AGV or classic conveyor technology?

Comparing the performance of automated guided vehicles and fixed conveyor technology

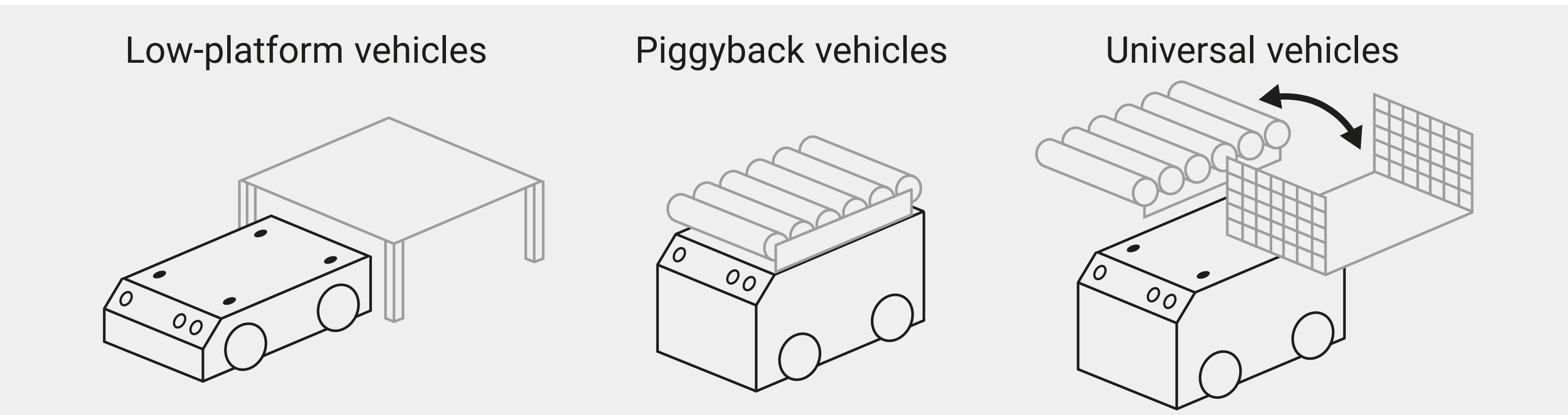
The increasing focus on Industry 4.0 has helped automated guided vehicles (AGVs) to gain momentum. But how do the autonomous vehicles improve production and automation? Can they replace classic conveyor technology? And how do engineers find the optimal conveyor system? Read this white paper to find out.

Some of the promotional images from automotive suppliers now resemble science fiction films. Autonomous vehicles whiz through the workshops, carrying or towing products. They make independent decisions and work as a group when required – similar to a colony of ants. Humans are nowhere to be seen.

The images of these automated guided vehicles (AGVs) correspond perfectly with the media image of Industry 4.0, the fourth industrial revolution whereby machines and products are interlinked, factories combine automation and flexibility, smart factories autonomously control production and even the smallest batch sizes are produced economically. AGVs also promise to resolve the issue of staff shortages.

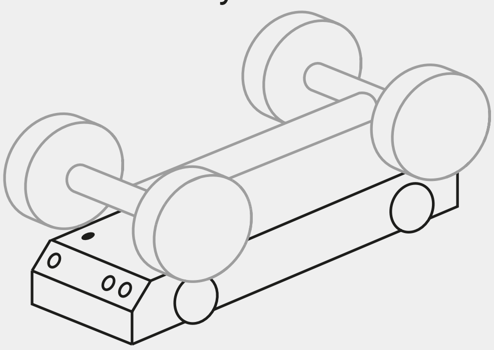
Industry 4.0 has led to a boom for AGV manufacturers

Jennifer Forster, a student at Bonn-Rhein-Sieg University of Applied Sciences, has compiled a benchmark for AGVs with appropriate load handling equipment as part of her bachelor thesis. She made a number of discoveries along the way: Driven by the Industry 4.0 trend, new AGV manufacturers have appeared on the market in recent years. Automated guided vehicles can be divided into several categories: Low-platform vehicles, piggyback vehicles, universal vehicles, assembly vehicles, pallet trucks and special-purpose vehicles.

