Technical Paper

Development of K100 Quick Boom Change System

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The challenge was to develop a new/unique and unrivalled Ultra Quick Boom Change system for the Komatsu PC490HRD-11 High Reach Demolition machine following customer requests from market surveys in major European territories. Komatsu UK is a leading manufacturer & retailer of High Reach Demolition Excavators used for demolition of high-rise buildings and structures. Conventionally this type of machine has interchangeable work equipment configurations which can change the machine's basic function from extended high reach, high reach, medium reach and finally digging equipment for material processing and/or general earth moving. Each machine configuration can be achieved in 2~4hrs depending on customer site conditions and experience. Whilst this is generally accepted as the industry standard, our customer surveys highlighted the need for a quicker and more simple method of changing over the work equipment and this sparked the decision to develop a new ultra quick boom change system; this paper reports on the detail of the development.

Key Words: *Demolition, Boom change system, High reach demolition*

1. Introduction

High Reach Demolition (HRD) machines in Europe typically have interchangeable work equipment, allowing work equipment configuration to be changed or removed to suite the application or transportation of the machine. A conventional interchangeable work equipment features a mechanical connection and multiple hydraulic and electrical connections, both requiring manual disconnection/connection, typically from a raised platform. Whilst the Komatsu conventional quick change system makes the changeover process very simple, utilising specially developed high flow hydraulic connectors, grouped low pressure connections and purpose built work equipment support stands, incorporating working platforms. A conventional system has several points that demand special care and can be improved.

(1) Safety
- Working at height has inherent risks due to slipping and falling from height, tools/equipment being dropped and requirement for operatives to use access systems correctly to ensure safety.
- Operatives must manually connect/disconnect hydraulic and electrical connections, contact with oil or accidents when using hand tools are inherent risks.
- Operators sometimes use the incorrect work equipment configuration for the application due to the time and additional personnel needed to carry out the changeover operation.

(2) Changeover time
- Multiple connections and requirement for connecting work equipment to be positioned very accurately to achieve connection demands a minimum of 2 operatives for the process and a typical changeover process takes 2~4 hours, depending on site conditions and experience.

(3) Transportation
- Cumbersome work equipment stands and platforms are required to ensure compliance with ISO14122 which can make transportation of work equipment sub-assemblies difficult in certain circumstances demanding additional disassembly/trucks to facilitate transportation to jobsite.

Fig. 1 Conventional change system process

Fig. 2 Conventional system joint detail

Whilst the conventional change system continues to be acceptable to some customers, customer surveys carried out in 2016 identified that some customers now demanded a safer, faster more efficient work equipment change system. Therefore, EUTC1 began developing the K100 quick boom change system for production at Komatsu UK Ltd.

2. Development objectives

(1) To Increase Machine Versatility

- Change work equipment in <5mins by operator only and without the operator leaving the operator cab
- Improve machine working efficiency. Making changeover simple, quick & easy means the operator is more likely to choose the correct equipment for the job which improves machine component durability / life.

(2) To Improve Transportation

- Faster & easier to break machine down into smaller transportable units
- Ability to load w/equip. more quickly & easily by simplified work equipment stands

(3) To Improve Safety

- No tools required for changeover
- No working at height required
- No human contact with hydraulic oil

3. Basic concept - Operator can connect/disconnect work equipment from Op. cab by themself

- Maintain existing work equipment configurations and machine performance.
- Automated hydraulic and electric connections using banked connections and Lehnhoff valve and connection components.
- Expansion of Working Range Indicator system to provide system functions and simple user interface.
- Simple workstand with integrated latch system to secure work equipment for transportation.

