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Flexibility in Fastener Feeding

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ABSTRACT

This paper details the Electroimpact Cartridge Feed Auto Select (CFAS) System, the Electroimpact Cartridge Filling Station (CFS) and the implementation of these systems on today's factory floors.

Problems inherent in handling tens of thousands of fasteners per workpiece have traditionally been an Achilles Heel to many aerospace-manufacturing cells. The CFAS system moves the job of sorting through bulk fasteners to the stand alone offline CFS. With the bulk feeding process offline, problems such as contaminated fastener lots get taken care of before they ever get to a fastening machine. Modular briefcase sized coiled tube magazines store and distribute fasteners to automated riveting and bolting equipment via the CFAS rack. Cartridges captively hold 500 to 3,000 fasteners from 1/8" to 3/8" diameters and are length independent which allow a small number of cartridges to work with a large array of overall fasteners. Nearby storage of preloaded cartridges allow machine operators to quickly change out empty cartridges with full ones. Preloading of the fastener cartridge is done with a turnkey CFS. The standalone CFS uses vibratory bowls, grip-independent tooling, quick fastener change out features and feedback from counters and sensors to turn itself off upon each completed cartridge fill.

Design factors and criteria will cover the driving issues behind cartridge filling, fastener storage, fastener delivery, orienting fasteners, reconfiguring the system, integration to current machines and the ability to be integrated with most automated riveting or bolting equipment.

INTRODUCTION

WHY A CARTRIDGE FEED SYSTEM?

Two separate philosophies prevail on how to automate fasteners before panel insertion in the aerospace fastening arena. One philosophy uses bowl feeders or hoppers to supply machines with fasteners, the other uses preloaded removable cartridges as a fastener source. Bulk feed systems have traditionally fed most automated assembly cells but an increase to eliminate feed errors has lead to the implementation of cartridge feed systems.

Bulk feed systems such as vibratory bowls and hoppers offer an inexpensive and convenient method of allowing operators a quick way to supply a riveting machine with fasteners. A downside to bulk feeding is the complexity of the task at hand. Bulk feed systems require complicated tooling to orient fasteners online just before feeding them to a machine tool. Large fastener lots that supply hoppers and bowl feeders are always subject to contaminates such as wrong size fasteners and foreign object debris (FOD.) Contaminates can easily jam bulk feed systems, creating downtime for expensive assembly cells. With cartridge feed systems bulk feed problems still exist but they can be handled away from an assembly cell, eliminating machine down time.

Cartridge feed systems use preloaded cartridges to temporarily hold and distribute pre-oriented fasteners to automated assembly cells. Cartridge systems have a distinct advantage over their bulk feed counterparts in that if a cartridge is contaminated or empty it can quickly be changed out with a new one, minimizing machine down time. The slim-line modular construction of cartridges offers greater online fastener density over the more cumbersome bowl feeders and hoppers. Bulk feed systems are still needed to fill fastener cartridges, but as long as the offline fill rate exceeds the online machine fastening rate machine downtime can be minimized.

MAIN SECTION

SYSTEM DESIGN

The 3rd generation CFAS system feeds slug rivets, lockbolts, index head rivets, button head rivets and cylindrical collars. The CFAS system breaks down to three main components: cartridges which store the fasteners, the CFAS Rack which empties the cartridges and the CFS which fills the cartridges away from the end use riveting machine.

Cartridges

Description:

Coiled tubing cartridges (Figure 1) hold many types of fasteners in an end-to-end configuration. Fill capacities range from five hundred to three thousand fasteners depending on style, diameter and grip length. Cartridges come in three sizes and all are 95 mm (3.75 inches) wide. Common widths allow any cartridge to be mounted in any slot on a host Cartridge Feed Auto-Select "CFAS" rack. Unique to each cartridge are specific diametrically controlled entrance blocks, escapements and of course the tubing which provides captive storage for pre-oriented fasteners. Cartridge feed path visibility is maintained by using a lightweight aluminum frame to support clear polycarbonate covers and translucent plastic tubing.