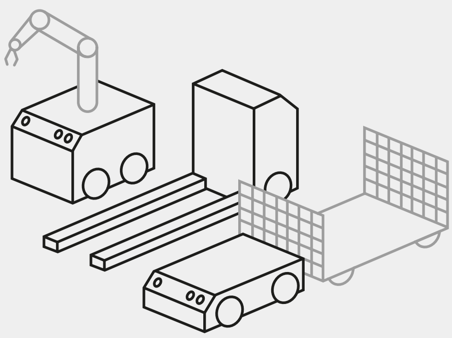


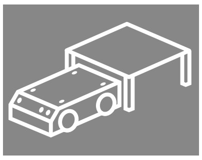
Low-platform vehicle with mobile profile frame and chain conveyor driven by friction wheels

Assembly vehicles



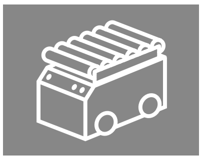
Pallet trucks and special-purpose vehicles





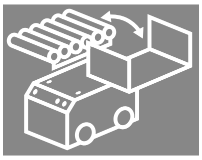
Low-platform vehicles

The low platform vehicles include the MiR 500 (with lift function) from MiR, the L600 from Grenzebach, the Carry Pick from Swisslog, the K05 Twister from Kivnon and the Fast-Move series from EK Automotion. Most models are flat. This allows the vehicles to drive under jacked-up containers, racks and pallets. They lift them off the ground using a lifting device and then transport them. These vehicles can generally handle weights of up to 500 kg.



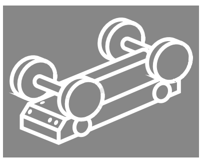
Piggyback vehicles

Piggyback vehicles include the ProAnt from InSystems and Sally from DS Automation. The vehicles work with various load handling devices, such as roller conveyors, timing belt conveyors, belt conveyors and chain conveyors. They pick up the load, e.g. lattice boxes, pallets or small load carriers weighing up to 1,000 kg, at the height of the conveyor technology. The transfer stations must all have a uniform height or be equipped with lifting units to compensate for height differences.



Universal vehicles

Universal vehicles include the LD60 and LD90 models from Omron (formerly adept) and MiR 100, 200 and 500 (without lift function) from MiR. As the name suggests, the vehicles are flexible and can be modified. The vehicles have mechanical and electrical connections to allow for various constructions, e.g. to mount individual assembly systems, simple frames, belt conveyors or roller conveyors. They can also be used as low-platform vehicles. The universal vehicle is currently the preferred type of AGV for new AGV manufacturers. Many users and integrators buy the AGV, add a load handling device and sell it as a complete solution.



Assembly vehicles

During the final assembly phase, assembly vehicles such as the Variocart from dpm are becoming increasingly popular – both in manual and automated assembly with robots. The AGVs transport products weighing up to 5,000 kg. In some automobile factories, for example, there are assembly vehicles that drive entire cars back and forth between assembly stations. However, adjustments are often required in robot cells in order to use the AGV. This is because the required accuracy is +- 0.1 mm. Most AGVs work outside of this range. Therefore, many users perform a camera-based calibration of the robot. The robot can then adjust its movement to the position of the product.

Pallet trucks, towing vehicles, mobile robots, special-purpose vehicles

The world of AGVs also includes pallet trucks such as the MLR from Phoenix, which replaces classic forklift trucks, towing vehicles such as the Tugger from Grenzebach, which pulls mobile racks from A to B for example, and mobile robots such as the Maxo-MS-HA001 from SEW that relieves employees of routine tasks. There are also manufacturers who develop special-purpose vehicles.