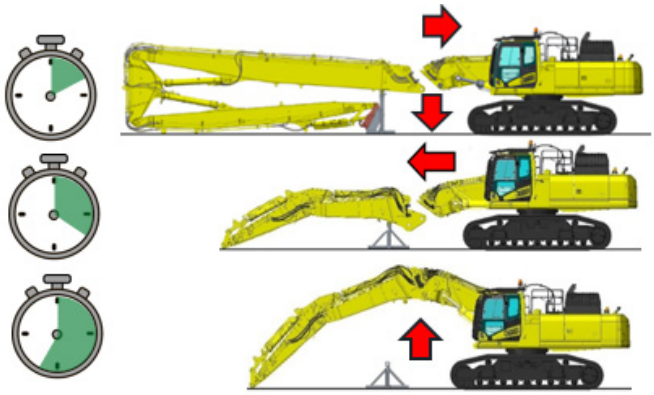

Fig. 3 K100 basic concept

4. Key design features

4.1 Summary of radial connection method

At concept stage a number of methods of achieving mechanical, hydraulic and electrical connection were evaluated, the concept evaluation process determined that radial connection, where the connections are made as the work equipment main structures connect was the most suitable allowing:

- Utilisation of existing proven conventional work equipment fabrication design.
- Adoption of Komatsu Group company Lehnhoff Hart Stahl GmbH hydraulic valve and electrical quick coupler connection technology.
- Ability to maintain 2 position digging boom configuration.
- Suitable for existing KUK manufacturing methods & production facilities.

4.1.1 Key components K100 radial connection

(1) Base boom U-Bracket – forms the initial connection with the mating work equipment radial pivot pin.

(2) Mating work equipment pick-up pin – connects with the U-Bracket of the base boom to form the top mechanical connection.

(3) Hydraulic connection pin – creates the mechanical connection between base boom and mating work equipment.

(4) Hydraulic and electrical connections are mounted on the side of the work equipment, connection is made as the work equipment pivots around the U-bracket axis. Full connection is made once the hydraulic connection pin is aligned.

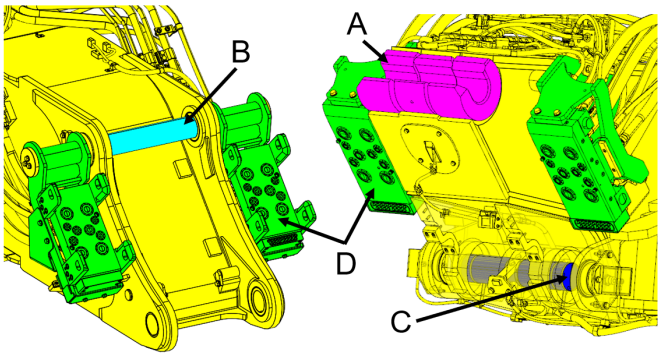

Fig. 4 Components of K100 radial connection

4.1.2 Process of radial connection

(1) Base machine travels forward towards connecting work equipment, adjusting boom angle so that U-bracket is below the pick-up pin.

(2) Travel and Boom raise continue until pick-up pin is seated into the U-bracket.

(3) Boom is raised, lifting the work equipment to the designated radial connection position engaging hydraulic and electrical connections.

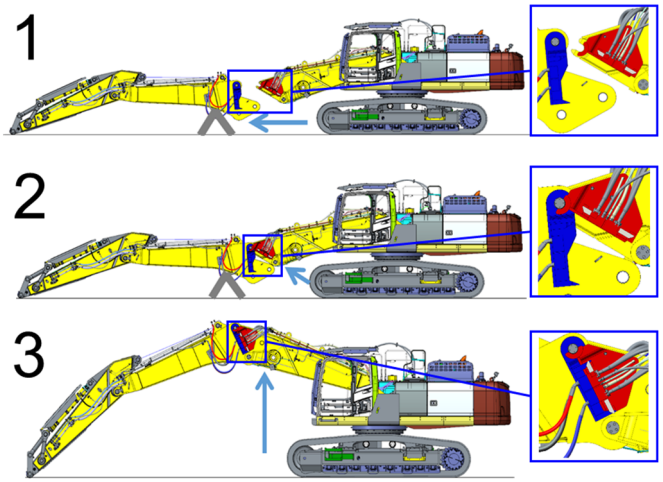

Fig. 5 Radial connection process

The hydraulic and electrical connections are maintained by an integrated locking system, once locked the valve is supported by the base boom assembly (S-Valve). Clearances are carefully designed for the floating work equipment connection assembly (A-Valve) to ensure it is now independent of the structure of the work equipment attached preventing structural loads being transferred through the connection assembly.

