Reaching for Automated Stacking

A preliminary study on automation of a reach stacker

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Automation around us is becoming a bigger part of our lives and the pace of that development will probably increase. Today some vehicles in the container handling industry are fully automated but for reach stackers, the container handler in figure 1, this process has not started yet. What movements would be suitable to start automate, how could such a system look like and what can be gained from it?

Containers can be placed 10 m above the vehicle operators head which demands experienced staff to operate the vehicles. The operators are often very skilled but not even the most skillful operator can move the spreader in three directions and around two axes at the same time. Automation would make it easier for the operators and make it possible to shorten the time needed for handling a container, resulting in more containers handled during the same time span. A automated system can also be more quiet than a human operator is. By automating the reaching, it is possible to have a more precise movement and less force and speed in the moment when the lifting spreader connects with the container. This is a great advantage since container terminals often are effected by noise regulations due to residential areas located nearby. Lower noise levels mean that the machine can handle containers even at night.

Two concepts was found suitable for automation, the first picks up a container and the other drops it down. The reach stacker has to be standing still while doing this which means that the alignment has do be done by the boom and spreader, the arm and hand of the reach stacker. These concepts were tested through simulations with a model build with a plug-in to Matlab called Simulink. The models contains both mechanical and hydraulic parts, just like a real reach stacker. The mechanical parts contain solid blocks and joints which act as a skeleton, the hydraulic part contains pumps and actuators, these can be described as the muscles.

The simulations showed a possible improvement of around 66% from a predefined displacement. A human operator aligned the spreader in 9-10 seconds, the simulation made the same alignment in just over 3 seconds. To do this the model uses sensors to measure the distance from its current position to the new desired position. From these sensor values the system calculates the movement and sends new reference values through controllers to the actuators which move the spreader. The movement calculator and the controllers can be described as the brain behind the system.

In the model there are two sensors measuring the distance between two points, each of these are the system's eyes. That is what a real sensor would do as well but there is several sensor technologies and placements of the sensors to achieve this and all have pros and cons. For example, a laser radar can be placed on the cabin roof but then it is not possible to see behind the first stack. Another option is placing 3D cameras on the spreader but it can not see the drop down location because the container is in the way. The most versatile solution is using a drone with a laser radar or 3D camera which scans the area around the spreader. The sensor technology and placement will be a crucial part of the further work. The technology must function in snow, rain, fog and cold weather and it must be placed in such a way that it can always guide the spreader.

The results pointed out an interesting and unexpected result. If the actuators are controlled by proportional valves the math behind the controllers can be very simple. The controllers in the model are of the type PI (proportional, integral) but have almost no integral gain at all.

This study has laid the foundation for further work on automation of reach stackers by pointing out what to automate and the improvement opportunities that automation can lead to. It also explains where research and development should be focussed to develop the best system possible.

Fig. 1: A reach stacker from Konecranes. The rectangle which has black and yellow stripes on the side is the spreader and the arm holding it is the boom. (Source: Konecranes, URL: http://www.konecranes.com/sites/default/files/main_image/smv4531tc5_front_low_preview_v02.jpg)