Piggyback vehicle with customised load carrier for transporting small load carriers

Pallet trucks and low-platform vehicles dominate the market

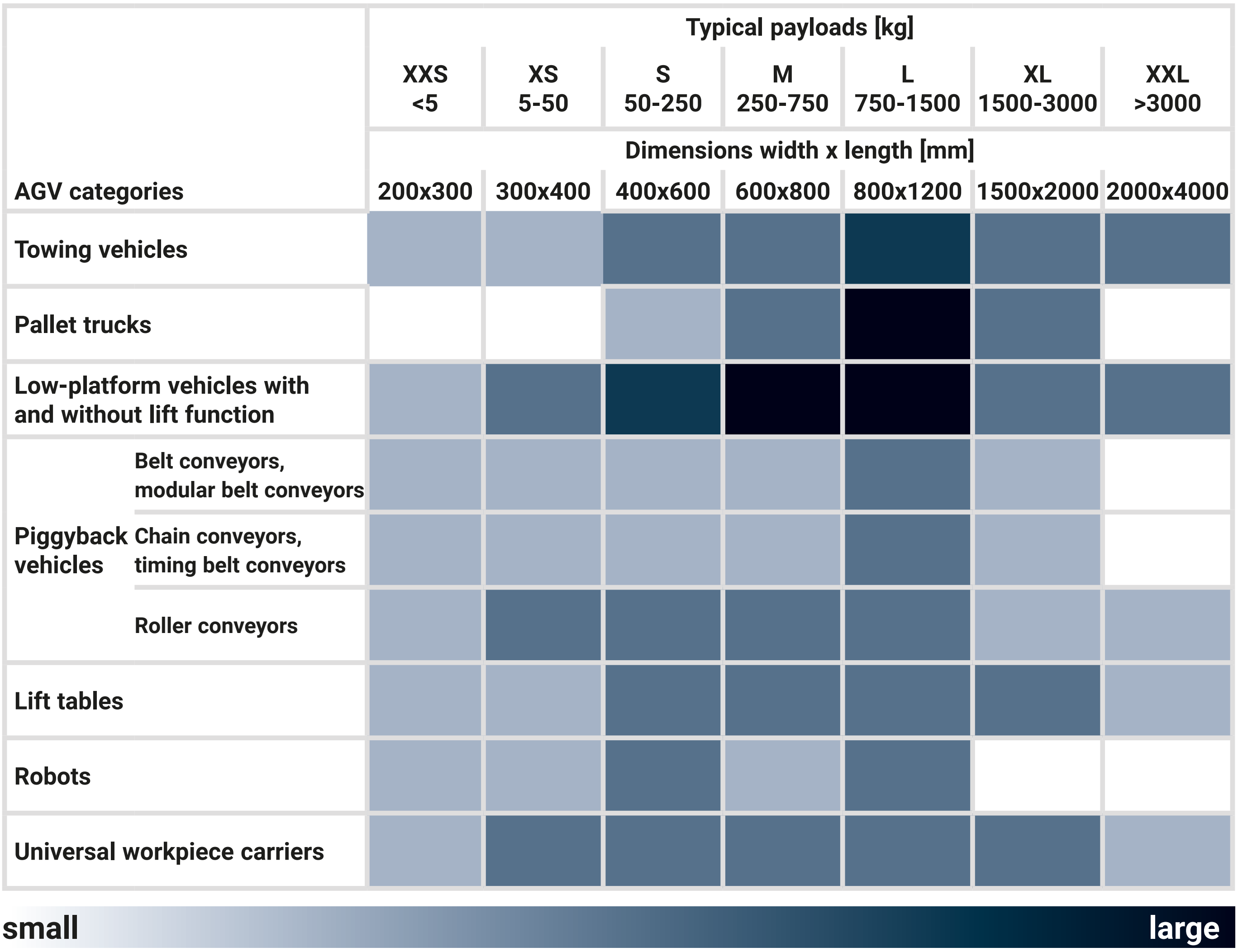
Which AGVs are used most frequently? Jennifer Forster has investigated this question and displayed the result in a benchmark matrix. The matrix shows the following: In the application area considered, pallet trucks currently have the highest market share for payloads of up to 1,000 kg. Low-platform vehicles are also among the most popular products (500 – 1,000 kg).