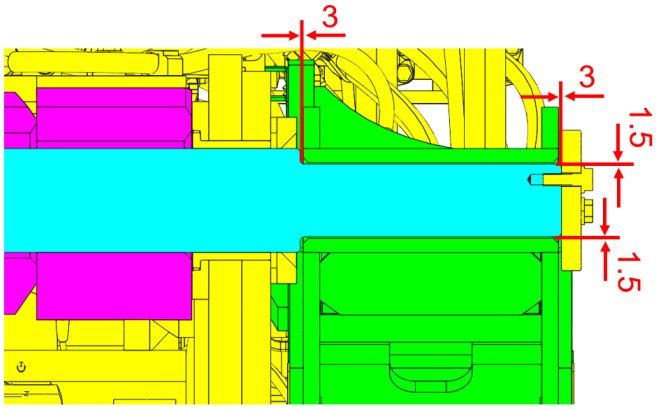

Fig. 6 Clearances of A-Valve assembly

4.1.3 Cam lock system

When the 2-position digging work equipment is installed, the floating S-Valve and A-Valve assembly remains connected as the boom is switched between cranked and straight position. During this process the work equipment is partially locked in position, to ensure that the connection valves are not subjected to load and that the connected work equipment remains seated within the base boom U-bracket by the cam lock system.

The pick-up pin and U-Bracket feature a central locking portion allowing the pick-up pin to engage or disengage the U-bracket at a specified angle beyond the position change range maintaining secure connection whilst changing position.

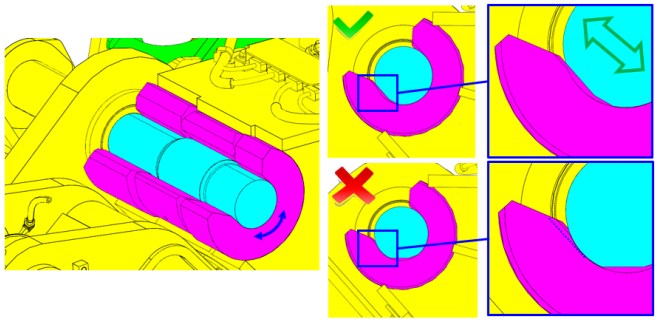

Fig. 7 Cam lock system

4.1.4 Misconnection prevention

During the development, a misconnection event occurred when the pickup pin was not correctly seated within the U-bracket and connection was attempted, the valve assemblies were not correctly aligned and damaged as a result. To countermeasure this issue a secondary locating pin and corresponding profiled stop were developed to ensure that the pick-up pin is fully seated during the final stages of radial connection providing X and Y positioning.

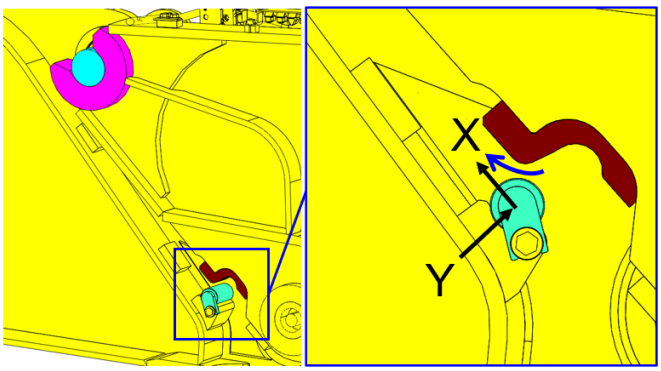

Fig. 8 Misconnection alignment stop

4.2 S-Valve and A-Valve development (hydraulic and electrical connection assemblies)

A significant development challenge to overcome was a connecting method of the work equipment joint that can reliably connect and disconnect 20 individual hydraulic connections and 34 individual electrical connections for the life of the machine whilst being subjected to a harsh demolition environment.

The valve assemblies were developed jointly with Lehnhoff Hart Stahl GmbH, utilising their existing short stroke KV-Valves used in a bespoke assembly to suit the existing Komatsu Work Equipment. The valve assemblies demanded several technical developments.

