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Implementation of new techniques for the remote delivery of tooling and components at JET torus

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ABSTRACT

For the JET Enhanced Performance (EP2) shutdown a second articulated boom has been developed. Support technologies have been developed to provide an efficient system for tools, services and components to the remote environment. This paper will discuss the challenges involved in the design and compatibility for remote docking of support cradles. These cradles are used to support equipment including:

– Six task modules with a capacity of 400 kg each.
– Sixteen sub-frames used to transport components up to 80 kg each.
– Multipurpose tray carriers to transport a large variety of equipment and components.
– Specialist equipment for transporting interfacing components.

In situations where people are required to manually load and unload these cradles this paper will discuss the systems implemented to aid:

– Contamination control between the JET vessel and the adjacent man access areas while the articulated boom is in use.
– Service feeds for in vessel work (power and data supplies).

There will also be examples of real data and design changes required as a result of the operational tests.

This paper will discuss how these developments have increased the efficiency of the remote handling work with an increased protection for the personnel working in the controlled area.

1. Introduction

EP2 produces significant additional challenges to the remote handling capability. The additional tasks that need to take place require a set of supporting structure, cradles/stillages and service feeds to assist the in-vessel operations. Due to the nature of the in-vessel work the tasks are time critical. Great emphasis is put on the efficiency and function of the equipment. The tasks to be carried out in EP2 are varied and require a large number of bespoke tools which are deployed and used by the two articulated booms (Oct 1 and Oct 5 booms) [1]. The Oct 1 boom can be fitted with various interchangeable end-effectors (EE) and the Oct 5 boom is fitted with a two armed (Mascot) manipulator. The Oct 1 has two remote methods of latching onto the EE described below. The task module and roll end effector are latched through the vertical traverse system (VTS) which engaged two mushroom dowels onto the EE interface plate. The subframe and tine are mounted to the boom by first mounting the roll end effector and then, through a pneumatic actuator, interface the subframe or tine. To successfully engage this feature ±1 mm of accuracy or compliance is required. For the increased productivity required by the EP2 shutdown, exchange of EEs has been designed to be fully remote.

An additional requirement was to limit the exposure (radiation & beryllium) of personnel during re-loading of components and tooling trays. To minimize this steps have been taken to limit the flow of contamination into that areas accessed by people.

2. Cradles for end effectors

Described below are the four main types of EE used on a regular basis that need supporting.

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[1] See the Appendix of F. Romanelli et al., Proceedings of the 22nd IAEA Fusion Energy Conference 2008, Geneva, Switzerland.

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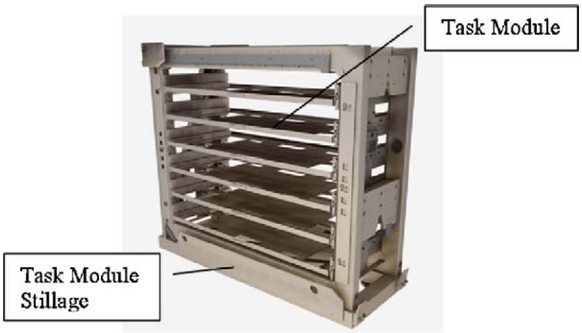

Fig. 1. Task module parked on the stillage.

2.1. Task module

There are six task modules which are used to transport components and tooling to and from the vessel. Each task module has six drawers and has a capability of carrying up to 100 kg per drawer with a maximum of 400 kg per task module. The task module is held in a stillage that allows the Oct 1 boom to pick and place it remotely (Fig. 1).

The task modules are positioned in echelon (within the ISO container) to allow the boom to access the lifting interface at one end. The final positioning is guided by angled location tabs. The engagement method is designed to accommodate boom positioning repeatability errors of 20 mm (max).

2.2. Subframe end effector stillages

The subframes (Fig. 2) are used to carry heavier individual tooling and components into the vessel with up to sixteen used on a frequent basis. The docking of these subframes is difficult to judge with the use of the boom cameras alone, so a limit switch system was developed to accurately relay to the operator that the subframe has docked correctly (Fig. 3).

Each subframe stillages has two park locations on it. There are a total of sixteen locations in the rack of stillages. Each location captures the subframe and pushes it into a known position so the boom can dock successfully to it.