Figure 1. A fastener cartridge (406 x 406 x 96 mm)

Operation:

As modular, portable, self-dispensing fastener storage units, cartridges are intended for supplying fasteners to automatic assembly cells. Filling cartridges can be done manually away from the riveting machine or by a turnkey CFS. Once cartridges are filled they are usually staged on or near an assembly machine for easy access. Cartridges manually snap into CFAS machine racks by hand. Each cartridge feeds a fastening cell until sensors determine the unit is empty. Most factory operations utilize spare preloaded cartridges so that change out times are kept to a minimum. Passive entrance and exit path tooling assure that fasteners remain captive within a cartridge until the machine actuates the release mechanism.

The cartridge escapement (Figure 2) located at the downstream end of a cartridge regulates the flow of fasteners to a host machine. Three unique escapement designs have been developed to handle bolts, rivets and collars. Each escapement is diameter specific but length independent such that each one can usually handle over 32 different fastener grips up to two inches in total length. Similar mounting styles, exit paths, and actuation centerlines enable all escapements to be located in the same position within each cartridge. All escapements have one moving part, passive devices that function with or without pressure to the upstream feed line. During machine operation escapements are actuated with pneumatic cylinders, but can also be operated by hand for a quick functionality check.

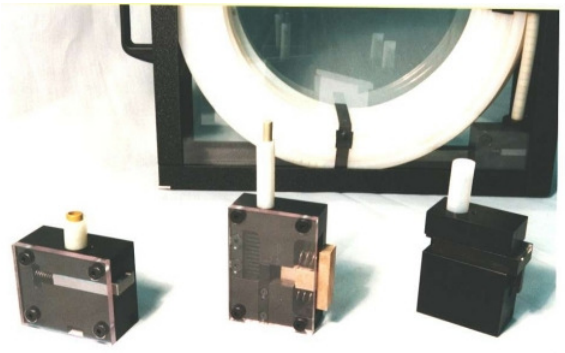

Figure 2. Collar, rivet and bolt escpapements

Flexibility:

Grip-independent cartridges give fastening cells great flexibility to change allocations between grip lengths at no added cost for modification. Modular frames also give cartridges versatility. Using a small family of cartridge frames provides a platform that can support a host of different fastener types by only replacing the diameter specific tooling in each unit.

The CFAS Rack

Description:

All cartridges plug into the CFAS rack located on or near a tube fed riveting or bolting machine. The CFAS rack is a standalone unit that connects to a riveting machine via a power cable, a communication cable, an air supply line and diameter specific fastener feed tubes. Features of each CFAS rack include cartridge bases, collectors,

pneumatic valves, inductive ring sensors, a tubular frame and a programmable logic controller (PLC) to communicate with the host fastening machine. Four-inch (0.1 M) spacing in a two row array provides ergonomic rack access to the cartridges at any time. Below the CFAS rack are diameter specific fastener collectors that receive multiple incoming feed tubes, which lead to one outgoing feed tube. Each collector has pneumatically charged flippers that open during the escapement sequence to provide a single path to the end of the collector.

Figure 3. A 60 Slot CFAS rack with PLC control

CFAS racks come in sizes from 2 to 72 slots wide and stand approximately six feet tall. All cartridges quickly snap into any feed slot within a feed base. Unique to each slot is a connected fastener manifold system containing feed tubes and a fastener collector. The collector is a sandwich of urethane, UHMW and polycarbonate sheets, which form a series of feed paths that all dispense into one outgoing feed line. The use of plastics and titanium flippers reduce wear to both the high speed fasteners and the collector itself.

Air is used to propel fasteners through the CFAS system. Each CFAS rack has two valves per cartridge slot plus two additional valves per collector.