4.2.1 Valve locking system

The integrated locking system utilises a wedge type engagement pin and a decoupled compact hydraulic cylinder supplied with constant positive pressure whilst working to prevent the spreading force generated by machine services forcing the radially connected valves apart. An internal pilot operated check valve prevents the locking pins retracting and the valves unlocking whilst the machine is inactive.

The function of the valve locking pins is shown in **Fig.9** in three steps.

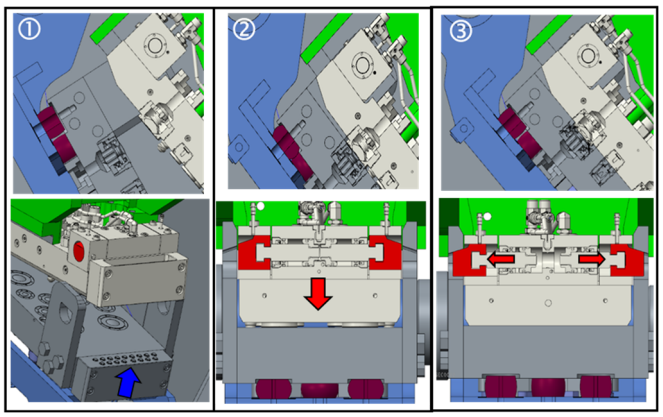

Fig. 9 Integrated valve locking system

4.2.2 Depressurisation system

The S-Valve assembly features a depressurisation system utilising a centralised drain gallery to connect all service lines to tank during the disconnection process. Depressurisation of the work equipment is a critical part of the disconnection process to ensure that no residual pressure within the work equipment prevents successful

connection and re-connection.

During disconnection, pressure is supplied to Port P opening the internal depressurisation valve, connecting all services to the hydraulic tank connection thus releasing any residual pressure.

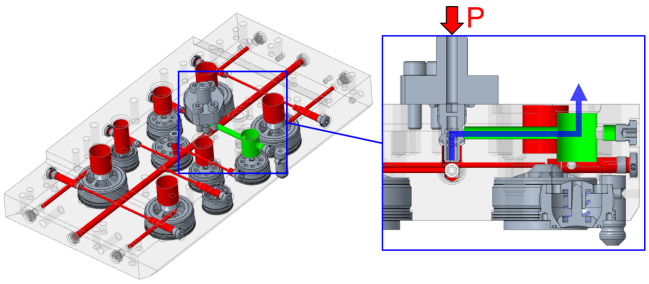

Fig. 10 S-Valve depressurisation circuit

4.2.3 Electrical connections

The existing conventional boom change system requires 16 electrical connections for various systems including work lamps, inclination sensors and arm end camera. The K100 system also requires an increase in electrical connections to support the various sensors and solenoid valves for the second work equipment joint so an electrical connection system was developed, suitable for a range of voltages and currents to accommodate the different signals and power demands of each component.

A reliable electrical contact block integrated into the wiring harness of each valve assembly was developed utilising silver and gold spring contact terminals to ensure a stable connection whilst the machine is operating. The contact holder was refined and tested during development to ensure the connections remain dry and uncontaminated.

Fig. 11 K100 electrical connections

4.3 Control system

In order for an operator to carry out the work equipment changeover from the operator's cab with ease, a control system had to be developed to activate the relevant valves at the correct time and utilise various feedback sensors so that the status of the system could be constantly monitored. Risk assessments and functional safety evaluations were conducted to ensure that each portion of the control system meets the required safety performance level.

The system uses a safety controller as an expansion of the existing working range indicator system fitted to EU Komatsu High Reach Demolition machines. Intuitive screens and action buttons provide instruction and the operator interface to carry out the connection and disconnection processes whilst the safety controller manages the functional safety critical actions ensuring a safe and simple to use system.

