DEA 288 *Ionic* – Cutting-Edge Technology, Ready to Meet the Challenges of Intelligent Production

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Fig.. 1. DEA 288 *Ionic*

Dielectric analysis – a technology that has been in use for 40 years but is not widely known. The literature agrees: Dielectric analysis, or DEA for short, has the greatest potential for characterizing the following in a process environment and thus for controlling industrial manufacturing processes:

- Material changes
- Glass transition
- Gel point
- Curing of thermosets
- Melting and crystallization of thermoplastics
- Flow behavior

The Potential Is Fully Available

Carbon-fiber reinforced plastic (CFRP) is the material with the highest potential for lightweight construction in the automotive and aerospace industries. It features excellent mechanical stability contrasted by high raw material costs. Compared to an equivalent component made of steel, however, a weight reduction of up to 67% can be achieved. As with typical household adhesives, the plastic in which the carbon fibers are embedded must cure. If the curing of a CFRP component is not entirely completed, the specifications for its mechanical requirements are not fulfilled. However, if the processing time is actually longer than it needs to be (to allow for an unknown duration of curing), the process becomes unprofitable due to the resulting increase in unit costs.

In order for this technology to make the breakthrough to medium- and large-series production with a minimum of waste, the production processes must be intelligent and robust. This can only be achieved by continuously checking the curing state of the complex mixed material.

Particularly in carbon composites, dielectric analysis had reached its limits in the past: Due to the electrical measuring principle, contact between electrically conductive fillers such as carbon fibers and the measuring electrodes resulted in an electrical short-circuit, making a meaningful measurement impossible.

Fig. 2. Dielectric tool sensor

The Limits of What Is Technically Feasible Have Been Extended

Having understood the problems already a few years ago, NETZSCH-Gerätebau GmbH took on the challenge of redesigning dielectric analysis and raising it to a higher level.

We are proud to now be able to present a package allowing data acquisition in the mold even for polymers with electrically conductive fillers, thus enabling a self-regulating production process. The secret behind this new technology lies in an update to the electronics and a sensor design that is unique in the world and exceeds state-of-the-art. Not only do the new sensors achieve unparalleled performance in dielectric measurement, but their application range has also been significantly expanded:

- Continuous operating temperature of 300°C
- Internal pressure resistance of the mold: 300 bar
- Extremely scratch-resistant sensors due to the ceramic base material
- Thermoshock-resistant
- Resistance to solvents

This is the ideal sensor for harsh process conditions.

Real-Time Process Monitoring and Intervention

Thanks to our know-how in material characterization and the DEA 288 *Ionic* (figure 1, sensor in figure 2) as process measurement technology, NETZSCH offers the best conditions for the critical but invisible manufacturing step of analyzing CFRPs in a closed mold and controlling the processes on this basis in real-time. To this end, sensors are installed directly in the molds. When certain characteristic values are reached, machine actions can be automatically triggered by the DEA. This results in an intelligent process yielding an optimum state of material in the shortest possible time.

Measurement, Control and Analysis Made Simple

The DEA288 *Ionic* comes standard with analog and digital interfaces for communication with production systems. In addition, with the intuitive, easy-to-use software environment in *Proteus*® 8.0, NETZSCH offers a solution which minimizes efforts for defining the measurement specification and data analysis. With the real-time "Critical Point" evaluation option, attainment of the following characteristic values is displayed during the running measurement:

- Recognition of the resin front
- Best flow behavior / Minimum viscosity
- Gel point
- User-defined degree of cure

Each of these characteristic values can, of course, be assigned to initiate a desired operation by the machine.

If a comparison of the "Critical Points" of different faultless or faulty components is required, these can be viewed jointly in the *Proteus*® 8.0 analysis software and exported in a data format of the user's choosing.

Process Analytics – A Complete Package for the Intelligent Production of Tomorrow

Intelligent production systems in the future will need to work almost independently, making decisions about the condition and progress of a component's production without user input.

In order to address such issues, NETZSCH-Gerätebau GmbH has set up the "Process Analytics" division to design the process package of the future in collaboration with partners from the processing industry. The data obtained from component analyses were hereby transmitted in real time via modern IoT (Internet Of

Things) interfaces and used for communication between the individual systems and sensors that are involved in other ways.

Based on the data, pattern recognition is carried out and neural networks are set up that can map and influence a reciprocal interaction of the process-influencing parameters. To this end, the DEA 288 *Ionic* as a base will be continuously supplemented over the coming years with new features for data preparation and analysis in the currently existing *Proteus*® environment, and will be expanded with its own adaptive platform over the long term.

Visual Example – What Can We Learn from a Measurement Curve?

The following figure 3 shows the production of a carbon composite component based on an epoxy resin at a mold temperature of 160°C. The DEA measurement was started via a trigger signal from the hot press at the beginning of the closure process.

We see:

1. **CP1: material arrival**

   The press is entirely closed at 0.14 min and the epoxy resin softens quickly due to the mold temperature.

2. **CP2: minimum viscosity**

   After 0.84 min, the material reaches the state of its best flow behavior. At this point, the cross-linking process begins to dominate the dielectric signal.

3. **CP3: gel point**

   The material's gel point is in the turning point at 1.29 min. This implies that the material is no longer capable of free flow and that the solid properties are predominating.

4. **CP4: 90% degree of cure**

   In this example, achieving a degree of cure of 90% is decisive for the mechanical performance of the component. This dependency was determined in advance by the correlation of destructive mechanical tests on components with differing degrees of cure. From 2.21 min onward, the component meets its requirements for usability.

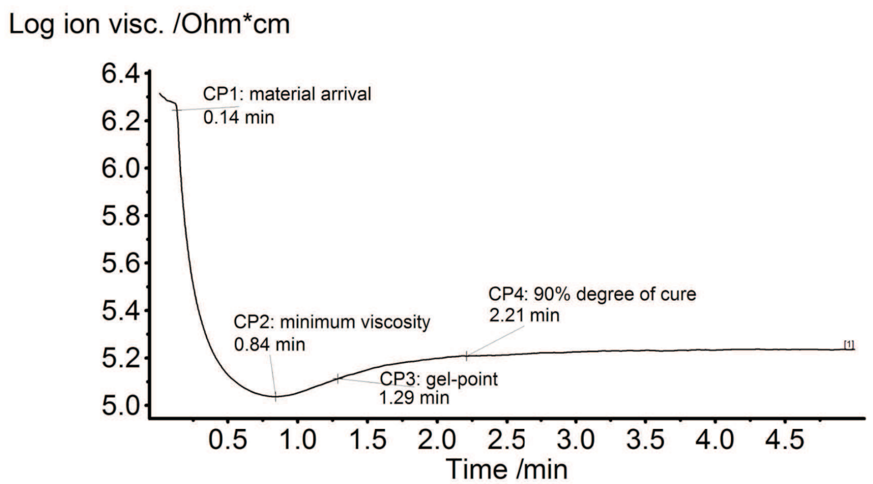

Fig 3. DEA measurement on a carbon composite component