Development of Improved Performance Laser-guided AGF

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In recent years, the need for automation in fast-growing multi-tenant warehouses has been increasing and more companies are considering introducing Automatic Guided Forklifts (hereinafter referred to as AGF(s)). However, the travel speed of AGFs is low compared to manned forklifts and AGFs cannot be operated using the same rack layout for manned forklifts. This problem has been a substantial impediment to the introduction of AGFs. Therefore, we developed a new AGF that can travel at substantially increased speeds and be operated using the same rack layout for manned forklifts and commenced sales in August 2021.

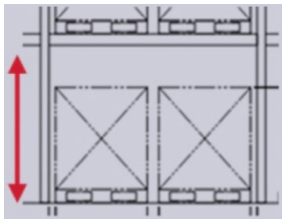
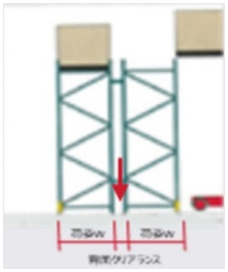
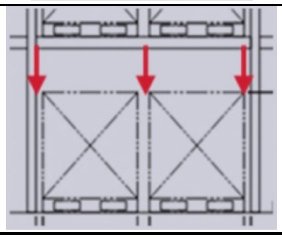
1. Introduction

Mitsubishi Logisnext Co., Ltd. has provided AGFs mainly targeted for logistics in factories (FA market) thus far. In recent years, in addition to the FA market, the distribution/warehouse business (DA market) has also seen the need for automation increasing due to a decrease in the worker population, a shortage of skilled workers, measures against the new coronavirus disease (COVID-19), etc. This need is expected to grow further. However, many of the tenants using multi-tenant warehouses are ordinary companies in the logistics industry and they require AGFs that can be used in storage/distribution facilities with the same basic specifications for manned forklift systems and provide a higher efficiency (higher speed) than conventional AGFs. In addition, fixed racks occupy about one-third of the storage area for goods and the conventional AGFs that require a larger clearance than manned forklifts cannot be well-adapted. Furthermore, when AGFs are introduced, magnetic bars must be buried in the floor of tenant warehouses and the magnetic induction type AGFs that require cutting work cannot be used in many cases. Therefore, we adopted a laser-guided type AGFs that allow easy layout changes with no floor work and developed a new AGF based on three development policies (layout adaptation, improvement of speed and safety), which can be adapted to operation in notably fast-growing multi-tenant warehouses in the DA market. The main features are introduced below.

2. Adaptation to rack layout for manned forklifts

Cargo handling with a conventional AGF was conducted in a certain operation pattern regardless of the weight of load. Therefore, as shown in **Table 1**, it required a clearance 50 mm larger in the height, depth and width directions, respectively, than for a manned forklift. In the newly-developed AGF (hereinafter referred to as the improved performance AGF), the accuracy of putting down loads in the height direction was improved by the optimization of the tilt operation timing, in the depth direction by the use of a rack beam detecting mechanism and in the width direction by the increase in the accuracy of stopping after turning, so that the AGF can adapt to the rack layout for manned forklifts.

Table 1 Specifications of racks

Item	Rack for manned forklift	Standard rack for AGF
Pitch of rack stage 	Height of the load + 100 mm or more (Limited depending on the weight and height of the load)	Height of the load +150 mm or more
Clearance behind rack 	100 mm or more (space between loads)	150 mm or more
Clearance between loads in rack 	100-100-100	100-150-100

(1) Optimization of tilt operation timing (patent pending)

The unloading operation flow of the conventional model is shown in **Figure 1**. When the load is heavy, the mast and fork bend and the forklift approaches the unloading position with the mast tilting forward. Therefore, a large clearance in the height direction was needed. The operation flow of the improved performance AGF is shown in **Figure 2**. In the improved performance AGF, the load is measured from the pressure condition of the hydraulic mechanism and the tilt operation timing is selected according to the weight of the load. When the load is light, the mast and fork do not bend and the forklift approaches the rack with the tilt DOWN and when the load is heavy, the mast and fork bend significantly and the forklift approaches the rack with the tilt UP. As a result, the load can be put down in the state of being kept nearly in a horizontal position. Thus, automatic cargo handling by using the same clearances as those for manned forklifts was realized.

