New Research Promises Safer Conductive Fabrics

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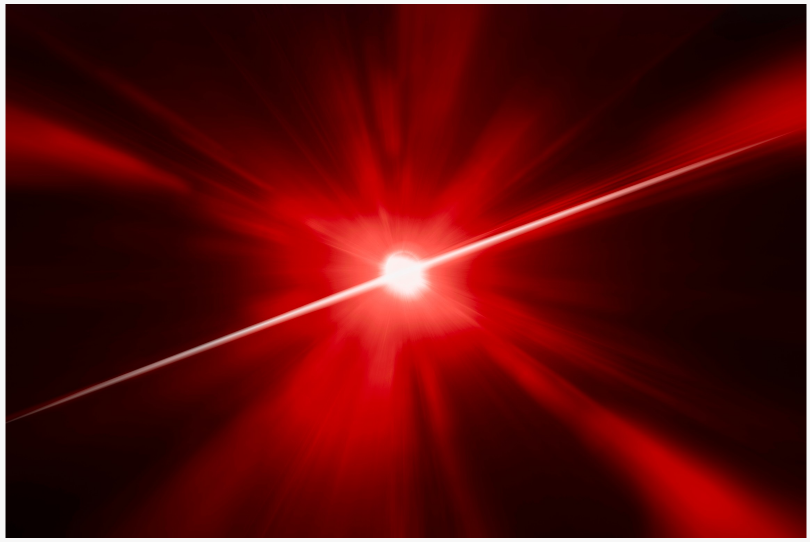
Thermal degradation

ABU DHABI, UNITED ARAB EMIRATES, September 20, 2021 / EINPresswire.com/ -- Conductive fabrics are growing in visibility due to their use in screen-friendly gloves or in new wearable computing devices. There is an uptick in leveraging these fabrics in industrial applications today, to provide lightweight, water repellant EMF shielding for electrical devices or to protect workers from lightning in the field. However, designers have until lately only analysed how these fabrics respond to low currents.

Now though, a team of researchers in the UAE's Technology Innovation Institute (TII) have developed a new model for characterising when and how these fabrics break down in response to high currents such as lightning strikes or electrical faults in equipment. Down the road, this finding could lead to safer fabrics.

> "New conductive fabrics made from composite material could reduce the weight, improve the shielding or increase the current that could be managed."
> *John Pantoja, lead high power researcher, TII*

John Pantoja, lead high power researcher at TII's Directed Energy Research Centre, said, "We started this research because conductive fabrics are a new technology available commercially, and their applications are relatively new. With our model, we can see the limits to what currents you can manage."

Researchers earlier analysed how wires burst under high currents in the 1960s. This is the first-time researchers have extended these models to conductive fabrics. The manufacturers of these materials typically, only provide specifications for how the materials behave under normal operating conditions. No one has really investigated what happens to them under extreme conditions such as lightning or an electrical fault.

This is challenging research because it requires specialised labs capable of generating the currents and analysing the results. Most electronic devices operate at a few milliamperes, while household devices can convey a few amps. But lighting can drive close to 100,000 amps for a few thousands of a second. The UAE team collaborated with scientists in Colombia, Brazil, and Sweden for this research.

Technology Innovation Institute

A better look

Normal fabric is usually woven from nonconductive materials such as cotton or polyester. Conductive fabric also includes some conductive layers composed of copper or other alloys that allow the flow of small electrical currents.

The experimental research with high currents begins at the National University of Colombia after Pantoja and professors Francisco Román and Felix Vega received two patents on protective applications of conductive fabrics. The researchers combined different ways of exploring the fabrics to craft a model of their behaviour. They started by analysing microscopic pictures of the fabric to understand how the conductive fibres touch each other. More energy is dissipated at the junction between these fibres at high currents. As a result, the temperature at these junctions rises the fastest and starts to melt. At some point, the fibre can be totally destroyed.

The researchers also analysed the electrical waveforms. They took pictures with the initial sample, applied the pulse, and then analysed the follow-up picture. This was correlated with the electrical waveforms measured with an oscilloscope. Pantoja said: “We could analyse the waveform to determine when the material started to melt, and then we used a picture to localise the point where the melting started.”

Melting, bursting, and vaporising are different ways that the fabric can break down under high current. Normal current just travels through the conductive layer but at some point, the more intense current begins to produce plasma. Then the current goes through the plasma. This was characterised by Prof. Roman and the team in Colombia, using videos with fast cameras to study the formation of plasma and correlate it with other views.

The researchers also analysed how currents can lead to scratches which result from thermal burns in the material. Alejandro Cristancho in his PhD thesis at the Universidad Nacional de Colombia found that these scratches are essentially the macroscopic effect of the bursting points in the conductive layers. Under high currents the material can break into two parts and as a result the conductivity of the material can be reduced or blocked.

One limitation with the model is that they only analysed one kind of common woven fabric and one kind of nonwoven fabric, although there are, in fact, several types of fabric. Conductive fabrics are commonly made by either weaving multiple fibres together or using a nonwoven technique to blend conductive materials into one layer.

One of the takeaways from the research was that nonwoven fabrics can conduct higher currents without damage since they evenly spread out the electrical current. In contrast, the woven fabric contains junction points between the fibres which can see a significant rise in temperature when exposed to high currents.

However, Pantoja mentioned that the conductive material is randomly distributed in nonwoven fabrics, so a statistical model is needed for analysis. Woven textiles are more predictable because the conductive material follows a consistent pattern.

Building a new model

A model like this allows designers to abstract the key details for a specific problem. One useful abstraction was to craft an equivalent resistive network model in which each fibre was represented with one resistor and the contact point between fibres were represented with another resistor.

A theoretical model can analyse these types of problems more quickly than traditional simulation techniques. Another benefit of a model is that it makes it easier to see the relationship between the dimensions of the material and the current. This makes it easier to explore the properties of different designs more quicky in order to find the best one from a performance perspective. These models can be combined with product design models to find the most cost-effective and the safest designs.

The earlier research on how wires break down in response to high current led to “specific action” as a metric for quantifying the impact of high current on how wires explode. This research also found a way to apply this metric to conductive fabrics. In addition, the researchers considered how to include the contact area between fibres as part of the model to increase the accuracy.

In the future, the researchers want to explore different conductive fabric materials and designs. One possibility lies in increasing the dimensions of the fibres to increase the contact area and disburse the energy more evenly. To access

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