Operation:

As a supply center to the host-fastening machine the CFAS rack determines which fasteners needs to be fed from what slot. Using a 16-bit communication code the online rack determines where a cartridge is located, when to feed the fastener and when to stop the feed cycle.

Ejecting fasteners into the system is done when the escapement is actuated and a pulse of air is sent into the cartridge, a resulting differential pressure pulls the fastener through the downstream collector. A sensor on the downstream end of each collector signals the system to open an additional blast line that propels the fastener upwards of 30 meters per second to the machine tool. Direct feed paths coupled with sensor driven blast valves yield fastener delivery times better than 1 second on systems that are located within 80 feet of the tool point. Diametrically controlled feed paths also assure correct fastener orientation at the machine tool point as well.

During machine operation inductive sensors detect empty cartridges. Replacing empty cartridges is done manually by the operator. A quick one step insertion process both seals the pneumatic blast line and latches the cartridge to the machine. Changing cartridges takes approximately ten seconds.

The CFAS rack design eliminates mechanical enclosures and utilizes line of sight collector spacing to allow frontal access to all parts of the system for ease of maintenance. As with the entire feed system, translucent feed tubing and transparent covers enable operators to quickly locate fasteners at any time.

Figure 4. Fastener feed collectors

Flexibility:

The CFAS rack is very flexible. Modular bases allow any cartridge to plug into any slot on a machine. Positioning of diameter specific collectors ensure that each manifold system can quickly be plumbed to a number of different slots. Reconfiguring an entire system can be done swiftly and only requires diameter specific tube fittings.

As an automated fastener distribution center the CFAS is designed for floor or wall mounting, which allows it to adapt to most tube-fed fastening machines with just four overall connections.

All CFAS systems are drop tube compatible such that fasteners can be manually fed by hand. Adding drop tubes to a cartridge system gives the operators the convenience of quickly feeding fasteners not supported by the attached feed system.

The Offline CFS

Figure 5. A five bowl CFS for 10 fastener types, 72 fasteners in total

Description:

Cartridges are automatically filled with fasteners using a bowl feeder driven CFS (Figure 5.) As a plug-in unit the CFS is an automated workbench that contains one or more substations, each designed to fill an array of fastener diameters and lengths. Filling substations (Figure 6) consist of a variable speed vibratory feeder base, specially tooled bowls, pneumatic blast valves, feed tubes, inductive fastener sensors, purge tooling and a sensor driven cartridge base. Each bench can hold up to three sub-filling stations, but only needs one common programmable logic controller.

System control over each bench is done via a bus style serial connection that drives all the low voltage inputs and outputs through modular nodal centers. Each nodal center is capable of handling 128 input/output points and multiple nodes can be linked in series for system expansion. The CFAS requires 120-volt power and standard shop air for operation.

Operation:

Each cartridge feed substation checks the system for initial FOD, fills cartridges with fasteners, determines when a cartridge is full and turns itself off. During a filling sequence the CFS uses feedback from sensors and internal counters to cycle bowl power, actuate escapements and turn on blast valves in series until the cartridges are successfully filled.

