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Inline Inspection of Ceramic Tape Casting Processes by Means of Optical and Eddy Current Methods

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Summary:
Tape casting is a ceramic forming technology used to produce planar ceramic components by means of a doctor-blade process. However, industrial casting plants are currently not equipped with inline measurement tools which allow detecting of defects and determine quality parameters of the ceramic tape. Here we use laser triangulation, camera-based monitoring and eddy current measurement tools to acquire different tape quality parameters. Initial results of the implementation of these tools and the insights gained by sensor data fusion will be presented.

Keywords: tape casting, process monitoring, ceramics, optical inspection, eddy current

1 Introduction

Tape casting is a highly productive method for producing large, flexible tapes of functional materials very efficiently and cost-effectively in roll-to-roll processes. Applications for the tapes range from classic ceramic microsystem technologies (LTCC and HTCC) and the current strategic field of battery research to filtration, gas separation, and a variety of special functional tapes. Finely ground ceramic powders are dispersed under addition of suitable dispersants, organic binders and plasticizers. The resulting viscous casting slurry undergoes a doctor-blade process and subsequent drying done in a drying channel of several meters of length. The result is a very thin ceramic tape with flat surface.

The tapes produced can show several defects such as air pockets, bubble formation, large particle inclusions, density fluctuations of the slurry and fluctuations of the tape thickness. At present, industrial casting plants are not equipped with process monitoring tools which allow detecting of defects and determine quality parameters inline. As a result, defects and parameters outside specification margins are only detected after the manufacturing process and the operators face high costs due to rejects.

The authors intend to evaluate measuring methods for defect detection, to develop an inline application and in future adapt the information of the different methods to an overall description of the tape quality.

Measuring method used here are laser triangulation for thickness determination at the beginning and end of the drying channel (measurement of wet and dry film thickness), optical inspection, and the eddy current technology at the end of the drying line (detection of inclusions, material defects, holes, deviation in dielectric constant). The methods have been evaluated and optimized with regard to hardware, location and method of implementation, data generation and evaluation, and were integrated at a demonstration casting plant.

In this contribution we show results of the different monitoring systems and the effects on operating tape casting machines.

2 Measurement System

For thickness measurement four laser triangulation sensors (Keyence, LK-H087) were installed (a static reference and a dynamic sensor each at the beginning and the end of the drying line). Hence, they were applied in differential mode to determine the film height. Furthermore, optical inspection is carried out with a single line camera (Teledyne Dalsa Linea) and alternating illumination in reflecting and transmission mode. Images were acquired exploiting the movement of the ceramic foil under the line sensor of the camera. This system was intended to detect defects in the ceramic foil. As a third component, an inline eddy current array probe set up by Fraunhofer IKTS [1] was installed at the backend of the drying line. This system allows to evaluate especially the (di)electric properties of the cast foil. It was operated in reflection mode.

3 Results

After the implementation of the described measurement tools initial results were obtained which allow a first inline characterization of the ceramic tape. For demonstration, a sample casting with an Al_2O_3-slurry was carried out. The tape width was 150 mm, the doctor-blade gap 150 µm (tape wet thickness) and casting velocity 0.8 m/min.

Thickness measurement results (backend of drying line) are displayed exemplarily in Fig. 1.

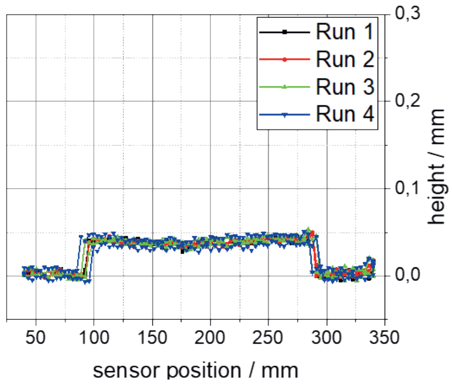

Fig. 1 Inline thickness measurement of the dry ceramic green tape.

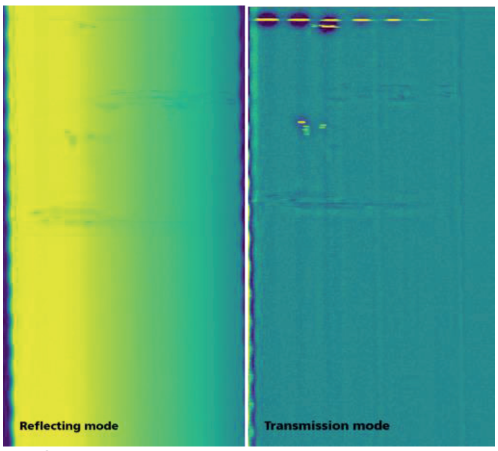

Fig. 2 Optical inspection with alternating illumination: left reflecting mode; right transmission mode. On the top right, a series of holes is detected which leads to exclusion of this foil are for further processing.

The optical inspection tool allows to detect specific defects (holes), favorably in transmission mode (see Fig. 2, top). Finally, a first test of the eddy current setup allows to detect NdFeB particles in the foil. They are marked as blue spots in the image in Fig. 3.

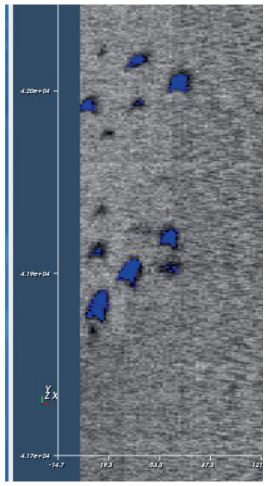

Fig. 3 Detection of NdFeB particles (blue spots) by means of the eddy current system.

Based on these first results and the ongoing work, our contribution will provide a detailed description of the measurement system in use, a classification of detectable defects and the benefits achieved by fusing the data of all three measurement tools.

References

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