Potential for emission-free drives for vehicles in ports

Gottwald Port Technology, Düsseldorf, Germany

Electrically powered mobility is a topic that is uppermost in everyone's minds and the objective of numerous research and development programs. In the field of personal and commercial goods transport on public roads, electrically powered vehicles have not been able to make much of an impression due to the low energy density and high investment costs of today's batteries. As well as the challenges faced by vehicle designers, there is the additional issue of finding solutions for the infrastructure to enable the batteries to be recharged, and to adapt the technology to the typical habits of human users. In stark contrast to this, we have seen battery-powered drives in use in handling machine applications for many years, but even here there are opportunities for introducing new concepts for additional, improved areas of use.

Container transport via maritime and river ports is an indispensable factor in our global economy. To be able to handle annual volumes of hundreds of millions of containers, high-performance machines such as container gantries and stacking cranes are used alongside innumerable heavy vehicles for horizontal transport within the container terminals. Depending on the handling strategy applied at a terminal, various types of vehicle systems are in daily use, such as straddle carriers, reach stackers, and driverless transport vehicles, also termed Automated Guided Vehicles (AGV).

In contrast to the cranes, which are electrically powered as a rule, heavy vehicles for horizontal transport are usually powered by diesel engines and consume large quantities of fossil fuel. This causes a corresponding negative impact on the environment in terms of high levels of noise emission and high local toxic concentrations. It is for this reason that leading international maritime terminals in Europe and North America are currently in the process of making sustainable improvements to the environmental compatibility of their terminals. Terminal operators are well aware of their responsibilities, which is why many companies already include details of their carbon footprint in the reports they publish.

Gottwald Port Technology GmbH (Gottwald), a subsidiary of Demag Cranes AG, has set itself the task of developing a transport vehicle which is free of local emissions, offers the same efficiency as a vehicle with a diesel engine, but can be operated as economically or better. In doing so, Gottwald has opted for an electrically powered Battery AGV, whose drive technology is based on proven diesel-electric vehicles. Recharging traction batteries can take several hours, so to prevent the charging time having a negative effect on system productivity the machines incorporate a battery-changing concept, which enables the battery-changing and recharging procedures, and the container transport itself to be fully automated.

