Summary for the final report
Model based calculation of the motion control for film packaging for high-speed pick-and-place applications (RoboBag)

In modern wrapping machines, pick-and-place robotic applications are increasingly being used to handle packaging. Here, the product is picked up by a vacuum suction cup or gripper and transported along a predefined path.

The frequently limiting element here is the interaction between the suction cup and the product. If the packaging material becomes detached due to, for example, excessive acceleration or suboptimal gripper geometry, the process has to be interrupted, resulting in a reduction in the overall output of the system. To increase the production rate, it is conceivable to increase the operating speed of the handling process, whereby detachment no longer occurs through targeted planning of the movement, taking into account the suction contact and the use of optimum gripper geometries.

To achieve this goal, the interaction between the suction cup and the packaging must be considered in more detail and included in the planned movement. Since the cost and effort of practical tests - especially with regard to variable gripper geometries - would quickly reach unacceptable dimensions, the interaction between the components involved is simulated using finite element models.

On the basis of an academic case study, submodels of the pick-and-place process were developed. A close collaboration between the experimentally and numerically focused research units is necessary to parameterize and validate the resulting FE models in a systematic way. Due to supply delays, the necessary experimental data could not be obtained in time. Initial estimates of the numerical results were there-fore made using empirical values for the input variables of the respective simulation models. A final comparison of the predictions obtained by this method with the experimental data determined later, demonstrated a good to very good agreement.

Parallel to the simulative solution approach, the dynamic behavior of the goods to be handled during the transport process was modeled with the use of kinematic equivalent models. For this purpose, the vertical and rotational oscillation behavior is simulated using Kelvin-Voigt models. The effective spring stiffnesses and damping parameters required for the parameterization were determined experimentally. The approach allows the prediction of the dynamic behavior of the entire system in response to a previously defined motion path. By applying additional impulses to the system, further translational and rotational oscillations are induced. If the impulses are adjusted in time, they are able to reduce the oscillation amplitudes of the original motion.

By combining both approaches, it is possible to investigate and evaluate the response of various motions to the interaction in an iterative process. Based on this evaluation, optimized movements as well as suction cup geometries can be developed, which take into account the specific requirements of individual and industrial oriented applications.

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