

Utilizing an In-Process Automatic Tool Change for Drilling and Reaming Large Diameter Holes

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ABSTRACT

A drill/ream cycle is necessary to produce high quality, large diameter holes in carbon-titanium stacks. Manual tool changes and traditional automatic tool changers limit hole-to-hole cycle times and hole quality. An in-process tool changer, mounted directly on the machine head, replaces a cutting tool with a reaming tool while clamp-up is maintained on the aircraft panel. By reducing or eliminating operator intervention, machine-axis moves, and optical resynchronization, an in-process automatic tool changer shortens cycle time, improves hole quality, and increases positional accuracy of holes. Automating this process also reduces risk of harm to the operator and aircraft structure.

INTRODUCTION

Automatic tool changers (ATC) are not new to the aerospace manufacturing community. They offer an automated process that has replaced manual tool changes in drilling machines. Although tool change automation provides faster cycle times, a traditional, floor-mounted ATC has significant limitations. An in-process automatic tool swapper (ATS) was developed for a next-generation post drilling machine operating on a CFRP/metallic outer wing box.

Traditional ATC's require that the machine unclamp from the work surface to make a tool change. This has several negative side effects to the overall drill/ream cycle. The machine axis moves associated with a traditional tool change increase cycle time. The loss of position on the panel requires resynchronization which decreases positional accuracy and repeatability of the machine head. Additionally, loss of position requires greater undersizing during the drill shot process, subsequently lengthening the reaming shot process and decreasing the accuracy and quality of the finished hole.

Today's aircraft designs require hole quality specifications which are hard to achieve. The drill/ream cycle times required to produce holes within specification are slow. Customer requirements for the lean technology drilling (LTD) machine dictated that no machine operator enter the drilling area while clamped on the aircraft panel. This requirement, along with the desired hole quality in CFRP/metallic stacks, led to the development of an in-process automatic tool changer. This paper describes the design, function, and benefits of an in-process tool change during a drill/ream cycle.

SYSTEM OVERVIEW

The LTD's automatic tool swapper replaces a cutting tool with a reaming tool. The ATS differs from a traditional automatic tool changer in that it provides space for only two tools. By limiting the number of stored tools, the ATS is able to remain compact and lightweight compared to a traditional ATC.

A major difference between the LTD ATS and a traditional ATC is that the ATS is able to perform tool change while machine clamp-up is maintained on the aircraft panel. The ATS is mounted on the clamp table to make use of the shuttle table axis (W_E) and spindle axis (W_S), thereby reducing the stroke necessary for the ATS to reach the drill spindle. Utilizing W_E and W_S minimizes the complexity and cost of the ATS. Hard indexing features are used to align the grippers in plane with the spindle centerline, eliminating the need for positional feedback and/or servo controlled axes.

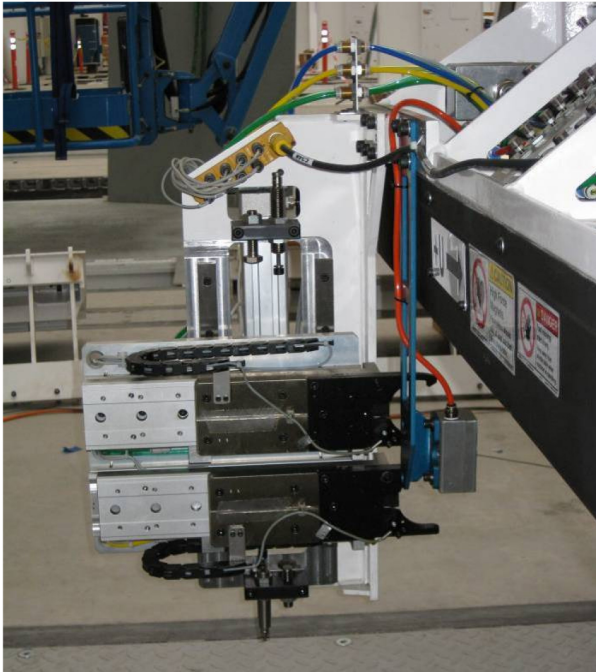


Figure 1. LTD automatic tool swapper is shown with taper blow off.