The navigation type shows a trend for contour navigation. The vehicles achieve accuracies between 10 and 50 mm. The positioning accuracy at stations is between 4 and 10 mm. To improve the accuracy, companies use hybrid navigation with magnetic strips or camera assistance. This improves the accuracy at the stations to +-1 mm.

And which load handling devices are popular? At present, non-actuated load handling devices are predominant in the market – for example simple workpiece carriers and shelves. With regard to actuated load handling devices, belt conveyors or modular belt conveyors and roller conveyors are frequently used. In contrast, chain conveyors and timing belt conveyors are less common.

Market share of AGVs: The most popular AGVs are currently pallet trucks and low-platform vehicles

By payload



Low-platform vehicle with load-bearing frame made from an aluminium profile with customer-specific product carriers

By industry

AGV categories		Automation	Intralogistics	Assembly
Towing vehicles				
Pallet trucks				
Low-platform vehicles with and without lift function				
Piggyback vehicles	Belt conveyors, modular belt conveyors			
	Chain conveyors, timing belt conveyors			
	Roller conveyors			
Lift tables				
Robots				
Universal workpiece carriers				

small large

Kinematics and navigation of an AGV

The kinematics are as varied as the types of AGV. There are differential drives with and without a rotary axis, coupled steering drives, independent steering units and mecanum drives. Of the many different drive types, two have proven to be particularly practical: The differential and mecanum drive are both very flexible and require minimal steering and turning space.

There is just as much variety when it comes to navigation. Some AGVs use guidelines laid on or in the floor – for example, active-inductive track guidance, magnetic tape or a visual track in the form of a coloured strip. Other AGVs are oriented with the help of contour navigation using laser scanners and GPS. The most popular navigation methods are currently contour navigation and visually coded navigation. These are flexible and relatively cheap and easy to use. However, users do not have to limit themselves to a single type of navigation. Often hybrid navigation, a combination of several methods, is the most appropriate.

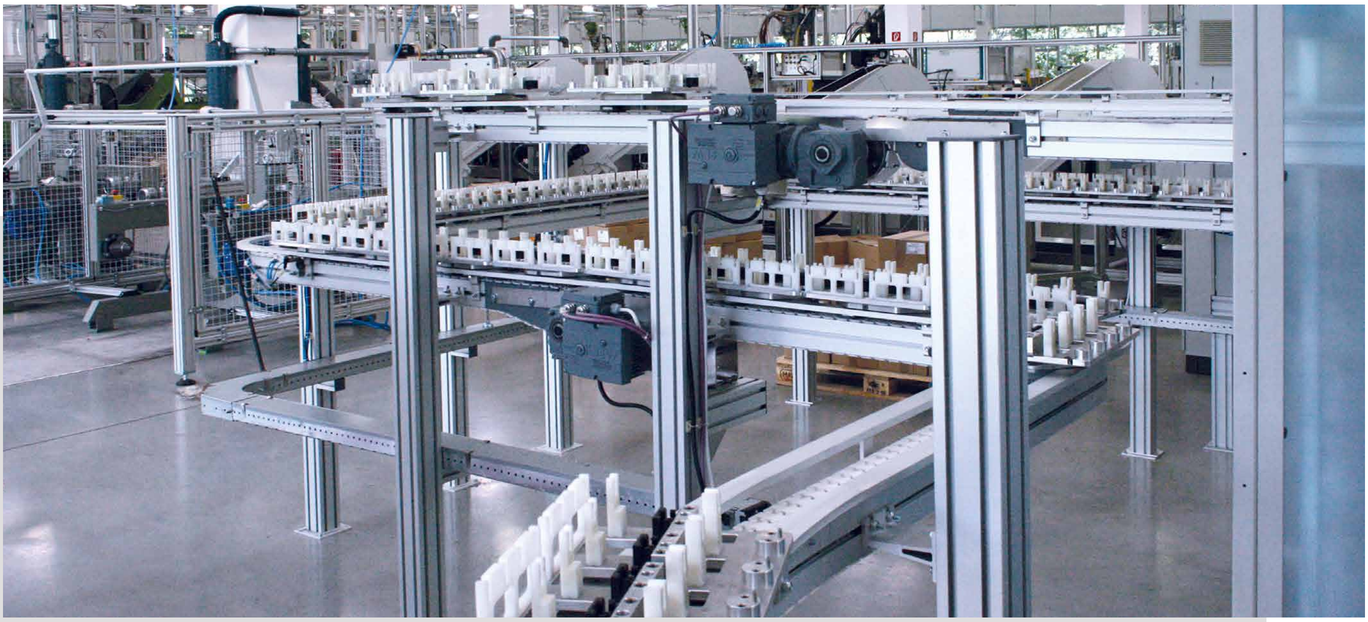
Industry 4.0 is also infiltrating classic conveyor technology

