Airport Baggage Handling:

QUEUE CONVEYOR DESIGN FROM A GEARMOTOR PERSPECTIVE

Rintaro Takasu,
Sumitomo Machinery Corporation of America

Introduction

The events of 9/11 and other terrorist threats have caused governing bodies around the world to heighten air travel-related security. In the United States, every piece of baggage that is checked in at an airport is now required by the Aviation and Transportation Security Act to be inspected for prohibited and hazardous materials by an explosive detection system (EDS) machine or by an alternative method. EDS machines utilize X-ray technology to inspect and detect explosive materials in baggage. In many airports, the baggage is checked in at the airline's ticketing and check-in counter, and then travels via a conveyor system through the baggage hall for inspection and delivery to the appropriate aircraft.

Depending on the configuration of the airport's checked baggage inspection system, the EDS can be of the inline type—where the EDS machine is integrated into the conveyor system (Fig. 2); or the EDS machine can be of the standalone type—where the EDS machine is separate from the conveyor system. Typically, in larger airports with higher baggage throughput, inline EDS machines are used.

The queue conveyor is a relatively short conveyor that transfers the baggage that travels from the check-in counter via the conveyor system to the EDS machine. Because baggage is introduced to the handling process once a bag is checked in by the passenger at the airline check-in counter, the spacing of the bags is typically non-uniform. However, an EDS machine requires the bags to be fed uniformly and at a designated rate. Therefore, the primary function of the queue conveyor is to control the baggage flow into the EDS machine. In order to do so, the queue conveyor is required to start and stop with high frequency.

As EDS machine manufacturers develop faster and more accurate products, the primary driver of the queue conveyor must be able to operate under the increasingly demanding operating conditions of frequent starting and stopping. The selection of the primary driver of the queue conveyor is dependent on multiple criteria, including dimensional requirements and durability characteristics.

Common Queue Conveyor Design Specifications

The design specifications of queue conveyors vary amongst different conveyor system manufacturers; however, comparing several manufacturers' specifications reveals several common features, as listed in Table 1.

Conveyor Dimensions

Based on available specifications, the dimensions of the queue conveyors were listed as having lengths ranging from 36 to 136 inches (0.92 to 3.45 meters), and widths between the sidewalls of the conveyor ranging from 26 to 56 inches (0.66 to 1.42 meters). The pulley diameters of the queue conveyors vary amongst the different conveyor system manufacturers. Because each airport and conveyor system is different, the dimensions are listed as ranges.

Conveyor Belt Speed

The conveyor belt speed is varied amongst the manufactur-

Table 1. Common Specifications from 4 Airport Baggage Handling Queue Conveyor Manufacturers

Dimensions	Conveyor Length	Ranges from 36" to 136"
	Conveyor Width	Ranges from 26" to 56" between frames
	Pulley Diameter	Various
Speed	Belt Speed	Variable (Ranges from 90-350 fpm)
	VFD Control	Typically Available
Driver	Motor	Various (Ranges from 3/4 HP to 3 HP, 3-phase AC-Induction Motor)
	Speed Reducer Type	Various (Helical bevel, helical shaft mounted, motorized pulley, belt drive, etc.)

ers with a minimum listed speed of 90 feet per minute (0.46 meters per second) and a maximum listed speed of 350 feet per minute (1.78 meters per second). The determination of the belt speed of the conveyor depends on multiple factors that can be independent of each conveyor system. These factors include the maximum desired throughput of the EDS machine as well as the ability to handle the fluctuations in throughput for different levels of baggage traffic.

One method of providing this flexibility in conveyor belt speed is the variable frequency drive (VFD). The VFD is an electrical controller that manipulates the frequency of the electrical signal supplied to the electric motor, which can alter the rotational speed and other operations of the motor. This method of conveyor belt speed control is available as an option for many queue conveyors.

Primary Driver of the Queue Conveyor

The primary mover of the queue conveyors is typically a 3-phase AC induction motor in combination with a speed reduction component. The sizing and the load capacity requirements of the motor and the speed reducer are dependent on the configuration and operation of the specific conveyor system. The typical motor powers listed by the four manufacturers ranged from ¾ to 3 horsepower (0.55 to 2.2 kW).

