Simulation for optimizing energy consumption in packaging machines

Munich, October 2013 - In times of global warming, national and international efforts to reduce greenhouse gases, and the energy transition, the costs of energy are rising drastically. These increases in costs are directly reflected in the manufacturing and handling costs for consumer goods.

In the packaging industry for consumer goods, handling processes in particular are a cause of high energy consumption. When packaging dairy products for retail, for example, directly after filling, a robot-assisted sorting machine regroups single-variety product pallets into mixed pallets, which are then immediately ready for delivery to and sale in supermarkets.

For this procedure, every product must be individually picked from the single-variety tray and then placed into a mixed tray together with products from other varieties according to a programmable pattern. The energy consumption for this handling task adds directly onto the manufacturing costs or packaging costs for the product, alongside the proportional investment and other operating costs of the handling facility. As energy costs rise, the influence of energy costs will therefore make itself increasingly noticeable in packaging costs.
Accordingly, it is well worthwhile to already consider the anticipated energy costs per product or package when developing or designing a machine. Working from a digital physics model of the packaging task, the technical process conditions can be modelled highly realistically in the software program industrialPhysics by machineering GmbH & Co. KG from Munich, for example (www.machineering.de).

With a realistic simulation of the handling process, the expected time curves of important parameters can be determined. When considering energy, a direct or indirect approach can be taken depending on the complexity of the kinematics to be observed. For simple kinematics, such as inverse kinematics, it is sufficient to derive a rough estimate of the expected energy consumption from the time curves of positions, speeds or accelerations, under consideration of system parameters such as mass and friction for example.

In the case of SCARA kinematics, the above method does still work, but the inertias of the axes, tools and workpieces have to be considered as variables with respect to axis positions. In this case, a mathematical analysis tool is needed that supports taking the integral.

If the kinematics are more complex, as with SCARA, delta or articulated arm robots for instance, then the kinematics have to be generated by building a dynamic model including inertia and drives with controls (see Figure 3).
With the task fully modelled, the paths of motion of all axes can be recorded for various operating states. The first thing of interest here would certainly be static operation of the plant in special sorting mode.

Depending on how long it takes to change operating mode changes in relation to static operating states, it can also be necessary in some cases to analyze the energy involved in product changeovers. In this case, the model has to be elaborated to even greater detail regarding controls, so that format changeovers, run-ups and run-downs can be accordingly considered.

Figure 4 illustrates the solution using Delta kinematics.

Given the level of realism, the digital model can reproduce technical influences from the controller such as contouring errors, picking logic and order, reachable accelerations and speeds, and conveyor tracking processes. This allows early analysis of the influences of essential parameters without having to investigate the task in reality on an expensive prototype.
By simulating the entire task, with process, kinematics, drives, sensors and controller logic, it is also possible to derive all process parameters for analysis. Powerful analytical functions help separate the digital wheat from the chaff and then present graphs in the familiar tool.
A purely digital model of the packaging task on the computer allows you to evaluate different variants in terms of achievable product throughput. The anticipated manufacturing costs of the solution can also be very accurately estimated. Furthermore, a simulation can be used to determine the expected energy consumption of each solution variant.

This can already be done in the software program industrialPhysics Advanced Control Design. Other available modules of this software let you use ready-made, standard robot kinematics as well as real-time coupling with a real controller. That provides the engineer with a single tool that has everything needed to support a packaging task from design to commissioning.