The centering of the subframe is done through two dowels locating in 'V' slots. The location of the subframe is monitored by vertical and horizontal switches. These switches activate two LEDs visible by the boom cameras to indicate when the subframe has docked correctly. The horizontal switches also ensure the subframe returns to a known datum in the 'V' slots. To ensure the subframe slides across the stillages with minimal friction there are a series of housed ball bearings that the subframe runs on (Fig. 3). Once the subframe is docked and the boom unlatches and moves clear, the subframe moves back to the datum position and the switches are remotely tuned off by mechanical means to save the battery life.

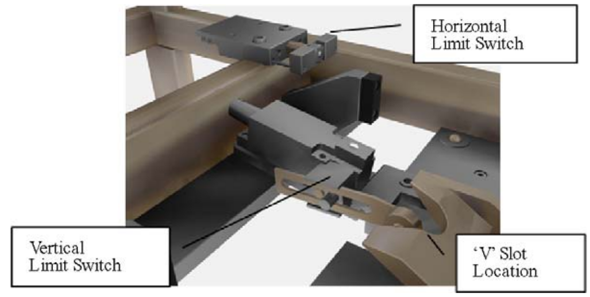

Fig. 3. Subframe stillage location and switching.

2.3. Gas box tine stillage

The tine is a load bearing end-effector with a remote latching mechanism for carrying specific components such as Divertor tile carriers or a range of multi-purpose trays and boxes into the vessel. This tine also needs to be stored when not in use. The tine stillage is used for this job and enables the operator's access to the tine when needed.

The tine stillage is designed to aid the operator of the boom with the docking and undocking of the tine onto the stillage. This is achieved by vertical and horizontal switches located at the rear of the stillage. The tine is set at 10° so when it is lowered into the stillage, gravity ensures that the tine is located against a datum. The tine enters the stillage at a known height and contacts that horizontal switch and the LED lights (Fig. 4). At this position the tine is lowered until the second limit switch is activated and the corresponding LED lights. At this point the tine is 1–2 mm from the surface of the stillage and the tine can be unlatched safely into the stillage. When the boom is unlatched and reversed away from the tine the horizontal switch forces the tine up against a hard stop to return the tine to a known forward position. In moving to the known datum the LEDs are automatically deactivated to save battery life.

2.4. Roll end effector park

The Roll end effector (REE) is used as an interface between the Octant one boom and a subframe or tine. The REE is used to roll the subframe or tine to the desired angle to enable larger bulky items to fit through the restricted access port into the vessel. The REE needs to be picked and placed remotely at regular intervals onto a parking position when not in use.

The REE has a pneumatically actuated interface that forces ball bearings to engage onto a corresponding locking ring. If the pressure is lost, the REE will remain locked. The park position utilizes a

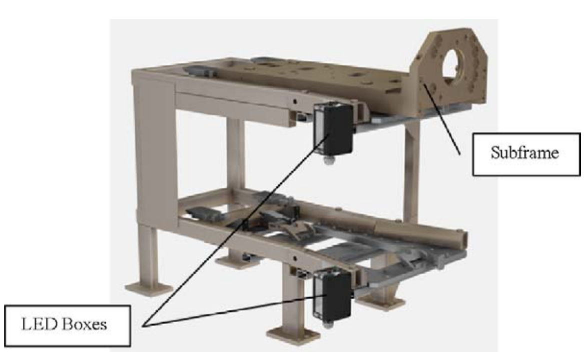

Fig. 2. Subframe stillage with subframe parked on upper location.

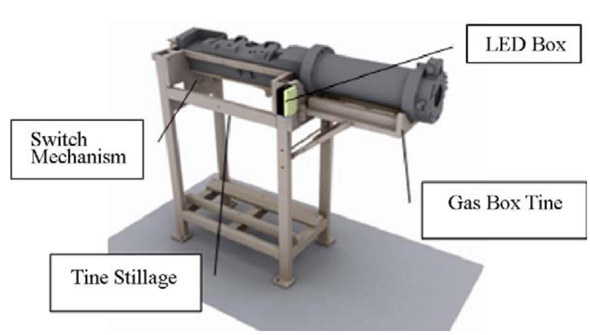

Fig. 4. Gas box tine mounted onto stillage.