Automation of Grab Ship Unloaders (GSU) for Bulk Materials

iSAM AG
Gesellschaft
für angewandte
Kybernetik

Driverless grab unloader for ships

- Automatic unloading of coal and ore – even below the hatch coaming

- Driverless operation under almost any weather conditions

- Integrated safety system for persons on the ship and the quay

- Monitoring of up to four ship unloaders by one operator from a central control station

THE 1ST DRIVERLESS GRAB SHIP UNLOADER
Proven in practice since 2010

The Customer

With a volume of more than 135 million tons per year, the Port of Hamburg is a central hub for the transshipment of materials from countries all over the world. Hansaport, the specialist for iron ore and coal, is integrated into the former as an open harbor where four unloading bridges are available for rapidly unloading sea-going ships. Leading-edge technology allows large volumes of coal or ore being put into store or reclaimed in a minimum of time. In combination with advanced weighing technology, computer-controlled equipment ensures utmost precision when transshipping bulk materials.

The Task

Unloading operations should be handled **fully automatically – without any operator** being present on the unloader – for the four existing ship unloaders in a reliable and effective manner.

The Solution

The task of operating a grab unloader driverless and fully automatically is a great challenge, if not a mission impossible. But with a combination of a 3D laser scanner, an inertial navigation system that has its origins in aeronautics and leading-edge control technology, iSAM was nevertheless successful in solving the problem.

At Hansaport, four ship unloaders were equipped with the iSAM Grab Unloader Automation System – and since the beginning of 2011, the whole system is operational.

One of the key components of the automation system is the intelligent grab guidance system based on the grab's position tracked in real time. Due to the high speed of the grab as well as possible swaying and torsional movements a **High-Performance INS** (Inertial Navigation System) is used.

The method is known from the field of aeronautics and has proved its efficiency for the unloading of ships by grabs, too. The INS is directly mounted onto the grab and permanently delivers high-precision attitude and position data.

In the control system, data from the INS ensure a continuous update of the energy and position model for the grab's moving path. This allows a precise "landing" of the grab at any given point with a precision of about 0.5 m in the cargo hold – whatever may be the weather conditions, at low tide and high tide.

we deliver solutions …
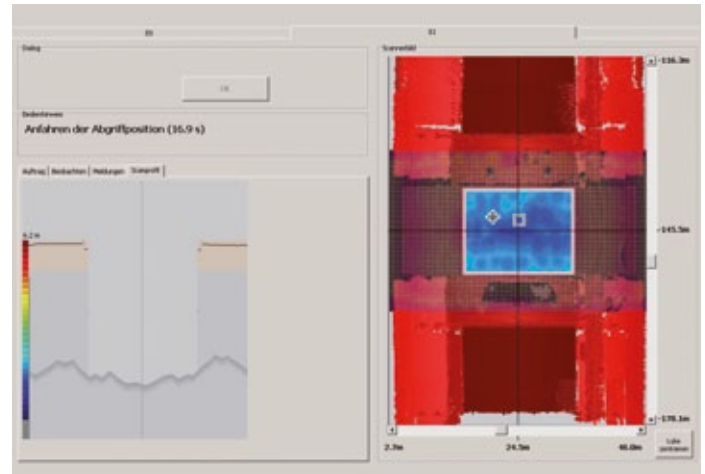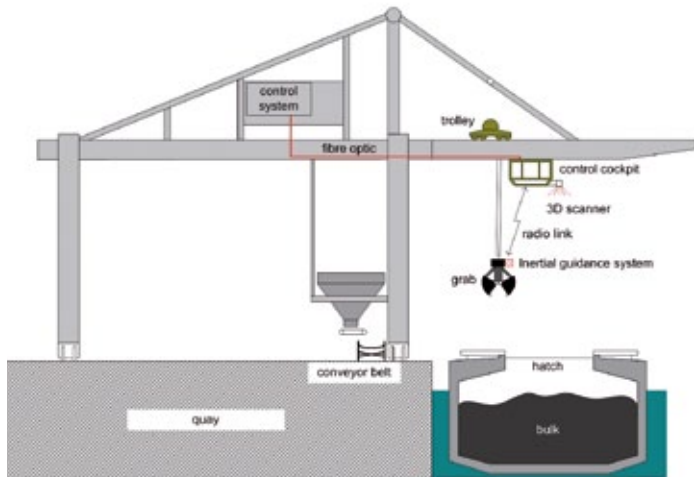
3D laser scanning – hatch and bulk material

The position of the unloader is permanently tracked by a RTK-GPS. A high-precision 3D laser scanner delivers the exact position of the ship and its hatches as well as data about the material distribution in the cargo hold. The scanner is even able to reliably detect coal from a distance of up to 100 m, under almost any weather conditions.

Whereas the INS and the 3D scanner are the **"eye and feel"** of the automation system, a high-performance industrial PC is mounted into the unloader and connected with the PLC – the **"brain"**. Ultimately, the best unloading strategy is determined here depending on the design of the ship, the material data and the current sensor data.

Knowing the different material properties, for instance a "performance-oriented" strategy with a reduced cycle time is chosen for materials that flow well, for instance pellets. For coal and ore which have poor flowing properties, however, it is necessary to unload right from the start "out of the corners".

In contrast to a human operator, the control system is not only able to calculate the current position, but also the **kinetic energy of the grab at any point on the moving path**. This makes sure that the grab does **not collide with the hatch or the unloader structure** during the whole cycle – not even in case of "hard" stops, for instance when an emergency stop is pushed.

Highlights
- Real-time determination of the grab's position
- Automatic unloading, even under the hatch coaming
- Real full automation, not a remote control
- Possibility of manual intervention from the central control station
  - "Freeing" from an extraordinary situation (for instance a buried grab due to collapsing material walls)
  - Change of hatch
- Permanent update of data for the energy and position model for the grab's moving path
- Operation of all equipment from a central control station, i.e. minimum stress for the operator in the central control station thanks to a maximum degree of automation

Competitive advantages
The use of fully automated grab unloaders for ships means a significant **reduction of personnel expenses**. **One operator** in the central control station handles four ship unloaders.
- Very uniform unloading performances
- Lower wear and tear because mechanical performance limits are respected in automatic mode
- Fulfillment of operational guidelines and safety rules
- Improved working conditions

Supported by:

Federal Ministry of Economics and Technology

on the basis of a decision by the German Bundestag

Facts

Client/Location:	Hansaport Hafenbetriebsgesellschaft mbH, Hamburg, Germany	Sensors:	3D laser scanner for the detection of ship, hatches and material distribution
Industry:	Transshipment of bulk materials		2 RTK GPS receivers for determination of the position of the grab unloader
Hardware:	■ 19" industrial PC ■ PLC-based control system		Grab guidance system INS
Software:	iSAM grab unloader automation system		4 TOF sensors – 3D camera according to the light time-of-flight principle
		Commissioning:	January 2011