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COLLISION MANAGEMENT OF FRAGILE PACKAGING

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ABSTRACT

Product handling of fragile packages requires specific attention to physical interactions. Factors such as product inertia, conveyor-load friction, and collision velocities all contribute to the final quality of the product. At times, collisions between fragile products are unavoidable. With a focus on maintaining both product flow and unit quality, manufacturing simulations demand specific attention to kinetic interactions. This requires a simulation environment capable of quantifying the impact of these interactions. Controls techniques are tested within these simulated environments for future use in process control.

1 INTRODUCTION

Two specific applications are the handling of products packaged in thin corrugate boxes and liquids in glass bottles. Primary packaging is the constrained operation; both upstream and downstream unit operations are over speed capable to maintain product flow between machine failures. In the manufacturing of products in thin corrugate boxes, machine failures in secondary packaging, while infrequent, do require enough product accumulation such that upstream operations are buffered from the stop and may continue to run at steady state. During accumulation, excessive static backpressure can cause box deformity.

Collisions of glass bottles, especially when filled, can cause breakage. For high-speed bottling applications, these collisions must occur under a pre-determined kinetic energy level in order to prevent glass leakage or breaking. Both scenarios present unique difficulties in product handling but utilize a similar approach in simulating the physical properties of each scenario.

2 THE PHYSICS PROBLEM

In the case of thin corrugate, the customer is experiencing product deformity and damage as boxes accumulate along sections of curved and straight conveyor. Average secondary package downtimes require accumulation in excess of 100 feet. As boxes accumulate linearly along long sections of conveyor, those closest to the front of the slug begin to crush due to excessive backpressure. The customer requires a controls methodology that does not compromise product quality due to machine reliability.

High-speed packaging of glass bottles presents similar product handling issues: bottle breakage due to collisions of slugs of variable length colliding at different speeds. A collision between slugs of empty bottles carries proportionally less energy than the same collision of filled bottles; as such the two collisions must be assessed separately. During steady-state product flow, bottles must distributed across down lanes according to the arrangement of bottles in a case and organized back-to-back for casepacking. Speed differentials during this steady state require that bottles collide, and do so without exceeding a kinetic energy threshold. The customer is experiencing intolerably high scrap levels and increased downtimes for cleaning due to improper product handling.

3 COMPUTATIONAL CHALLENGES

In both scenarios, there is a requirement to model a range of physical properties and interactions. For accumulating corrugate boxes, relevant factors include the mass and coefficient of friction of the box and the speed and coefficient of friction of the conveyor belt. Similarly, glass bottles break according to the relative velocity and combined mass of colliding slugs. Relevant factors for bottle breakage include the empty and filled mass of the bottle, slug length and conveyor velocities.

Both systems require a simulation platform capable of modeling the physical properties of each scenario, and continuously monitoring the active forces between products throughout the length of the run. As work-in-progress increases, so does the frequency at which the CPU must calculate the effects of these active forces within the system. Even with top-of-the-line computing power, simulation speed is sometimes reduced to a crawl as product accumulation requires thousands of real-time physics calculations. Also needed is the ability to assess system performance over longer periods of time (8-24 hours). Historically, either speed or detail is relaxed in order to feasibly model the system. Using Demo3D 2013, products are created in a simulated environment to real-world specifications. The state-of-the-art physics engine allows the simulation speed to meet and exceed real-time, even in highly populated states.

4 APPROACH

The primary goal of corrugate box packaging is minimizing product damage by reducing the risk caused by excessive back pressure. Starting with a Demo3D standard box, we apply custom code to constantly measure the active forces on each box and record when crushing forces exceed a user defined threshold. As a visual aid, the color of the box will also change when the box becomes crushed. Visually monitoring active box accumulation easily highlights problematic areas and scenarios. This approach delivers a backpressure measurement for a given quantity of back-to-back boxes and collision velocities of two slugs of bottles. Adding in a series of pneumatic brakes and control sensors breaks a long slug of product into several smaller slugs, thus reducing backpressure. Advanced control techniques manage slugs so that line accumulation is maximized and collisions between slugs do not cause product damage. Several 24-hour simulation runs verify that the new controls maintain consistent product flow through the system regardless of line accumulation levels.

Simulated glass bottles also begin as standard Demo3D objects with a known mass and product dimension applied. Custom code continuously monitors collisions between bottles and report breakage visually and in recoded data tables. Engineers quickly identify problematic scenarios and test new control logic to control line collisions. Reducing the length of slugs counts and bottle velocity virtually eliminates glass breakage during normal operation and between machine starts and stops. Further testing with different glass sizes and types deliver unique controls parameters with little added development costs. Several scenario runs over 8-hour periods validate the improved product control.

Demo3D's advanced physics engine enables engineers to scientifically assess forces acting on and between products in high-speed environments. Standard catalog items and load-specific programming abilities deliver a highly detailed virtual environment simulating unique physical aspects of product handling.

AUTHOR BIOGRAPHIES

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