Summary

The application of twin lift spreaders and Long Twin spreaders for Straddle Carriers (SCs) is still growing, although with an increasing interest in Long Twin spreaders. Simultaneously the average container load has increased as well over the last year. These two developments and the design limitations in SCs have resulted in a requirement from SC manufacturers to reduce the dead weight of Long Twin spreaders to a figure close to the dead weight of a normal twin lift spreader. In addition there is a desire to replace the hydraulic system used in spreaders.

The goal of this research is a conceptual design for a Long Twin spreader for SCs, preferably completely electrically driven, which weighs approximately 10-15% less than the present design, while maintaining the same functionalities and life time expectations. Although the mass increase for the all the electro mechanical systems will be taken into consideration, the design procedure is narrowed to an electric drive system for the telescoping function.

The present Long Twin SC spreader mass is 9800kg. The telescoping function is performed using a hydraulically driven belt drive system in single operation and hydraulic cylinder drives in Long twin operation. Prior to the redesigning of the present spreader, the loads affecting the spreader structure are analyzed. The use of standard defined load and stress spectra is hereby taken into consideration with the use of a real SC load spectrum.

In this research, redesign options have been determined in 5 sections considering the reduction in mass and the application of electro mechanical drive system for the telescoping function. Via first hand calculations and fairly simple Finite Element Analysis (FEA) models the feasibility as well as properties, mass and price have been checked. The sections are:

Drive system: the long twin function requires that a connection is established between the Long Twin unit and the telescopic beam. In the present design the connection is made via a heavy linkage beam, which transmits the drive force from the hydraulic cylinder at the Long Twin unit to the telescopic beam. Omitting the linkage beam results in a direct mass and height reduction of the spreader. Redesigns that have been considered are: linkage via the container structure, direct linkage via slots in the mid frame and digital linkage using sensors.

Drive components: the drive system requires electro mechanical drive components to fulfill the telescoping function. The present design consists of a hydraulically driven belt system for operation in single operation and the hydraulic cylinders for operation in Long Twin mode. Because the implementation of drive components depends on the drive system selected, various implementation methods have been considered for the following drive components: rack and pinion, roller screw, roller chain and wire rope drives. For every system, the required motor gear unit is determined.

Basic steel section design: the basic steel sections of a spreader are the telescopic beams and the mid frame. These sections determine the highest part of the total mass of the spreader. The basic section design of the present spreader is reconsidered upon shape and the implementation of High Strength Steel (HSS). Attention is paid to the use of HSS, because this results in difficulties.

Structural design: the direct linkage drive system requires that slots are implemented in the mid frame section. The slots can affect the structural integrity of the mid frame and are therefore checked via FEA. The implementation of slots in the side plates as well as the top plate is considered.

Other measures: possible redesigns that might lead to reduction in spreader mass but cannot be dedicated to one of the above parts are considered in this part. In this part, systems are considered that reduce effects of stress and friction on the spreader structure: stress distributing plates between the edge of the mid frame and the topside of the telescopic beams, shock absorbing suspension between the spreader and SC and rollers instead of slide plates.

The final concept design is selected according the Kesselring value analysis, which is part of the methodic design procedure. Via a morphologic overview various concept designs are selected, which are expected to perform well on the rating specifications. The expectations are based on first hand calculations, FEA models and mechanical properties. The rating specifications are based on the functional requirements of three SC manufacturers and finally selected in consultation with Stinis.

The final concept design resulting from the methodic design procedure has the following properties:

- The telescopic beam with equally placed side plates is performed in HSS;
- The mid frame with bended side plates is performed in HSS;
- Direct linkage via slots in the top plate of the mid frame;
- Vertically placed roller chain drive system for Long Twin operation electrically driven;
- Original belt drive system for single operation electrically driven;
- Stress distributing plate between the mid frame outside edge and the topside of the telescopic beam.

The performed methodic design procedure has resulted in a concept design that satisfies to the stated goal. With the concept design a mass reduction of 1350kg (13,8%) can be established with respect to the present Long Twin SC spreader design. The chosen concept design is not the least weighing concept that has been considered, but performs the best on the various concept specifications, thereby maintaining functionality and expected lifetime performance. However, there are some points that can be concluded from this research.

The use of a SC log file rather than conservative load cycle distribution prescribed by the standards results in a more favorable classification. The more favorable classification results in lower application factors and a higher permissible fatigue strength. It can be stated that spreaders designed with the conservative load cycle distribution are over dimensioned; the actual lifetime performance will be higher than the requested lifetime performance.

The implementation of electric drives and HSS will result in increasing costs. The increasing costs are mainly caused by the drive system. The high costs due to use of HSS is expected to decrease over time.

Mass increase will be unavoidable with the replacement of hydraulic drives for electric drives. In addition the robustness will decrease as the drive system will have to be dimensioned on the edges of what is possible to save mass.

The use of HSS in the final concept design is necessary to reach the stated goal on mass reduction. The fatigue strength of HSS is the limiting factor in the spreader design. Therefore, post treatment of the welds will be required to reach higher fatigue strengths and higher mass reductions.

In addition to the decreased mass of the spreader, the height has been decreased. Although the concept design leaves little space between the stacking height and the maximum hoisting height, the SC manufacturers will not have to increase the SC height.