

English summary

The objective for more sustainability has resulted in a growing interest for electric drives, even in mobile equipment. The container handling sector is gradually following this trend by installing hybrid and even fully electric drive systems in transportation equipment. Reach Stackers have not yet been implemented with hybrid or electrical drive systems, they are still equipped with diesel engines.

In addition to the interest for electric drives, there is a desire to replace the hydraulic system used in Reach Stackers. Hydraulic systems are ideal for heavy load linear movement systems due to the high power density. However, hydraulic systems are also energy inefficient and require sensitive maintenance.

The goal of this report is to investigate possible electro mechanical systems that are able to replace the diesel hydraulic systems used for both the lifting function and the extension function of a Reach Stacker.

Both functions require an electric drive system that basically consists of an electric machine and a control system. The control system makes it possible for the electric machine to provide the desired torque and speed.

The total lifting speed of the Reach Stacker is a combination of the boom lifting speed and the extension speed. In a diesel hydraulic Reach Stacker the drive power is generated centrally making the total lifting speed basically independent of the way the function movements are performed: together or separately after each other. The replacement of the hydraulic system by a mechanical system requires separate drive of both mechanisms. With the drive power no longer generated centrally the order of movements has to be together in order to overcome over dimensioning of the drive systems. The time to reach a certain container position with the total lifting speed is taken as the maximum time for both individual systems.

The mechanical system designed to replace the hydraulic system for the extension function uses a roller chain. This results in the following main properties:

- The chain track results in a transmission ratio of 1:2 between the boom extension and the chain travel. This transmission ratio has a positive effect on the chain size and the required drive force.
- The chain track allows the electric motor and gearbox to be placed at the backside of the boom where they have a positive effect on the required lifting force.

- The mechanical system is driven by a 90 kW motor. The motor is able to keep the cycle times to given container positions of this individual system within the time stated.
- The motor will need to run in overload during the heaviest cycles. The time of overload is within the limits given by the motor characteristics.
- The chain system requires mainly structural adjustments to outer boom.

The mechanical system designed to replace the hydraulic system for the lifting function uses an extra lifting mechanism that is rotated by a tackle. This results in the following main properties:

- Lifting mechanism is required because the boom can not be directly lifted within reasonable space on the Reach Stacker available.
- The lifting mechanism results in a reduction ratio of 1:1,5 between the angle of the boom and the angle of the mechanism. The tackle connected to the lifting mechanism provides a further reduction ratio of 16. The total transmission ratio has a positive effect on the cable size and the required drive force.
- The open structure of the lifting system allows the placement of the tackle sheaves at the back and the winch at the front of the Reach Stacker, which results in a low wear rate of the cable system.
- The mechanical system is driven by a 132 kW motor. The motor is able to keep the cycle times to given container positions of this individual system within the time stated.
- The motor will need to run in overload during the heaviest cycles. The time of overload is within the limits given by the motor characteristics.
- The lifting mechanism mainly requires reinforced hinge points on the chassis and the outer boom. The tackle system only requires no big structural adjustments.

The replacement of the diesel hydraulic system by an electro mechanical system for both functions is possible. however, there are some points that can be concluded from this research.

A great number of the first designs fail based on the break load factor or a similar safety factor, which is the result of the dynamic performance of Reach Stackers. Electro mechanical systems are generally more rigid than a hydraulic system, making it difficult to fit them in a dynamic environment.

The implementation of an electro mechanical system could be simplified by implementing smart drive control systems. Drive control systems should reduce the dynamical forces on the mechanical system due to the electric motors.

The replacement of hydraulics will require adjustments to the reach stackers structure. Equipping an existing Reach Stacker with an electro mechanical system is therefore not expected to be profitable. Replacement of the diesel hydraulic system will only be applicable to newly build Reach Stackers.