The speed reducers specified by the surveyed manufacturers are of a geared speed reducer or a belt drive variety. Several possible configurations of the geared speed reducer include a shaft-mounted, right-angle type (hypoid, helical-bevel) and a shaft-mounted, parallel-shaft type (helical shaft-mounted, motorized pulley).

Dimensional constraints in the baggage hall—such as the available spacing between multiple conveyor lines—may restrict the sizing and configuration of the speed reducer and the motor. In such cases, a more compact design for the motor and the speed reducer becomes necessary. Two ways that this can be achieved are by:

1. Direct-mounting a hollow-shaft speed reducer to the conveyor pulley
2. Utilizing an integral gearmotor design or a motor that is direct-coupled to the speed reducer

Employing one or both of these design options aids in reducing the space required of the drive components and also minimizes the number of components in the design.

The performance specifications of the queue conveyor create challenges for both the speed reducer and the motor because of the frequent starting and stopping of the conveyor that is required in order to index the baggage appropriately for the EDS machine. Frequent starting and stopping is strenuous on the motor because the in-rush current at startup is typically six to ten times higher than the rated operational current. This leads to temperature rises in the motor that can push the limits of the thermal insulation.

The speed reducer is subject to greater fatigue wear due to the frequent starts and stops. Each time the speed reducer is started, it endures a shock load, which over multiple cycles can lead to fatigue wear and eventual failure. Therefore, the durability of the speed reducer is of great importance in terms of selection criteria.

Sumitomo Drive Technologies Hyponic Gearmotor

Sumitomo Drive Technologies' Hyponic gearmotor is a hollow-shaft mounted, right-angle gearmotor that employs a hypoid gear design to provide a compact and durable solution to drive the queue conveyor.

The hypoid gear set design places the driving pinion at a right angle to the driven hypoid gear, but differs from a worm gear set or a straight bevel gear set in that the pinion contacts the driving gear at a position that is in between the tangential contact of the worm gear set and the isoplanar axes of the straight

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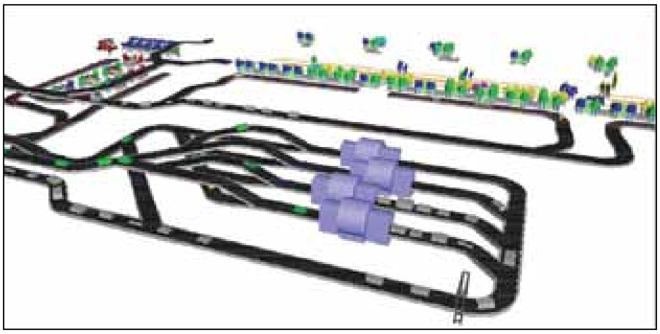

Figure 1—Schematic visualization of a medium-volume inline system (Ref. 9).

Figure 2—Inline EDS and queue conveyor (Ref. 10).

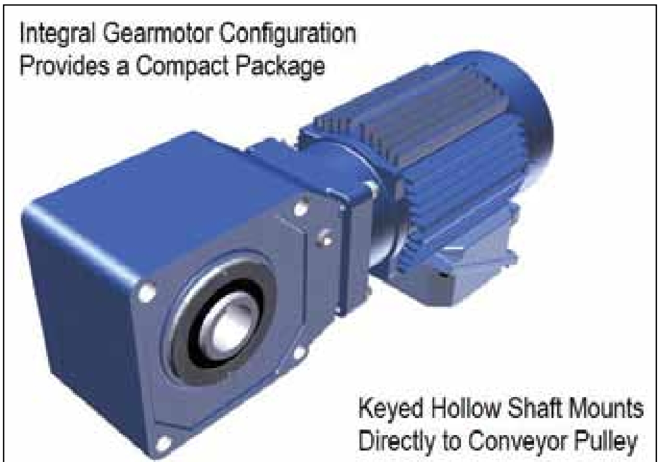

Figure 3—Sumitomo Drive Technologies' Hyponic integral gearmotor.

bevel gear set (Fig. 4).

The positioning of the hypoid pinion allows for a larger tooth contact surface between the pinion and the driven gear than a straight bevel gear set. This larger tooth contact surface area allows for smoother, quieter operation. The offset positioning of the hypoid gear set is also theoretically more efficient than a worm gear set because there is less transmission loss due to the sliding that occurs between the pinion and the driven gear.