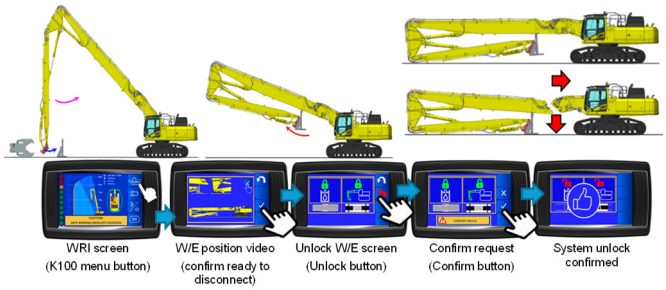

Fig. 12 K100 HMI example

The Safety controller activates 10 separate solenoid valves depending on the K100 function being operated and monitors inputs from 60 sensors/switches across the base machine and work equipment variants. A simplified base machine circuit representation is shown in **Fig. 13**.

The operator uses the intuitive HMI screens to navigate to the actions they want to undertake, such as work equipment disconnection. Animations are displayed on the screen to instruct the operator of the necessary actions. The software will only progress if the correct conditions are met which mitigates the risk of operator error carrying out functions in an incorrect order.

In addition, to aid alignment of connecting work equipment a camera positioned below the base boom provides a live view of the machine position. A corresponding target on the work equipment is used by the operator to align the base machine for the preparation for the connection process. **Figure 14** Shows an example of the screens displayed during disconnection and alignment camera view in base machine configuration.