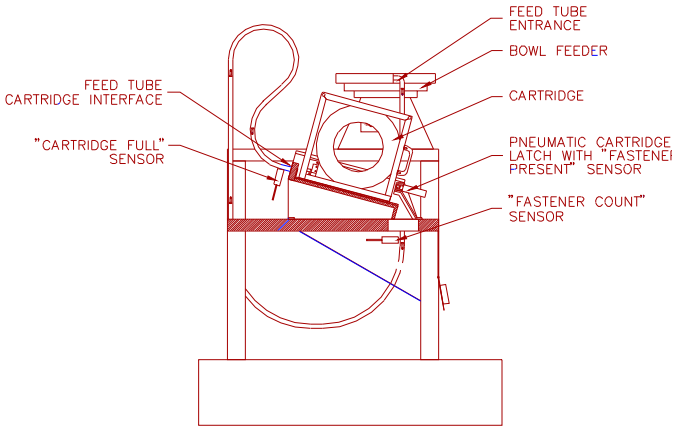

Figure 6. Filling Station Layout

An operator starts the filling sequence by inserting the cartridge into a sensor driven feed base and placing a batch of fasteners into the bowl feeder. A cartridge detector turns on the bowl feeder, which sorts, orients and vibrates fasteners into a common feed path. Two different methods of getting fasteners into a tube exist. Cylindrical fasteners, (slug rivets and collars) are vibrated one by one until they literally fall down a tubular passage. Headed fasteners, (bolts and pins) are hung inside of the bowl and escaped one by one into a vertically standing tube where they are then blown into a cartridge at intermittent intervals.

The CFS requires one part time operator to start each filling cycle. Noting that thousands of cartridges go through one CFS, system ergonomics became a design criteria. The design includes quick release escapements, internal shut down timers, one meter high work surfaces and automatic purge.

As with any bulk feed system, lingering fasteners from previous filling cycles are always a concern for contaminating the next fastener lot. Any fasteners that remain in a loading station after a filling cycle is over are treated as FOD for the next filling cycle. With the touch of a button a purge routine empties the substation of unused fasteners into a removable tray located beneath the CFS table. The following features help reduce machine down time due to FOD: slotted feed paths weed out smaller fasteners, proving rings weed out larger fasteners, gravity assisted feed tubes are self clearing and a FOD detector looks for contaminates at the starting of each filling cycle.

From time to time cartridges may need to be emptied so each CFS comes with a manual purge station (Figure 7).

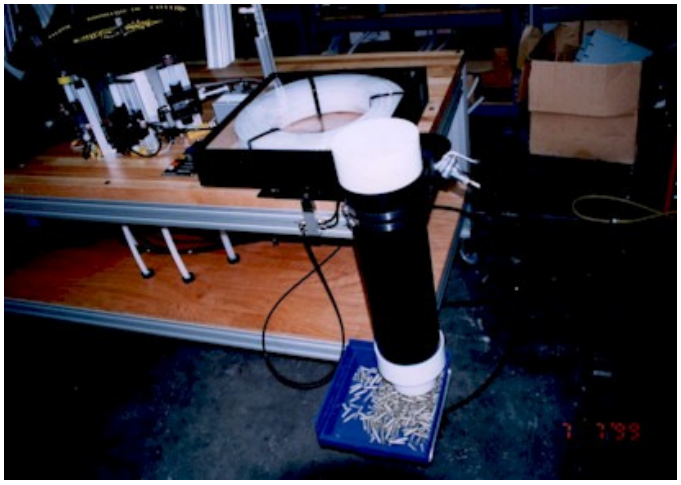

Figure 7. Manual cartridge purge station

Flexibility:

Robustness in feed system design drives the need for cartridge feed systems. These cartridge systems require filling stations for automatic operation. CFS fill rates are many times faster than assembly cell fastening rates. The excess filling rate of a CFS system makes it ideal for being a pull type fastener supply center for many assembly cells that previously could not afford to invest in both a cartridge system and filling station.

As a standalone turnkey unit the CFS sits on casters enabling one operator the ability to quickly move around in changing production environments which to also adds to the system flexibility.

CONCLUSION

Attaching a bulk feed system to an assembly machine can compromise system performance. Today's "Just In Time" manufacturing techniques require extremely robust fastener delivery systems be attached to each assembly cell. Bulk feed breakdowns are currently being eliminated by cartridge based feed systems. Cartridge feed systems offer safe media for fasteners as soon as they come into a plant as well as the flexibility to meet the demands of an ever changing production environment.

CONTACT

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

CFAS:
Cartridge Feed Auto-Select

CFS:
Cartridge Filling Station

Online:
Directly attached to an assembly or riveting machine.

Offline:
Located away from the assembly machine, in some cases in different buildings.

PLC:
Programmable Logic Controller

UHMW:
Ultra-High Molecular Weight Polyethylene