Popular Science Summary

Simulating the Transport of Paperboard Confetti in Pipes

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Tetra Pak is a global food processing and packaging company, best known for their sustainable carton packages, which are produced by the billions each year. Many of these packages require holes for straws and caps, creating additional billions of confetti-like paperboard scraps. These confetti must be removed from the machines to keep them running smoothly. To ensure this, the transport of confetti is studied by both real-life experiments and virtual computer simulations, informing the design of reliable extraction systems.

Experiments are made with a see-through four-way pipe that has air sucked through it by a vacuum. When confetti is released at one of the three inlets, it quickly passes through the system during a fraction of a second. The process is too quick to observe with the naked eye! Instead, a high-speed camera is used to capture what happens, many times over. A computer is programmed to find confetti in each recording, saving every path that they take through the pipe.

Simulations are made with models that recreate the experiments in a virtual environment. The pipe geometry is copied and split into two regions, each representing air and confetti by assigning corresponding physical properties. A set of complex equations, formulated from a set of physical laws, states how airflow and confetti should evolve. To solve the equations, the air region is split into millions of tiny parts, on which simpler equations can be used. With information from neighboring parts and historical values, all parts are evaluated separately. When all parts are put together, it results in a flow that can move the confetti. Repeated thousands of times, confetti transport is slowly recreated over three days using a very powerful computer.

In both virtual and real experiments, the confetti took a new path through the pipe every single time! The transport process is seemingly chaotic; small initial differences can lead to significant variations in the path taken. Comparing models to experiments, trajectories are similar but imperfect simulations that predict too large velocities.

With chaotic traits, it is impossible to accurately predict individual confetti trajectories and velocities. However, with statistics from multiple simulations, the model can approximate trends of confetti transport that are similar to results obtained by experiments. Akin to a weather forecast, it does not predict the exact location of each rain cloud, but it gives you a fairly good idea of what to expect. While not perfect Tetra Pak can use these models to better understand issues arising from confetti being transported through pipes.