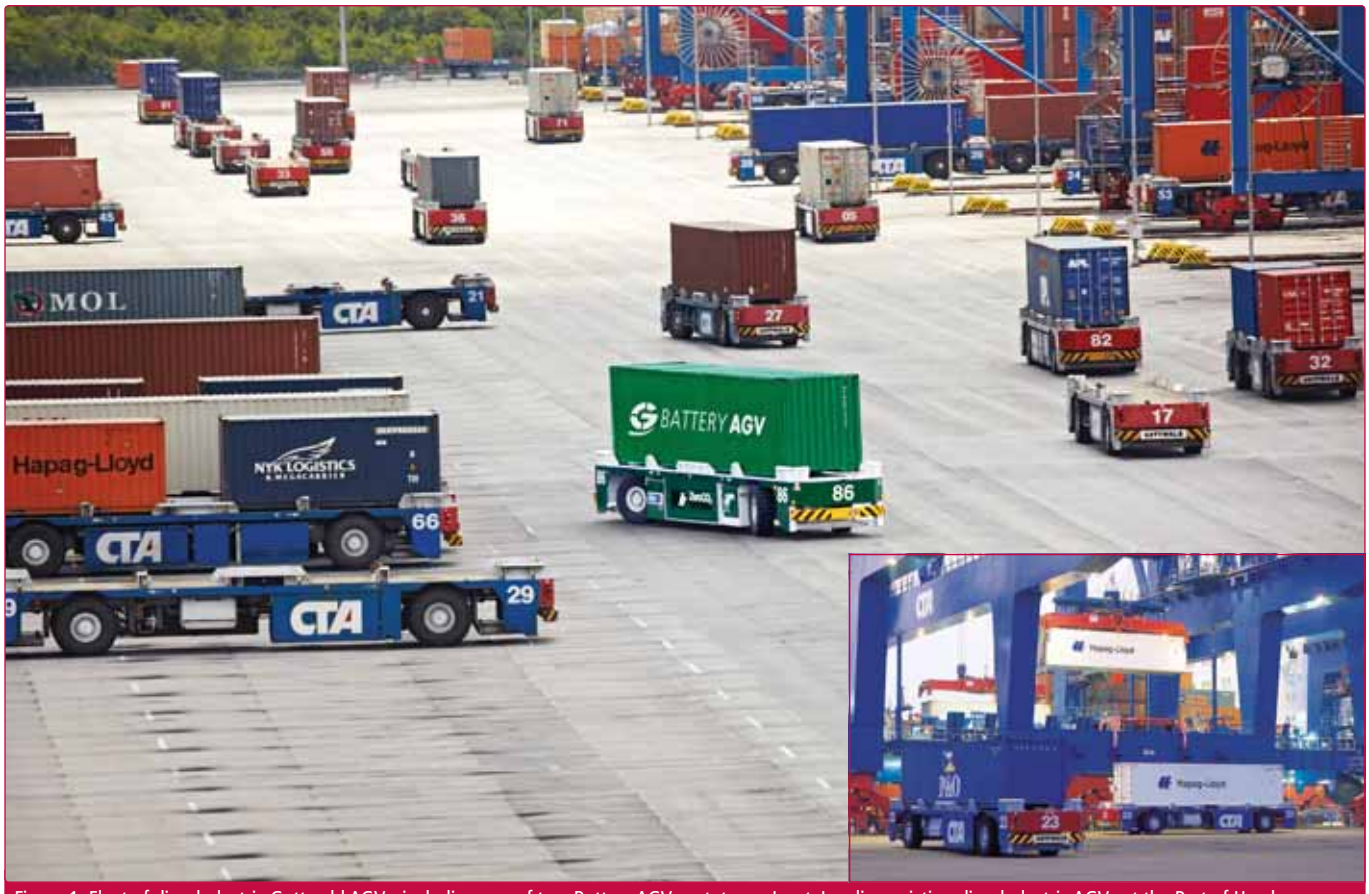

Figure 1. Fleet of diesel-electric Gottwald AGVs, including one of two Battery AGV prototypes. Inset: Loading existing diesel-electric AGVs at the Port of Hamburg.

From a battery-powered test vehicle to a mature prototype

Gottwald AGVs are heavy transport vehicles with a payload of 60 tonnes and a total laden weight of over 90 tonnes, and operate non-stop 24 hours a day in ports and terminals. The vehicles can carry either a single 20', 40' or 45' container or two 20' containers at the same time and achieve speeds of up to 22kph.

In transport vehicles of this size and weight, battery operation is something completely new. To minimize development risks, the first step involved setting up and trialing a test vehicle in cooperation with HHLA Container-Terminal Altenwerder GmbH (CTA), Hamburg, a long-term customer of Gottwald. This meant that one of CTA's 84 AGVs was converted by Gottwald to run on batteries, where the batteries themselves initially were integrated in a standard container on the AGV's load area. Over the course of extensive tests it became clear that, under realistic working conditions, a battery-driven container transporter is a feasible reality.

During the second step, two battery-powered AGV prototypes and a fully automated battery-changing and recharging station were developed, set up and tested in field tests within the context of a project funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). This funded project also involved HHLA Container-Terminal Altenwerder GmbH, Hamburg; the Institute for Vehicle Technology (ika) at the RWTH Aachen University, and the Institute for Energy and Environmental Research Heidelberg GmbH (ifeu).

The advantage of this consortium was that the battery-powered drive train could be scientifically analyzed while being tested under practical conditions. This enabled economic and technical risks of the development work to be minimized, while monitoring and optimizing ecological interaction at the same time.