Long before the AGV boom, classic conveyor technology was evolving in the fields of production and automation. Classic conveyor technology includes belt, modular belt, timing belt, chain and flat top chain conveyors, as well as roller conveyors. Thanks to their modularity in terms of product transport, there are virtually no limits to the imagination of engineers. Flat top chain conveyors, in particular, have proven useful in mapping complex three-dimensional routes.

Flat top chain conveyors are designed for the transport of small products with low masses (a total load of approximately 150 kg). For load carriers or pallets with high masses, engineers usually opt for roller conveyors or chain conveyors. Chain conveyors are often equipped with pallets in the form of a double-line conveyor and configured as a pallet circulation system in order to reliably fulfil positioning tasks with short cycle times and high accuracies. They can move products with a total load of up to 1,000 kg.

Other types of AGVs used for transporting piece goods include overhead conveyor systems and rail-mounted ceiling transport systems, which are often found in the final assembly area in the automotive industry.

The Industry 4.0 era has also led to developments in classic conveyor technology. For example, it is now possible to equip conveyor belts with sensors that send measured values to the cloud. This allows not only efficiency monitoring but also proactive maintenance.



Complex flat top chain conveyor on multiple levels for the transport of pallets

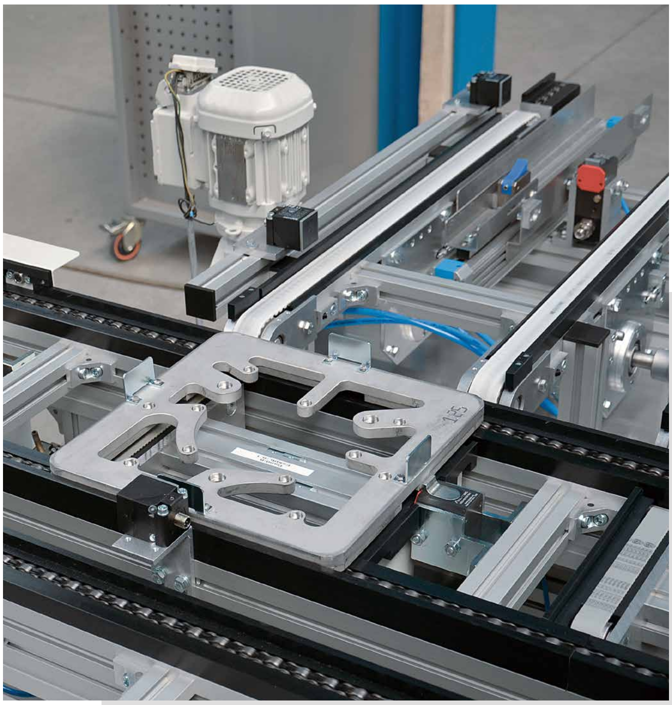
Application examples:
How do engineers decide between conveyor technology and AGVs?

As the Industry 4.0 trend continues to grow, engineers are increasingly asking themselves whether they should replace conveyor technology with AGVS for everyday tasks. The following three use cases show how the decision was made in each case.

Example no. 1: Interlinking processing cells

In this example, engineers needed to interlink two processing cells with an automated washing system. An area of approximately 32 m^2 was available. The throughput was 30 units/hour; the product load was 15 kg. The obvious solution was to use a double-line conveyor with pallets. The alternative was to use a piggyback AGV with roller conveyors. The AGVs would travel at a speed of 30 m/min and navigate using a rigid guideline.