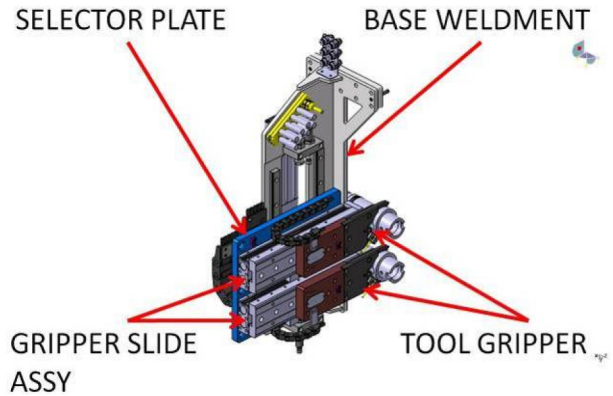


Figure 3. ATS components

Two gripper slide assemblies, mounted on the selector plate, include an air table and a single finger tool gripper. The tool gripper passively holds a 2.4 kg tool holder in place. Approximately 70 N, or over 20 g's acceleration, are required to pull the tool from the gripper.

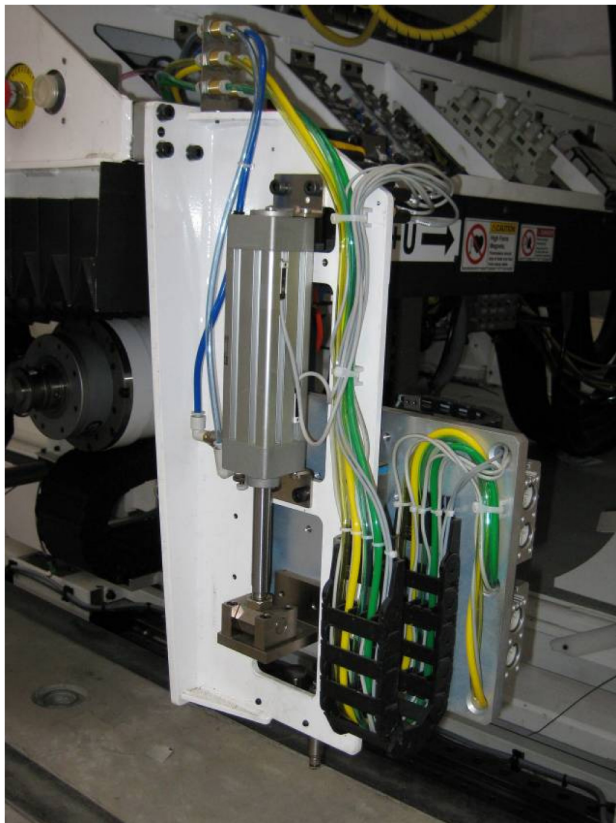


Figure 2. A two position air cylinder actuates to select gripper position.

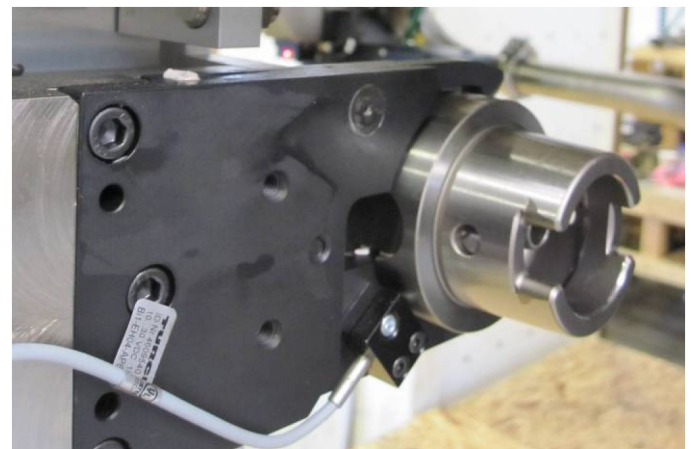


Figure 4. Single finger tool gripper shown with HSK 63A tool holder and proximity sensor.

TECHNICAL BENEFITS

The largest benefit the ATS provides is reduced hole-to-hole cycle time. This cycle time reduction results from the elimination of many machine axis moves traditionally associated with a manual tool change [1]. The ATS allows the LTD to remain clamped on the aircraft panel, which negates the need for any major machine axis moves. From drill to ream, the ATS offers a tool change that takes less than 20 seconds. For comparison, a manual tool change would take 360 seconds. The ATS saves over 5 minutes of cycle time over a manual tool change.

To safely enter the drilling zone during a manual tool change, the CNC must command a feed hold that pauses the drilling