Fully automated battery swap in only five minutes

The energy storage media used in the Battery AGV are lead-acid batteries which, in comparison with other kinds of batteries (for example, lithium ion (Li-ion) or nickel-metal hydride (NiMH) cells), currently offer considerable cost advantages and are fully recyclable. In addition, there are numerous and extensive standardizations and experience reports available for these batteries regarding long-term behavior, service life and recharging technology.

To achieve the required duty time of over 12 hours with a single charge, it is necessary to use batteries whose mass and volume are five to ten times that of standard traction batteries. The traction battery for the Battery AGV consists of an interchangeable battery cell frame, which houses nine standard 80-volt battery boxes. The interchangeable battery cells are positioned in the middle of the vehicle due to the considerable weight of approximately 10 tonnes. The electrical connections are made via special purpose, automatically actuated couplings.

Not only the vehicle technology is new – the battery-changing method also involved breaking new ground. The application of a fully automated battery-changing and recharging station is a completely new concept. In close cooperation with Vollert, a well-known manufacturer of heavy-load handling systems, a new fully automated battery-changing station was developed. The ten-tonne battery packs are handled by a manipulator, which is similar to the storage and retrieval robots used in high-bay shelving systems.

When the battery charge level in the vehicle drops to a certain point, the terminal operating system (TOS) automatically sends the AGV to the battery-changing station. Here, the manipulator performs the battery change by extracting the batteries from the side of the vehicle and inserting them into a free slot in the shelf system. The vehicle is then fitted with a fully charged cell pack and can return to work after an interruption of only around five minutes.

