More than 40% cost reduction through drop test simulation with Ansys LS-DYNA

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1 Introduction

The cost-sensitive development project for a new sewing machine series within Bernina International AG includes optimizing the packaging to the new logistical conditions and adapting it to the new product design. Packaging protection also had to be increased. Regarding specifications, no acceleration forces more significant than 100G may occur on the machine during a standardized drop test from a height of 0.9m. Furthermore, polystyrene should be reduced by at least 20% for cost and environmental reasons. For the end customer, the package should be easy to transport by hand and leave a tidy and logical impression when unpacked, which was difficult to specify and led to some loose ends concerning the arrangement of accessories.

2 Model and Methods

To achieve the goal of a virtual drop test, various preparatory steps had to be taken before the actual simulation. In the first step, the testing lab Swiss Technology Partners determined the material data for the polystyrene packaging material. The various curves from the compression tests were transferred to the LS DYNA compressible foam material model.
In the second step, the machine model from CAD was reduced for the simulation to the geometries essential for stiffness and connections to the outer casing. The parts that were not explicitly modeled were simulated realistically using substitute masses. Linear (metal and plastic structures) and non-linear (casing parts) material data were then defined based on data from ANSYS Granta.
The packaging model consists of detailed CAD data of the polystyrene, which is modeled with the experimentally determined material data. The cardboard box and the accessory data were simplified and enhanced with ANSYS Granta material models.
The modular structure of the machine model, which is separate from the packaging, made it relatively easy to model various packaging variants in a virtual drop test.
The virtual drop tests in the specified directions were carried out using the ANSYS LS-DYNA calculation tool with explicit time integration.

3 Results

Thanks to the new simulation workflow and the involvement of packaging experts during development, the goal of realizing functioning packaging was achieved with the first drop test.
By reducing the packaging size, the number of packages per pallet (Seafreight 1140 x 1140, CP3) could be increased from 18 to 24 machines, corresponding to an increase of more than 30%.
The volume of polystyrene could be reduced by almost two compared to the previous solution. The savings of around 45% corresponds to the equivalent of CHF 2.9 per package or more than CHF 55’000 per year. Over the product life cycle (15 years), costs amounting to CHF 825’000 can be saved, and CO2 emissions can be reduced by more than 225 tons (analyzed with ANSYS Granta Eco Audit).
In addition to the economic improvements, the most essential point, product protection, was also improved through packaging optimization and machine design optimizations. As a result, all G-values acting on the machine during the drop tests are now less than 100G. Thanks to the horizontal machine arrangement (based on the simulation results), the customer can now be impressed by both the machine and the tidy accessory arrangement as soon as it is unpacked.