The engineers decided not to use the AGV. It would have been a smart but impractical solution. The space was simply too small. The potential flexibility of the AGV would not be utilised in this situation. In addition, there is a higher susceptibility to errors and higher maintenance effort compared to conventional conveyor technology.

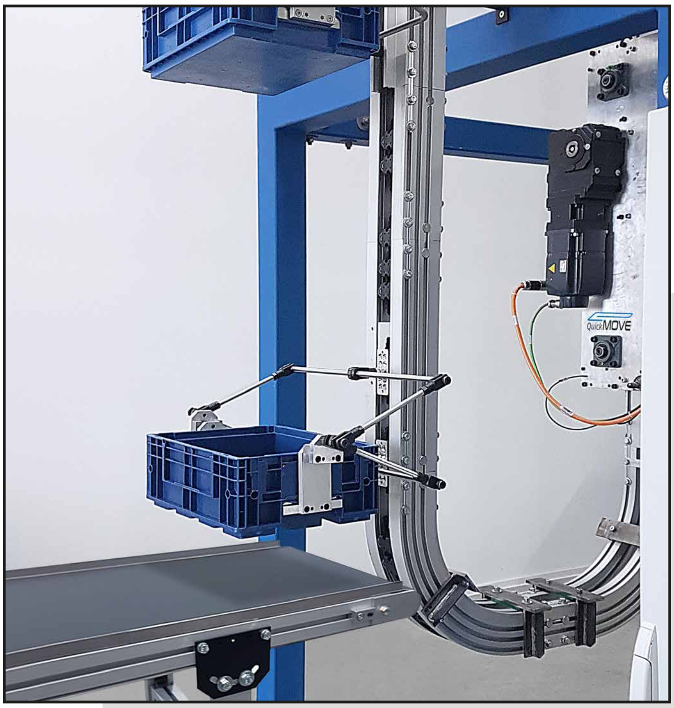


Chain conveyor with customer-specific pallet in corrosion-resistant design for automated washing systems

Example no. 2: Transport of products in a factory

In a production facility with a continuous material flow and high throughput, a tugger train with driver currently transports kanban shelves back and forth between the order picking and assembly areas every 40 minutes. The company wanted this line to be interlinked. This could reduce conveying times by 30%. There was one specific instruction: A relatively large area must remain available to be used as a traffic route. Therefore, there was insufficient space for classic conveyor technology.

The engineers had a choice between an AGV with contour navigation and an overhead conveyor system with a throughput of 50 boxes per hour. They opted for the overhead conveyor system. The costs were the deciding factor. The AGV was 25% more expensive than the overhead conveyor system.



Overhead conveyor system with transfer station to conveyor technology

Example no. 3: Automation in a research laboratory

A research laboratory was looking for a way to transport specimens back and forth between test chambers and storage areas. In this example, the engineers decided against classic conveyor technology and opted for an AGV. The specimens stand on a frame that is equipped with a gravity roller conveyor and is transported by a low-platform vehicle. The vehicle is navigated with the help of grid navigation, whereby magnets or transponders are embedded in the ground. At the stations, a magnet pulls the specimens from the rack. A high throughput was not required in this case. The specimens spend more time in the storage spaces than they do being transported.

Why did the engineers opt for the AGV? The costs were also the deciding factor in this scenario. The AGV was up to 30% cheaper than conveyor technology. The freedom of movement was also a key advantage.

AGV to transfer station: A magnet pulls the specimens from the frame via a gravity roller conveyor

AGV development in production is still in its infancy

The terms AGV and matrix production are often used in the same breath. Classic production chains are no longer used in matrix production. Instead, there are manual, partially or fully automated cells that can be quickly adapted to new production tasks. Due to their flexibility, AGVs seem perfectly suited to product transport. In contrast, classic conveyor technology would only be used for the supply and removal of products. At least that's what the Industry 4.0 hype would have you believe.