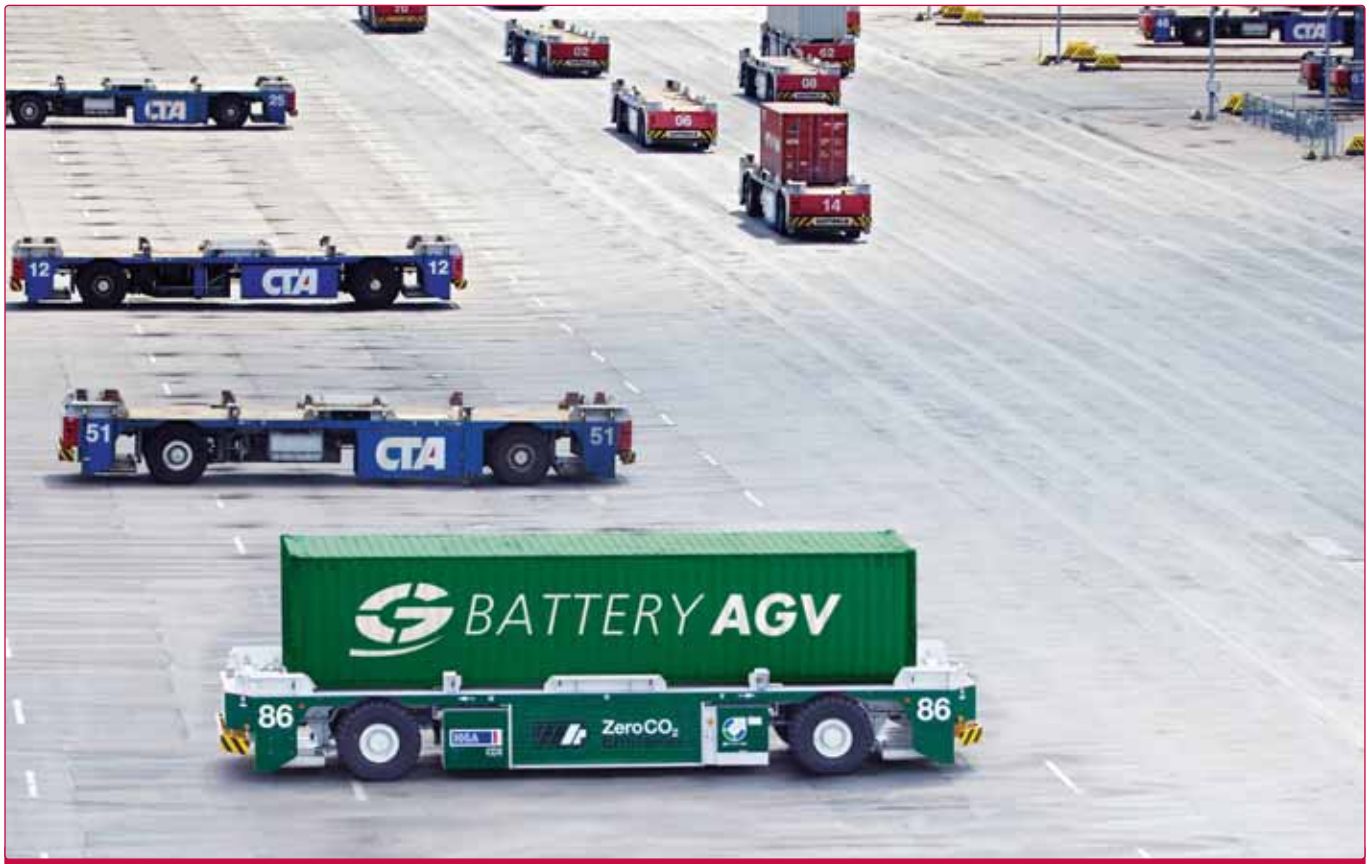

Figure 2. One of two Battery AGV prototypes at the Container-Terminal Altenwerder (CTA), Hamburg.