4 Figures and Tables

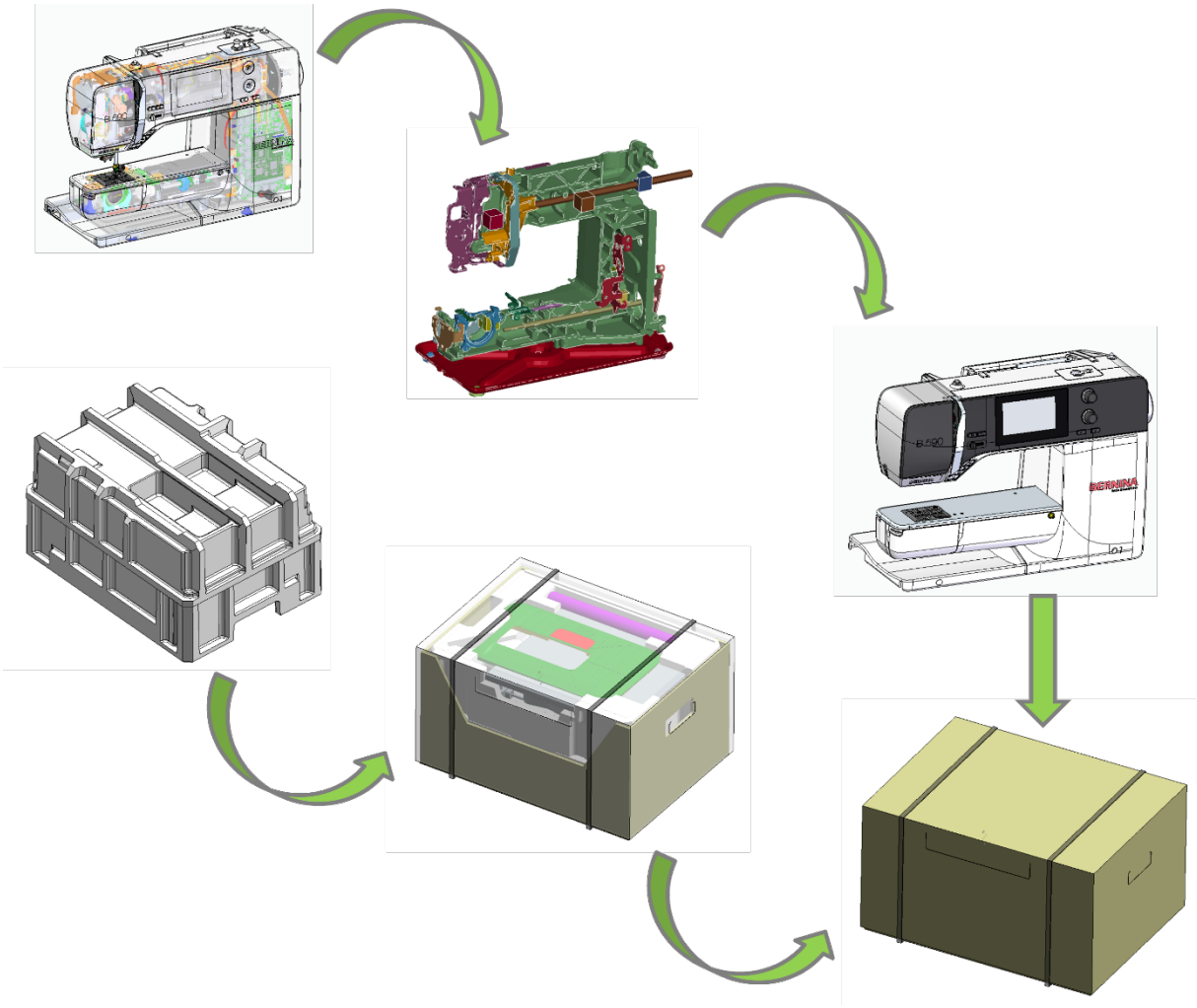

Fig.1: Modular model: simplified machine model (top), detailed packaging model (bottom)

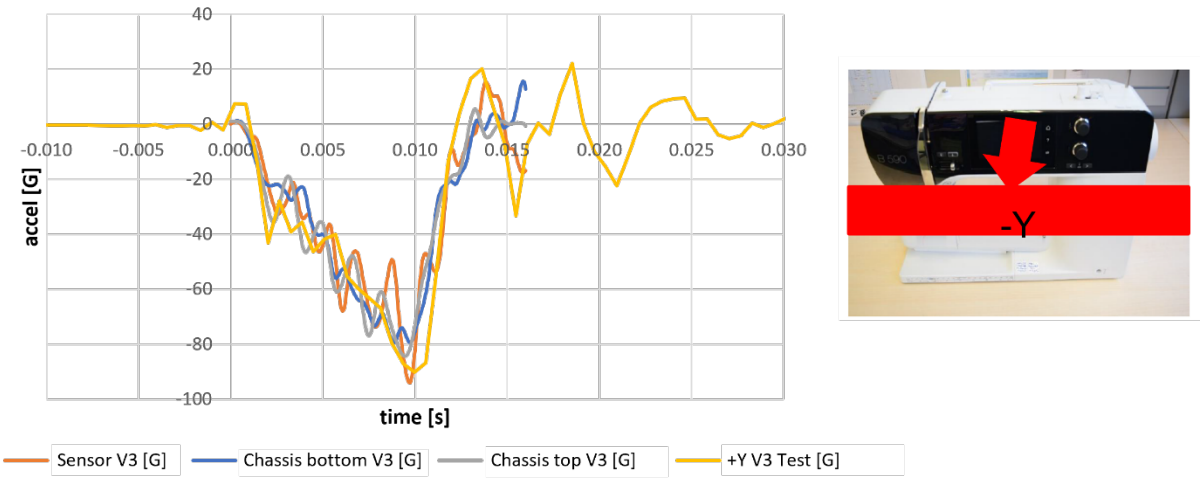

Fig.2: Comparison of real drop test (yellow) and simulation results in one exemplary direction.

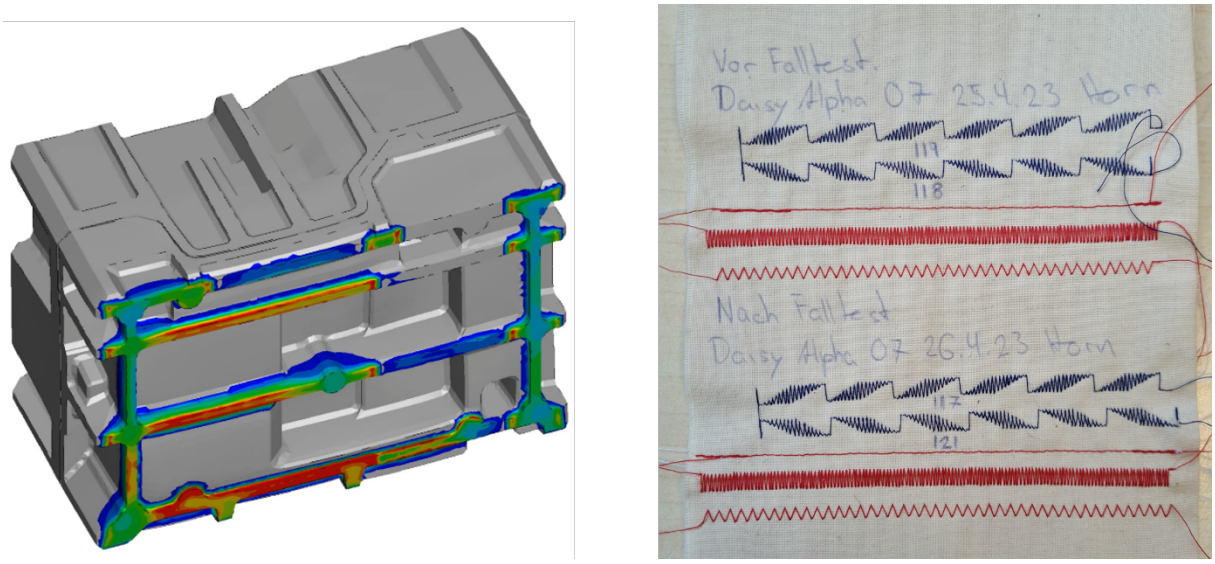

Fig.3: Compressive strains in the polystyrene ribbing (left). Standard sewing test pattern for assessment of sewing quality before (top right) and after (bottom right) drop test – passing with flying colors.