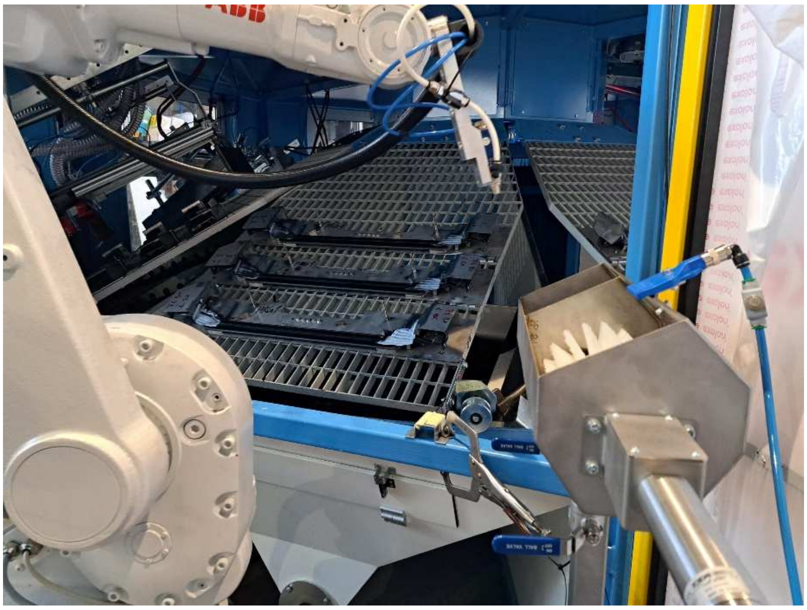
- In the first robot, the one envisaged for **plasma pre-treatment, there** is a camera equipped with appropriate lighting systems. The camera serves two distinct functions:

    - **Identification of the type of profile** to be treated in order to choose the recipe to execute

    - **Identification of the precise position** of each individual part for referencing robots in order to carry out robotic operations precisely,

- **Adhesive application**, on this area, a spray gun was identified with the possibility of significantly varying the application rose, from very small, min 5 mm, to a max of 15-20 mm. The robot manages the application rose with a proportional valves that allows to vary the spraying characteristics according to the various areas to be treated with the adhesive:
- small area for the edges for limiting the over-sprayed areas
- wider area for the central zones to shorten the application time (essential to reach the productivity target).
  An advanced sensor is used in the glue distribution system to keep under control the flow of adhesive.

  This measures the adhesive passage flow in order to confirm the correct functioning of the system and will alert the operator in case of abnormal passing measurements that are not in line with the pre-set data.



- **Flocking with electropneumatic guns** for fibre distribution, with a special device for filtration and recovery of excess flock. The guns attached to a third robot or to movable axis devices, are built in special isolated material. Flock is carried through transparent pipes, the transparency of the tube permits to monitor the presence of the flock and the amount of fibre sent to the guns with an optical sensor. In this way we can control the inverter speed of the fibre flow fan with the signal received from the sensor. In this way, the quantity of flock arriving on the profile is optimised, and in the event of a blockage in the pipe, the system provides an acceleration of the fan speed to remove the blockage autonomously, without requiring operator intervention and a prolonged stop of the line. If the blockage persists. the sensor can command an alarm signal and line blockage

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- A flocking plant equipped with a variable intensity electrostatic field that contributes to excellent flock abrasion resistance. The flock distributor is enclosed in a **climatic chamber** with automatic humidity and temperature control to ensure consistent operation of the flocking operation.

- **Drying is** done using a system of infrared lamps. Each group of lamps is equipped with a pyrometer that allows the intensity of the lamps to be modulated once the target temperature has been reached. The lamps have different wavelengths depending on the curing stage of the adhesive.

- Suitably enclosed plant to **minimise fibre pollution** in the working environment.

Pressure switches in all exhaust fans are used to control the correct air flow and to signal any faults in the aeraulic circuits.

The system is **managed by a PLC for the management of the main production parameters.** The system also allows 'recipes' to be set for specific products: the production parameters set can be memorised and re-proposed later for similar processes. Any line anomalies can also be monitored with analysis of their impact on productivity.

The PLC is connected, with a SCADA System (CitectSCADA or WinnCC Professional software), to a data collection PC offering:

- Synoptic diagram of the line highlighting the parameters used, workpiece recipe currently being processed, production in the predefined time frame, productivity, any deviations from target.
- The Plc has an internal counter that keeps track of the hours of operation and parts produced to keep the wear of consumable parts under control in order to alert the production manager for **maintenance** schedules.

The study involved the acquisition of a technical solution for robotic systems capable of guaranteeing quality and repeatability of the production model and consequently of the final product.

Safety systems, sensors and barriers to protect operators were also studied for future industrial applications.

The result in terms of plant capacity is approximately 180 angles per hour (depending on the shape of the profiles to be flocked).

In terms of defectiveness, a result of 2-3 % is achieved.

Going into even more detail, the flocking plant required a number of evolutionary elements to ensure product quality and control.

Systems were thus developed for:

1. **Visualisation** and management of profiles that have not correctly received flaming, coating or flocking phase. Visual markers indicate the profiles that remain in 'quarantine' because an emergency has occurred during processing. The production process therefore does not stop to avoid creating waste on other profiles.

2. Identification and registration of the various **batches** produced with registration on plc

3. Management of **parameters** such as profile traversing speed based on processing time and dwell time in the oven. The parameters of oven temperature and profile traversing speed are stored e.g. every 10 minutes. In this way the operator has proof that the individual batch has been produced with constant and verifiable characteristics.

4. Control of the weight of **raw materials** (glue and flock) by means of loading cells for the management and **control of consumption** and for the warning of approaching product reserve so that the operator is activated for the replacement of the glue drum and the necessary loading of flock into the distributor hopper.

5. **Flock flow** control with alarms in case of low or no supply.

6. Control of **electrostatic generator values** with alarms in case of non-compliance with preset values.

7. In-line **quality** control systems with advanced visual/sensor systems

CONCLUSIONS AND PERSPECTIVES

It is believed that developments on the automatic flocking of rubber profiles in recovery can continue and open up new horizons for these production techniques as well as for other types of flocking lines as has been the case in similar experiments in the past.

The project evolved through the following preliminary activities:

a) **Analysis of production methods and products** for the definition of functional models to systematically identify the innovative potential of the flocking line for moulded profiles as well as the best technical and technological opportunities, also imported from other industrial sectors.

b) **Reconstruction of the state of the art of technology** and research in the relevant scientific and technical areas, highlighting which players have invested and developed new knowledge in technologies of potential interest and with what results.

c) **Definition of potential technological opportunities** and guidelines for possible subsequent implementation.

This led to:

- **Summarise the state of the art of electronic technologies** in the technical-scientific areas of product quality control and management (the profiles covered as described) and the production system to achieve it (evolved flocking lines)

- **Develop new knowledge and apply it** to the product and system based on the above

- **Define new development targets** for electronic systems applied for future new implementations

Dedicated software was therefore developed and commercial components adapted to specific needs were selected and integrated.

It is foreseeable for the future to be able to apply these technologies to industrial plants, certainly for rubber profiles, but in succession also to other industrial products of various kinds: gaskets for light industry, for consumer durables such as household appliances, for construction, etc.

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