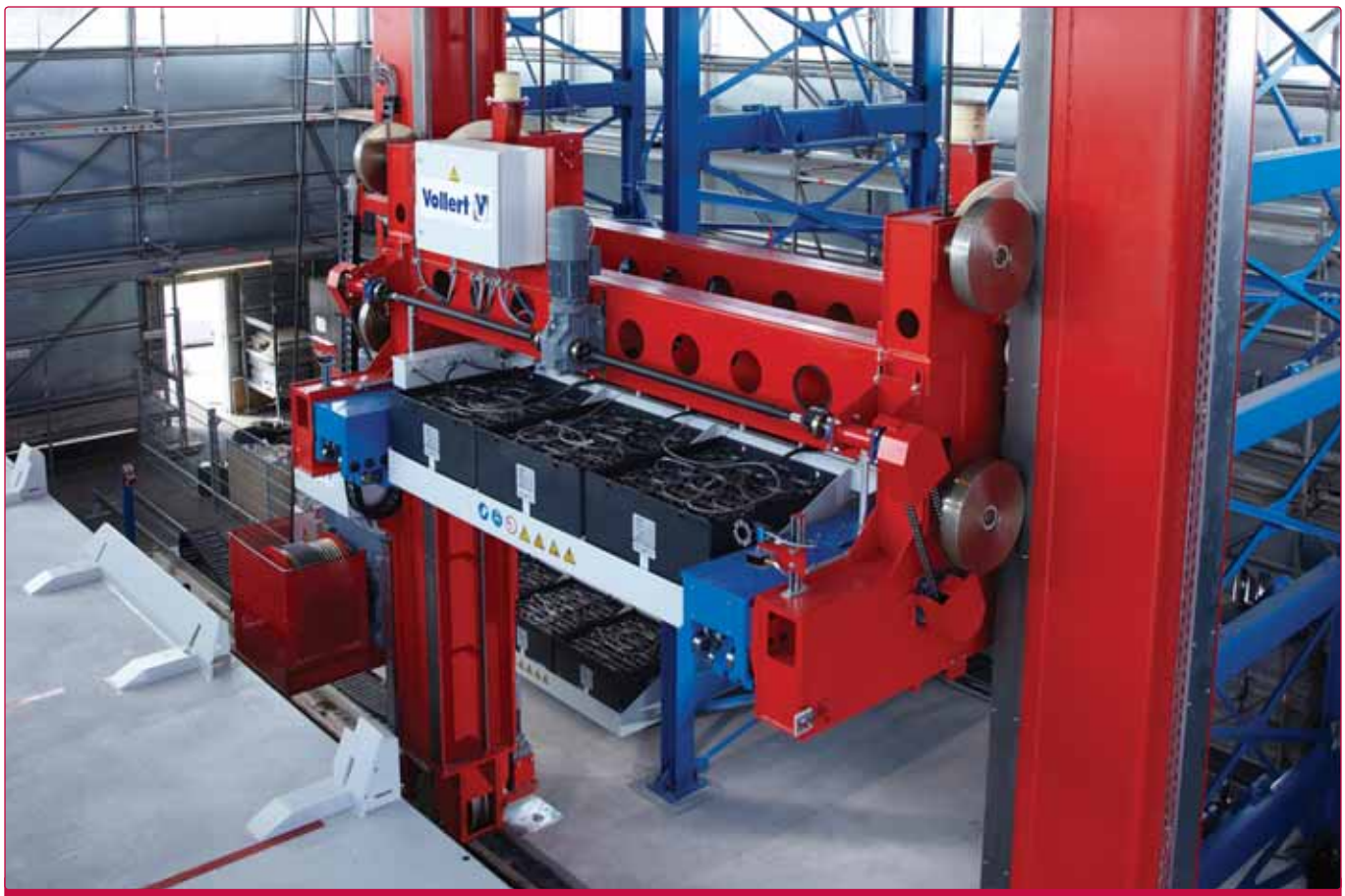

Figure 3. Fully automated battery-changing station.

The flat battery is then moved to a charging point where it automatically makes contact with the charger and its recharging process begins. The very short downtimes offered by the fully automated battery-changing procedure enables the productivity of the system to continue at much the same level as the current system, which uses diesel-electric vehicles. As a result, using Battery AGVs does not necessitate having more vehicles available.

For each of the two prototypes there is one spare battery available. With larger fleets of vehicles, where each battery can be used in any of the vehicles, it is expected that only one spare battery will be required for every two vehicles.

Economical & environmentally compatible

This battery-driven system considerably reduces the amount of energy required and the environmental impact. There are, for example, no waste emissions during operational vehicle downtimes, as there are with diesel vehicles. Furthermore, the efficiency levels are also high in partial load operation and some energy can be recovered during braking actions. First test results have demonstrated that CO_2 emissions can be reduced by around 30% in comparison with diesel-electric AGVs, taking into account the full energy chain and based on the current German fuel mix. This benefit will be expanded as the amount of electricity acquired from renewable sources rises in the future. The system also offers the opportunity to minimize CO_2 production by exploiting green sources of electricity generation.

In terms of the acceptance of container transport vehicles of this kind, it is not only the possible reduction of hazardous emissions and noise that plays a key role, but also the cost effectiveness of the system. First trials indicate that annual overall costs can probably even be reduced, taking into consideration investment write-downs for the vehicles and infrastructure, operating costs and interest paid as compared to conventional diesel-electric vehicle fleets, while maintaining the same level of productivity. The increased initial investment costs for the traction batteries and battery-changing and recharging station will be quickly offset by much reduced maintenance and energy costs. It is anticipated that this effect will be seen even more clearly as energy prices rise in the future and environmental legislation becomes more restrictive.

The battery-powered AGV project has demonstrated that much improved environmentally compatible container transport in ports and terminals is not only technically feasible, but also cost-effective. The framework conditions for such a transport system provide tremendous potential for harnessing the undisputed advantages of electric mobility in the near future.

ABOUT THE COMPANY

Gottwald Port Technology GmbH, based in Düsseldorf, Germany and a subsidiary of Demag Cranes AG, is a manufacturer of harbor cranes and terminal automation technology. With a total of over 1,300 mobile harbor cranes sold, the company is world market leader in this product sector. In the field of terminal automation, Gottwald Port Technology offers system solutions that incorporate both the company's own software and hardware. Gottwald Port Technology supplies customers in around 100 countries.

ENQUIRIES

Gottwald Port Technology GmbH
Postfach 18 03 43
40570 Düsseldorf
Germany
Tel: +49 (0)211 7102 0
Fax: +49 (0)211 7102 3651