The reality is very different. Although autonomous AGVs are finding their way into logistics – for example in the warehouses of online retailer Amazon – in production, AGVs are still in the pilot project phase. They are by no means considered best practice. It is also interesting that most of the pilot projects are taking place in the automotive industry, where binding processes and lack of flexibility, yet optimum process reliability are required. The AGV rarely demonstrates its advantages in terms of autonomy and flexibility in these projects.

In addition, the limitations of the AGV are evident in practical applications. Due to the time-consuming load transfer situation, cycle times are much longer than those achieved by fixed chain conveyors. As a rule, companies use AGVs for low flow rates and higher cycle times.

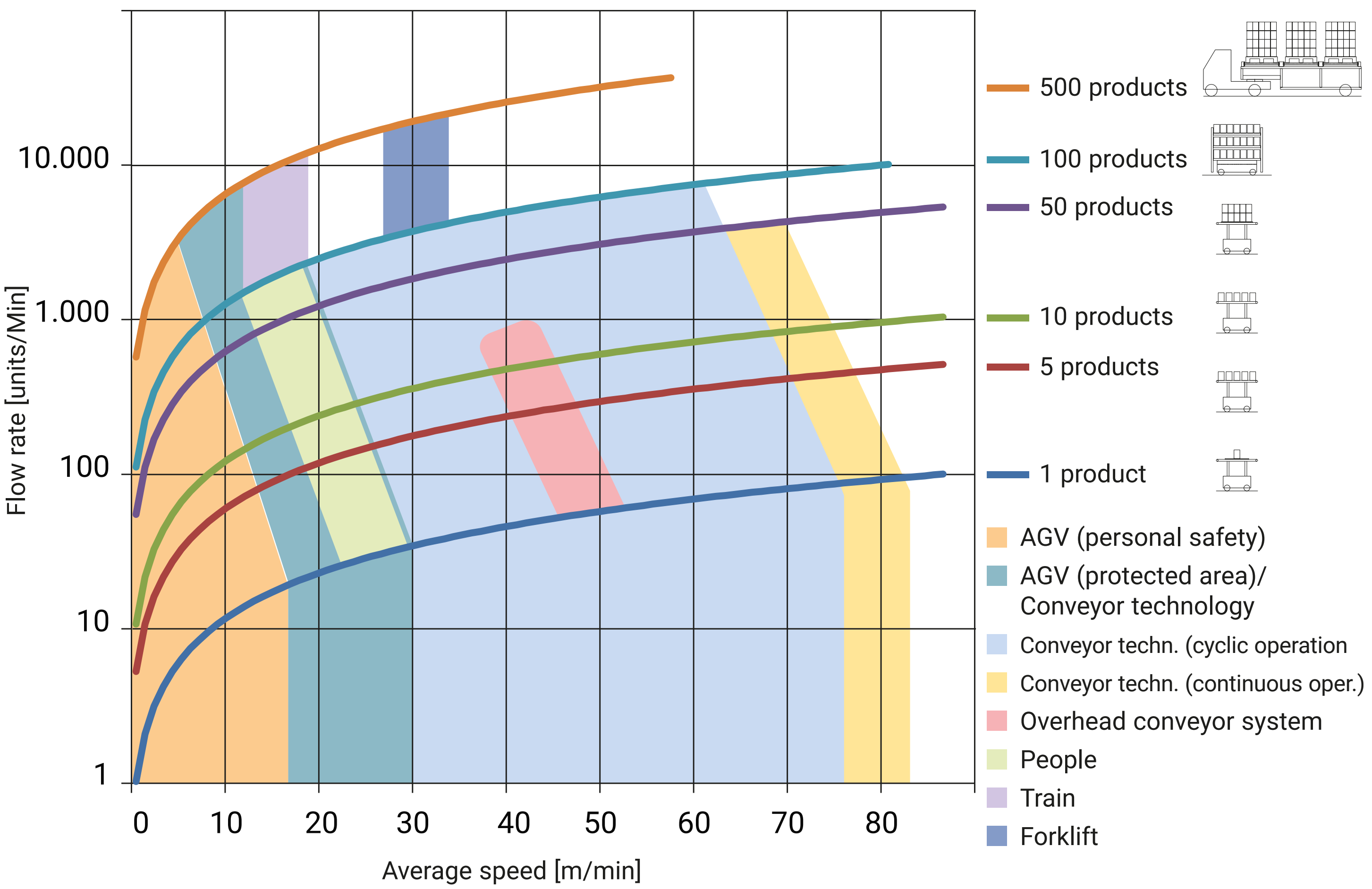
Allowing engineers to find the right conveyor system