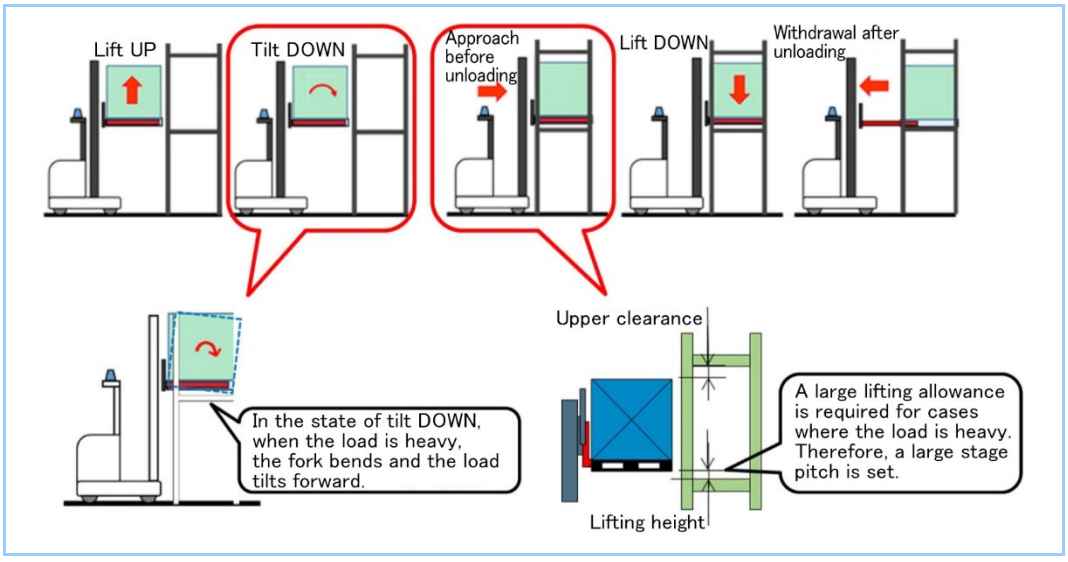


Figure 1 Unloading operation flow of conventional model

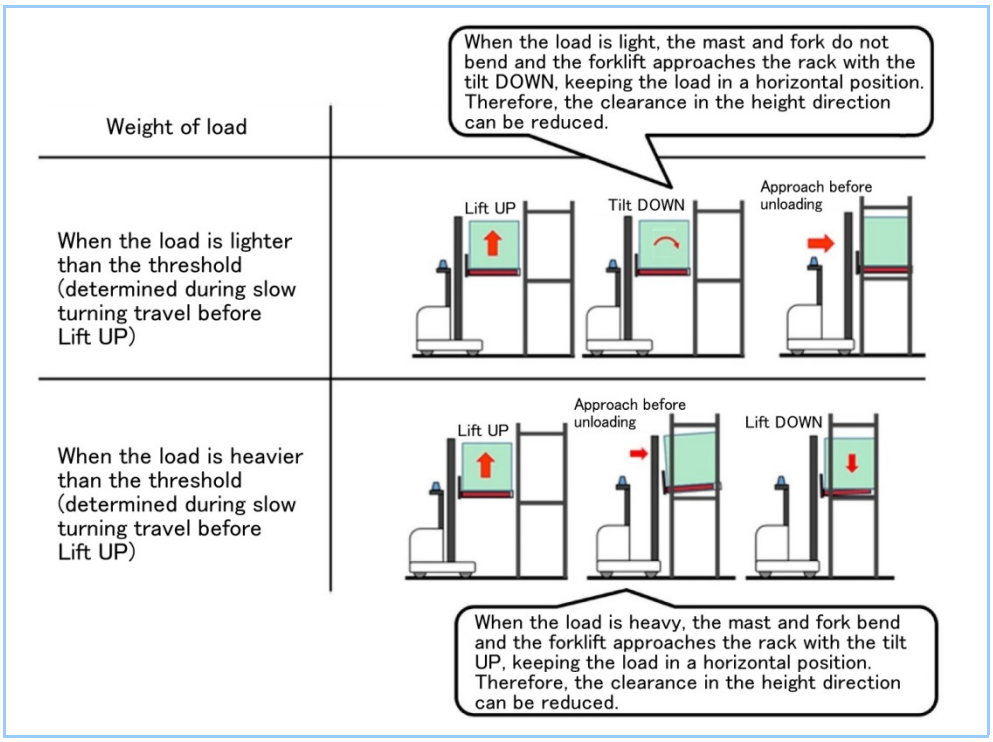


Figure 2 Unloading operation flow of improved performance AGF

(2) Rack beam detection mechanism

The conventional model needed to stop at a predetermined position on the layout to put down the load onto a rack. Since the mast bends due to the weight of the load, the putting-down position in the depth direction was unstable. The improved performance AGF is equipped with a laser sensor at the base of the forks to detect a rack beam. At the position where the sensor detects the rack beam, the reach operation is stopped. Thus, the load can always be put down in the same position regardless of the weight of the load (**Figure 3**).

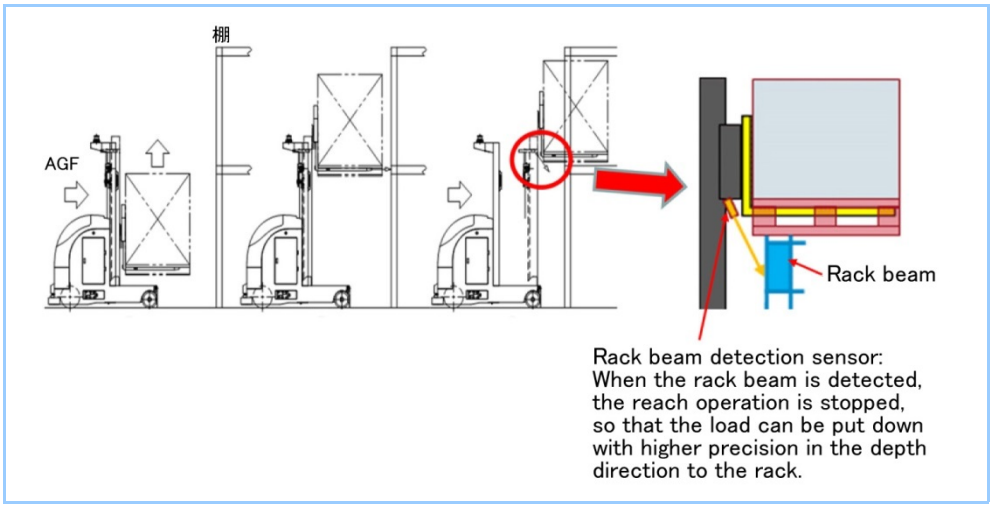


Figure 3 Rack beam detection mechanism

3. Improvement of travel speed

For the cycle pattern shown in **Figure 4**, the conventional model required about twice the time compared to manned forklifts. With the increase in the running speed, turn speed, lift speed and the optimization of the turning pattern, the improved performance AGF achieved a roughly 30% reduction in the travel speed compared to the conventional model.

(1) Increased running speed

If the weight balance of the forklift body is poor, the body swings at an emergency stop, which is unsafe. Therefore, in the improved performance AGF, the components were arranged so that an optimal weight balance was secured and the traveling stability was improved. As a

result, even at an emergency stop, the swing of the forklift body can be reduced to the minimum and the maximum travel speed of 9.0 km/h (conventional model: 3.6 km/h) was achieved.

