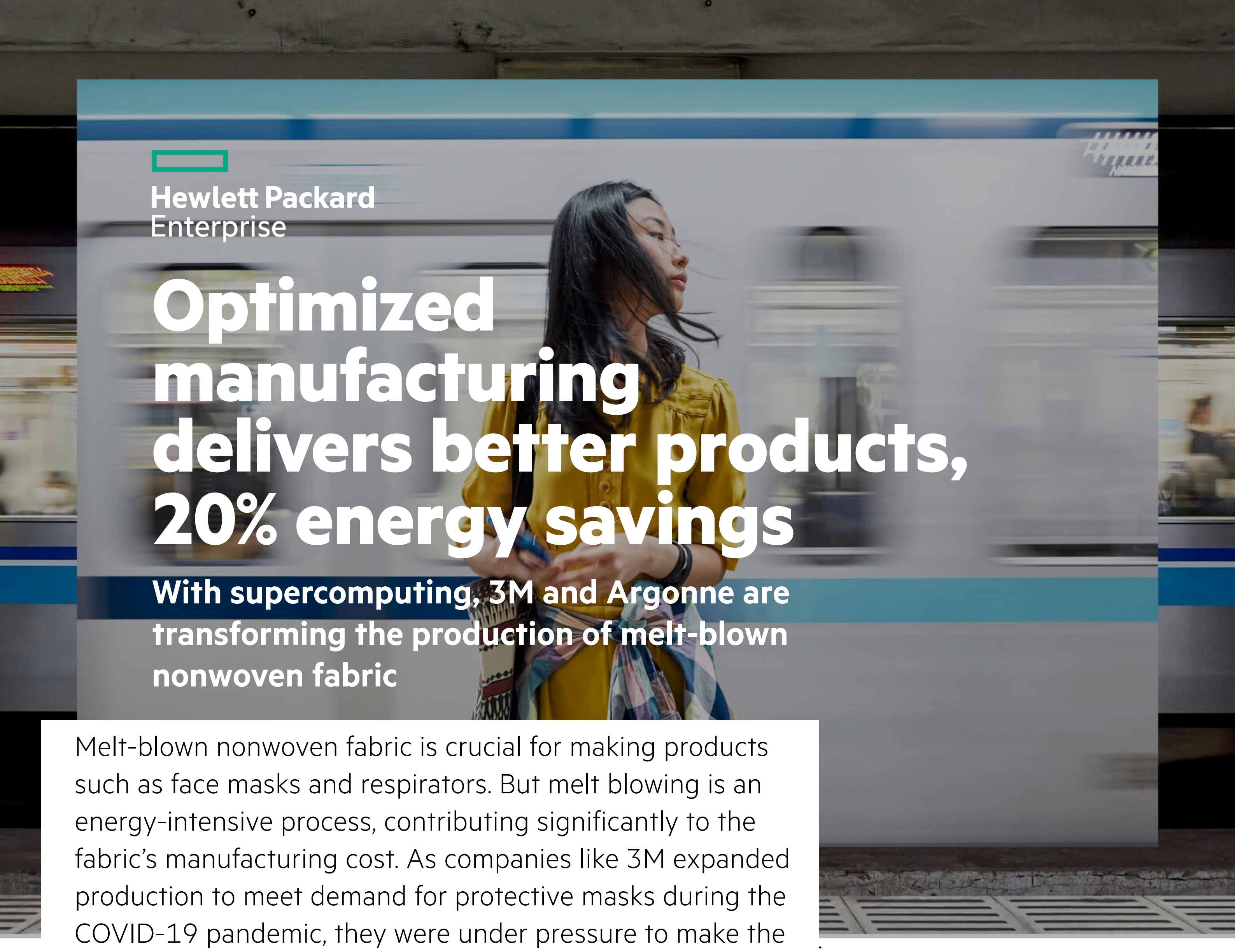

Hewlett Packard Enterprise

Optimized manufacturing delivers better products, 20% energy savings

With supercomputing, 3M and Argonne are transforming the production of melt-blown nonwoven fabric

Melt-blown nonwoven fabric is crucial for making products such as face masks and respirators. But melt blowing is an energy-intensive process, contributing significantly to the fabric's manufacturing cost. As companies like 3M expanded production to meet demand for protective masks during the COVID-19 pandemic, they were under pressure to make the process more efficient. Now the company and researchers from Argonne National Laboratory are transforming production through machine learning and supercomputing. The enhanced process could cut energy consumption by up to 20% while improving processes for developing new materials and making manufacturing more sustainable.

Meeting demand for melt-blown nonwovens

COVID-19 made face masks one of the world's most sought-after commodities, setting off an estimated global use of 129 billion masks every month. This triggered a spike in the production of melt-blown nonwoven fabric, a key material for making high-quality face masks, respirators, and a range of other items.

But manufacturing the fabric is highly energy intensive. Polymers such as polypropylene must be melted and then drawn into fibrous, randomly laid webs—requiring compressed air at high temperatures.

"We're talking about heating high volumes of air to hundreds of degrees Celsius. It's substantial," notes Alex Flage, a process development specialist at 3M. This makes energy a major contributor to manufacturing cost, which can be significant for companies with considerable melt-blowing production.

Argonne NATIONAL LABORATORY 3M

Industry: Manufacturing

Country: United States

Vision

Make the process of manufacturing melt-blown nonwoven fabric more energy-efficient and sustainable

Strategy

Model and optimize the production of the fabric using machine learning and simulation

Outcomes

- Optimizes the production of melt-blown nonwoven fabrics
- Cuts the energy consumption and costs involved in melt blowing by up to 20%
- Improves processes for developing new melt-blown nonwoven materials
- Reduces carbon emissions from the manufacture of the materials

Now 3M and Argonne National Laboratory are tackling this challenge. Using machine learning, they are discovering ways to cut energy consumption by up to 20% in the production of melt-blown nonwovens, significantly reducing costs and carbon emissions while improving the development of new materials.