The comparison matrix shown here helps engineers to choose a conveyor system. There are three steps to using the matrix. First, calculate the volume flow from the annual production. Calculate how many products the system has to transport per minute.

Next, calculate the average speed over the total transport route. Take into account all non-productive times, such as the transfer and loading times, and the maximum permissible speed in protected areas.

Plotting these two values as x and y coordinates reveals the section of the comparison matrix that corresponds to the most suitable conveyor system.

Comparison matrix for AGV variants



A tendency towards the appropriate system can generally be determined via the flow rate and the average speed. An exact determination depends on the manufacturer-specific properties of the transport medium.

The diagram shows that the field of application of AGVs is relatively limited. The systems are primarily used for longer distances and fairly low throughput. This is because the vehicles drive outside protected areas at a speed of only 0.30 m/s on average.

In addition, the transfer takes time. A frontal transfer takes up to 25 seconds. A lateral transfer movement is much faster. This only takes around two seconds.

AGVs are only able to perform at a similar level to classic conveyor technology when the vehicle is in the protected area travelling at a speed of up to 1.5 m/s.

Low-platform vehicle with trolley made from an aluminium profile
incl. actuated roller conveyor and protective device guard at transfer station

When carrying out a cost-benefit analysis, it is also important to consider whether the route is suitable for the use of an AGV due to empty trips and load cycles or due to space constraints, e.g. differences in height. The need for the flexibility provided by the AGV must also be assessed in the process.

AGV vs. conveyor technology: Conclusion

AGVs score particularly highly in terms of flexibility compared to classic conveyor technology. The only option that offers even greater flexibility is manual handling. However, AGVs are also relatively expensive and the monetary value of this flexibility must be considered for each specific application. The use of AGVs is particularly cost-effective when both the machinery and the underlying processes are well suited.

Currently, companies primarily use AGVs in production and automation for long, variable transport routes. AGVs are also used in cases where products have long cycle times or holding times. AGVs rarely compete against classic conveyor technology in these situations. They are much more likely to be compared with manual industrial trucks.

AGVs can be employed as a partial automation solution to bridge the gap between purely manual activities and the in-house milk run concept (multi-stop, regular routes) or can even be employed as a complete automation solution. When combined with flexible supply trolleys with load handling devices made from aluminium system profiles, they offer a quick-to-implement, expandable and versatile solution.

The new 5G mobile communications standard and intelligent, complete networking of entire fleets are expected to further expand the scope of AGV technology.

Classic conveyor technology offers excellent process reliability and high throughput. In addition, classic conveyor technology is significantly cheaper than AGVs, especially over short distances.

The higher the degree of automation, the more likely it is that classic conveyor technology is the method of choice.

However, each application is individual. Decisions regarding systems cannot be generalised. It is therefore important to consider several solution scenarios for each application as impartially as possible, before finally deciding on the most economical and future-proof transport solution.

The images used show application solutions implemented by the mk Technology Group. The pictures were taken at the customer site.

Sources:

- Forster, Jennifer: Fahrerlose Transportsysteme als flexible Lösung der Fördertechnik in Industrie 4.0 - Benchmark
- FTS und Lastaufnahmemittel mit Realisierung einer angetriebenen Rollenbahn, 2019 (Automated guided vehicles as a flexible solution for conveyor technology in Industry 4.0 – benchmark for AGVs and load handling equipment with implementation of an actuated roller conveyor, 2019)
- Documents from AGV manufacturers
- Specialist literature

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