The Hyponic gearmotor is supplied with a keyed hollow-shaft output that allows the unit to be installed directly on the pulley shaft of the conveyor, and an integral motor that is assembled directly to the speed reducer section, thereby providing a compact package.

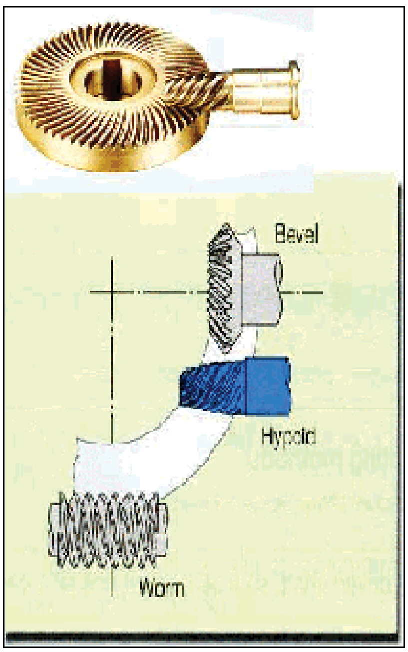

Figure 4—Pinion position: hypoid vs. worm vs. bevel.

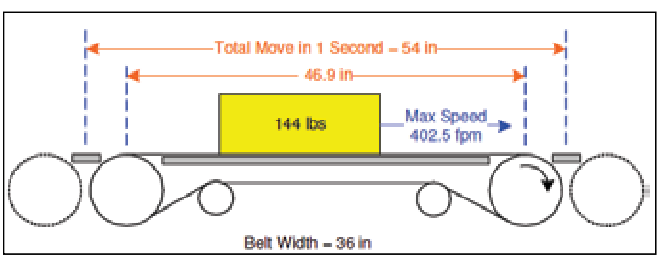

Figure 5—Simulated conveyor (Ref. 2).

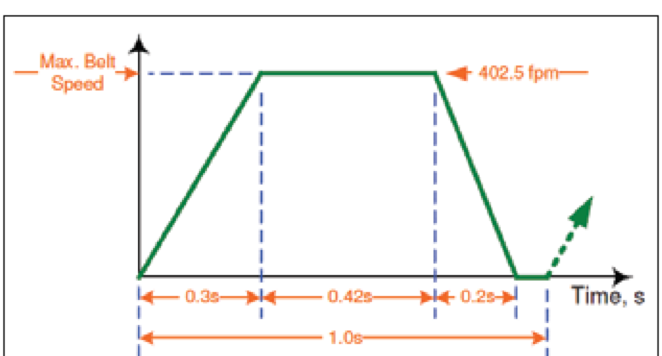

Figure 6—Simulated conveyor speed profile (Ref. 2).

The durability of the Hyponic gearmotor as it applies to the queue conveyor application was studied by Sumitomo in the research paper "Applying Hypoidal Gearmotors in High-Cycling Queue Conveyors" (Ref. 2). In the study, a Hyponic gearmotor was driven by a VFD and programmed to simulate maximum-capacity operation of a queue conveyor. To simulate the load conditions, a separate gearmotor was coupled to the output of the Hyponic gearmotor and driven backward. The initial objective of the study was to observe the gear surface wear characteristics and other effects to the Hyponic gearmotor as it was subjected to 2,500,000 start/stop cycles.

The simulation configurations and conditions consisted of the following:

- ***Hyponic model: RNYM2-1520YA-AV-10***
    - Integral Motor: 2 hp, 4 Pole, 3-phase, 1,750 rpm, Class H Insulation
- ***Simulated conveyor dimensions:***
    - Belt width: 36 in.
    - Distance between the centerlines of the pulleys: 46.9 in.
    - Total displacement of the queue conveyor: 54 in.
    - Pulley diameter: 6.75 in. (6 in. diameter + 0.325 in. lagging)
- ***Simulated load:***
    - 144 lbs.
- ***Simulated conveyor speed profile:***
    - Cycling Rate: 1 cycle per second
- ***Number of cycles:***
    - 2,500,000
    - To failure

The testing of the unit resulted in minimal gear surface wear and no motor failure after 2,500,000 cycles. The minimal wear consisted of "a polished appearance where the teeth made contact" (Fig. 7 and Ref. 2).