(2) Increased lift speed

A 1.5 ton-class hydraulic motor was adopted to the improved performance AGF with a rated load of 1 ton and a lift-up speed of 390 mm/sec (conventional model: 220 mm/sec) under loaded condition was achieved.

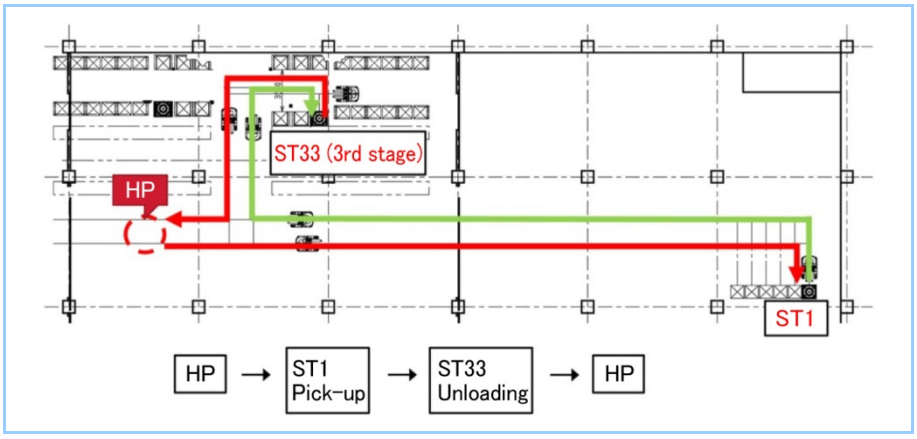


Figure 4 Cycle pattern

4. Improvement of safety

The conventional model had one obstacle detection sensor installed in each travelling direction, which only detected obstacles in the travelling direction. On the other hand, the improved performance AGF features obstacle detection sensors that can detect obstacles all around the body. The detection area is controlled depending on the running direction, speed and the turning angle of the tires, preventing obstacles from being caught when the forklift is turning (**Figure 5**).

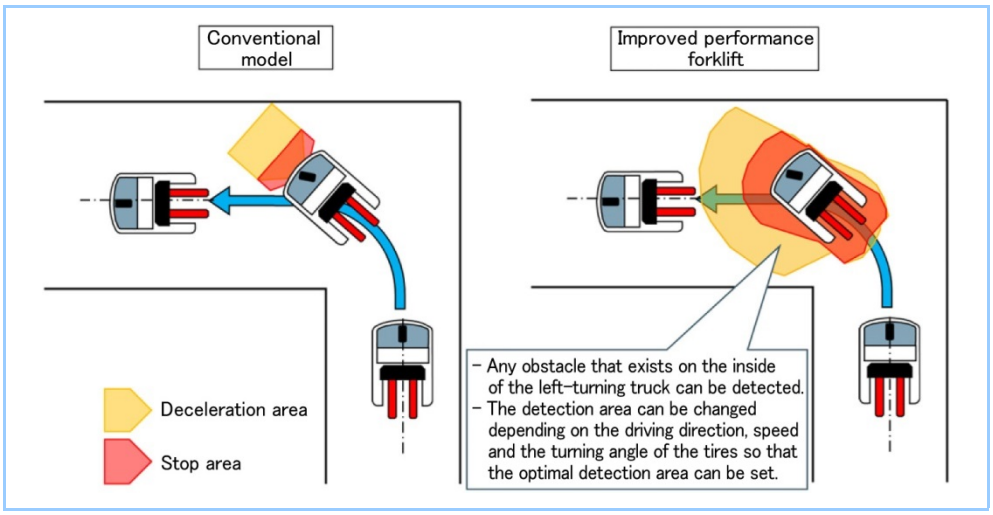


Figure 5 Comparison of obstacle detection areas

5. Conclusion

The AGF market is still very small compared to the manned forklift market. But the needs for unmanned operation and labor saving have been increasing every year and there is significant demand for a replacement. With the improved performance AGF introduced in this report as a stepping-stone, we will develop the market.