Summary

Port terminals focus on minimized berth times as well as minimized downtime, because of the demand for rapid transshipment and low service costs. By automating the unloading process, port terminals aim to increase efficiency. In this literature survey, current knowledge about automated grab unloading technologies is described and an overview is given.

The literature survey is focused on two sorts of cranes, namely two-dimensional portal grab cranes and three-dimensional floating grab cranes. The principles of an ideal unloading process are described, which are discussed in combination with automated unloading. A portal grab crane follows eight steps in its unloading process, which need to be followed either in manual or automated operation. These steps can be executed simultaneously to decrease cycle times. During the unloading operation, the grab suffers from motions due to forces on the grab. These motions are further described and discussed. The possible effects of automation on an unloading process are also described.

The two main players in automated grab unloading systems are iSAM AG and ABB. They have produced portal grab cranes that work automatically without operators present on the crane. The cranes are supervised from a control room, which handles multiple cranes from one station. The unloading process is divided in four aspects, namely; the visual aspect, the grab filling aspect, the transportation of the load, and the safety aspect.

The visual aspect of the automated grab cranes is mainly dependent on three-dimensional laser scanners. The 3D laser scanner is suitable for bulk material detection and positioning of the objects. The main problems are dust production and weather influences in bulk terminal areas, which can result in failure of the sensors. For accurate grab positioning and sway control iSAM AG uses an inertial system. The principles of the automated portal crane cannot be plainly copied to the floating crane, because of its extra degree of freedom and motions of its base.

The grab filling process is a difficult part of the unloading cycle, since it requires high accuracy. Within semi-automated systems the grab filling process is done manually, while within fully-automated systems the grab is automatically loaded. There are two phases in the grab filling process, namely the free-digging and the cleaning phase. The free-digging phase

can be done automatically, but the cleaning phase is always done manually due to limited accuracy and port regulations. For three-dimensional systems, the process is similar, although the required accuracy is more difficult to achieve.

For the transport of the bulk material from the pick-up point to the drop-off point and back, three points are of importance, namely; the determination of the optimal path, sway control of the load, and the load discharge. For load positioning several techniques can be used and applied on both quay and floating cranes, which are mostly simulated and experimented on. Control techniques from different types of container cranes can be applied for positioning and sway control.

Safety is an important aspect in automation, because it determines the applied regulations on an automated crane. iSAM AG has split the unloading area in three parts, to keep the personnel separated from the load path. Safety does not seem to be an issue for the two-dimensional crane, except for the cleaning phase. For a three-dimensional floating crane, safety margins might make automation of such a crane unattractive.

With the information provided in this literature survey several recommendations can be suggested. First of all, research should be done on the effects of dust and weather conditions and solutions should be found to possible problems. Secondly, the accuracy of the grab must be increased and research should be done on positioning control to achieve full automation. Finally, research should be done on the applicability of floating cranes and the possible advantages of automating these cranes.