Optimizing the melt-blowing process

Even before COVID-19 sent demand for protective masks soaring, 3M was already working to improve the energy efficiency of its melt blowing, which forms a substantial part of its manufacturing portfolio. Aside from face masks and respirators, it uses melt-blown nonwovens to make furnace filters, air purifiers, and more.

But 3M stepped up efforts to optimize its melt-blowing process as it expanded its global production capacity in response to demand for N95 face masks. "When you expand a production line, the energy output is a major consideration along with the cost of installing it," says Dr. William P. Klinzing, Associate Corporate Engineer at 3M.

The company's strategy was to model the production of melt-blown nonwovens in partnership with Argonne, a leading research center in energy systems. 3M typically develops processes in its research laboratory, but lab experiments on a process as complex as melt-blowing is extremely time consuming and costly.

"It involves not just airflow, but highly turbulent airflow. And it is complicated by a very difficult polymer problem because the fiber is a molten polymer," explains Klinzing.

With computer modelling powered by supercomputing, it is easier to understand and break down this kind of process. "You can isolate the problem and the components of the airflow, study that, and try to improve it or operate in a realm you aren't currently operating in, and derive energy savings out of it as well," adds Klinzing.

In particular, he and Flage wanted to study the airflow that is used to break molten polymers into fine fibers—and how the consumption of compressed air and heat can be minimized during this process.

Accelerating outcomes prediction

To model the process, the research team from Argonne and 3M combined simulation, data analysis, and machine learning using the computing resources at the Argonne Leadership Computing Facility. The team initially developed a model by running simulations on the facility's HPE Cray XC40 supercomputer, Theta, with the computational fluid dynamics (CFD) software OpenFOAM. They then modeled the process using the CFD code CONVERGE for better scaling with increasing numbers of processors.

"What we've done to minimize energy consumption is to look at simulations with different initial conditions for various process parameters and the system geometry itself," says Debolina Dasgupta, a research scientist at Argonne. "This gives us an inkling of how to get to a design and a set of conditions that help in the reduction of overall energy consumption."

> "We can be smarter about what experiments we are running and that's where I see supercomputing being critical. It allows us to do very computationally intensive work."
>
> – **Alex Flage**, Process Development Specialist, 3M

The simulations include capturing the complex airflow pattern for the melt-blowing process. The team has successfully created a metric that can be estimated from these simulations. This will help them identify optimal parameters for the melt-blowing process—bringing them closer to realizing a 20% energy reduction in the manufacture of melt-blown nonwovens.

Machine learning has notably accelerated the research process through the creation of models that predict outcomes without running large numbers of simulations or experiments. Instead of building massive data sets, the team lets artificial intelligence suggest the next optimal simulation, allowing them to construct accurate models at a low cost.

"We can be smarter about what experiments we are running and that's where I see supercomputing being critical," says Flage. "It allows us to do very computationally intensive work."

Improving materials development and driving efficiencies

Besides providing actionable insights into how 3M can reduce energy consumption, machine learning improves the development of new materials by enabling the examination of a process in detail, says Noah Paulson, an assistant computational scientist at Argonne.

"The machine learning and simulation that we do are essential to accelerating the development of materials and their transition from lab to industry," adds Paulson. "There's really a direct connection between the machine learning and simulation methods we're developing for this project and improving materials production, and then discovering new materials as well for many different applications."

The success of the research and its methods will have benefits and impacts far beyond melt blowing.

"You can pick any number of things that you want to optimize and any number of inputs to the process that you want to change, and you can apply these techniques to really improve the process," says Paulson.

Flage agrees, adding that using the research strategies for various applications can help industrial businesses drive efficiencies. "It's a time when cutting costs is a primary effort. And anything we can do to support that, especially with energy efficiency, is going to be helpful."

Advancing 3M's sustainability agenda

For 3M, making its melt-blowing process more energy-efficient also supports its goal of becoming carbon neutral by 2050. The company has been reviewing its production facilities and accelerating improvements in its manufacturing operations to further drive down emissions.

"There are a lot of different initiatives going on right now. But this project will be a large contributor if we can make a sizable difference to the energy consumption of this process," says Flage.

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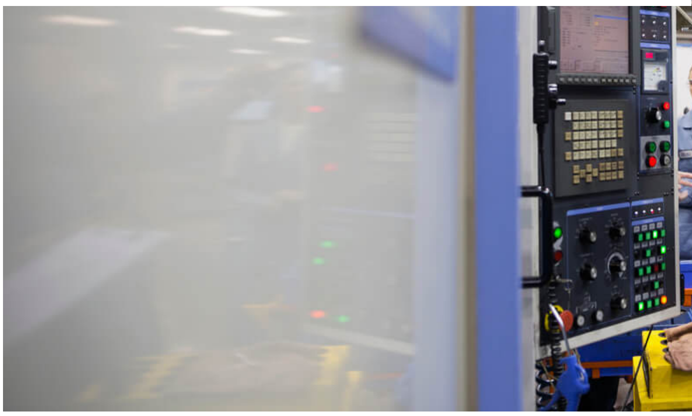
– **Noah Paulson**, Assistant Computational Scientist, Argonne National Laboratory



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"Melt blowing is a substantial piece of 3M's portfolio, so making the process energy-efficient would have a beneficial impact on meeting the company's sustainability goals."

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- HPE Cray XC40

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