The unit was reassembled and placed back in the simulation until after 14,500,000 cycles— when the thermostat installed in the motor tripped and the simulation was concluded. The inspection of the unit that followed revealed initial signs of pitting on the hypoid pinion, while general appearances suggested that the gear teeth could continue to handle many more millions of cycles (Fig. 8 and Ref. 2).

Conclusion

As EDS machines continue to improve in terms of increased baggage throughput and accuracy, the primary mover of the queue conveyor is subject to greater demands in design and durability performance. Sumitomo Drive Technologies conducted a series of tests on its Hyponic product to simulate continued high-cycling, maximum-capacity loading. After 14,500,000 cycles, limited wear was found on the gears (Ref. 2). The combination of a compact, shaft-mounted, right-angle integral gearmotor design and its proven durability characteristics suggests that Sumitomo's Hyponic product line is a suitable selection as the primary driver of airport baggage handling queue conveyors.

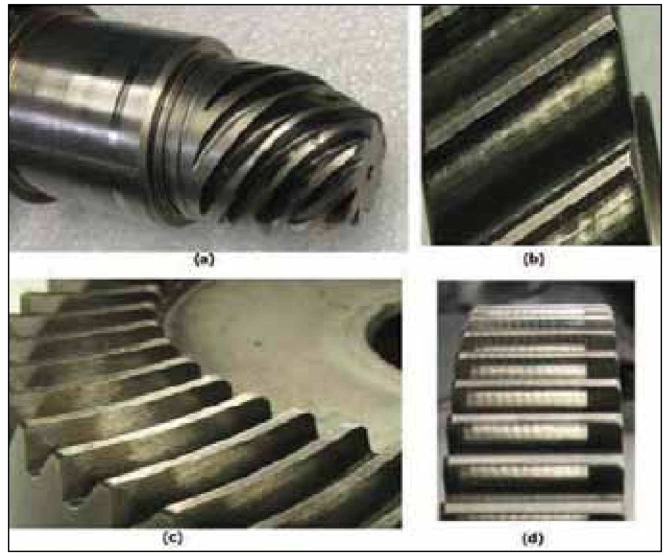

Figure 7—Hyponic gear components after 2.5 million cycles: a) hypoid pinion; b) spur gear; c) hypoid gear; d) spur gear pinion (Ref. 2).

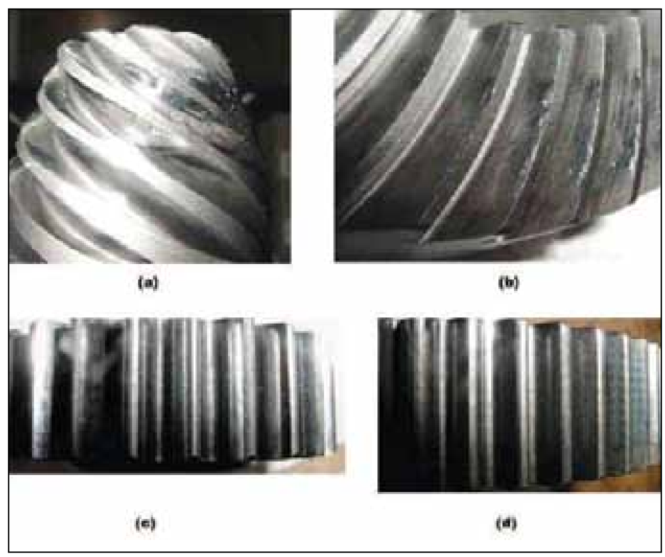

Figure 8—Hyponic gear components after 14.5 million cycles: a) hypoid pinion; b) hypoid gear; c) spur gear pinion; d) spur gear (Ref. 2).

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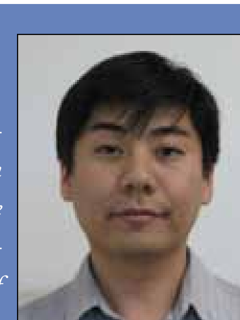

Rintaro Takasu *is an applications engineer for Sumitomo Machinery Corporation of America. He has held this position since 2007, upon graduating with a B.S. in mechanical engineering from the University of California, Berkeley.*