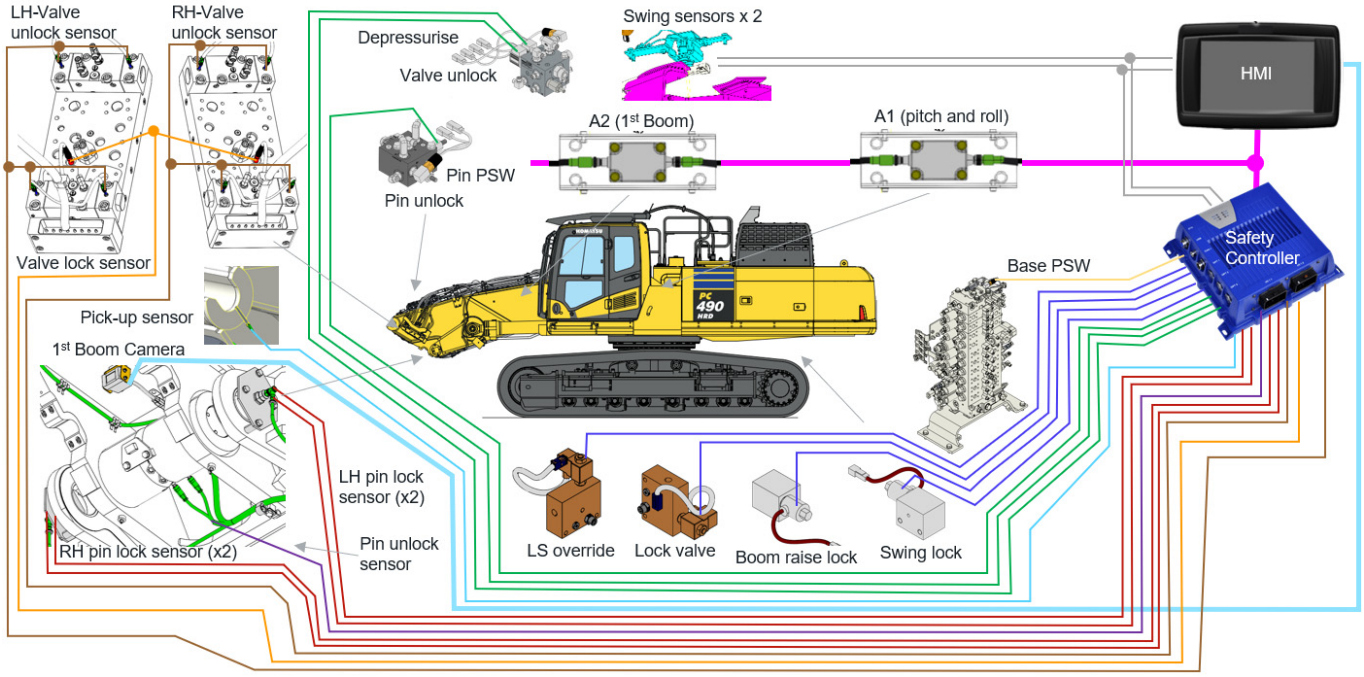

Fig. 13 Simplified circuit representation of K100 base machine

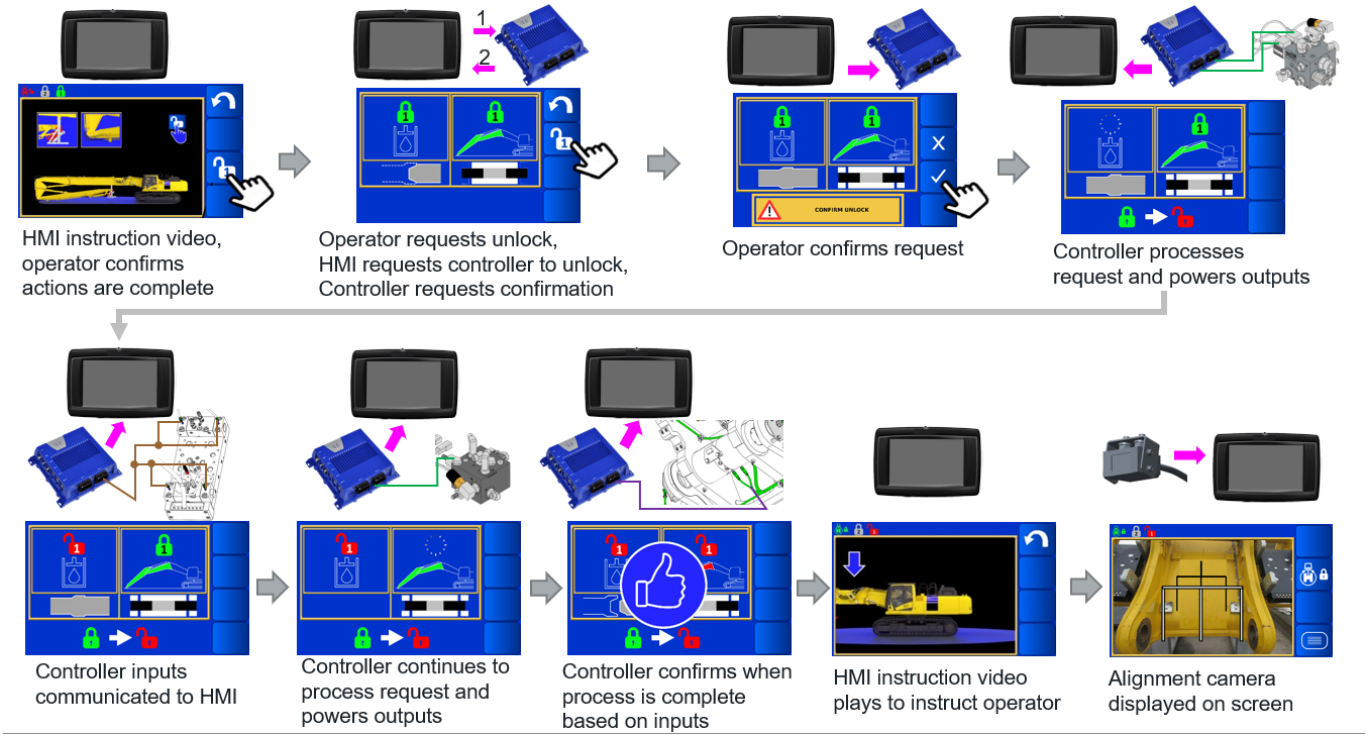

Fig. 14 Example of K100 screens during disconnection process

5. Market effect

Since introduction in 2021 the K100 option has proven very popular, by the second year of production K100 sales exceeded the conventional quick change system by almost double.

The K100 has rapidly become the dominant system and year on year since introduction is taking more share of volume. A second observation is that in 2023/2024 standard machine production has reduced significantly but HRD production has remained more buoyant due to the contribution of K100 system demand.

Many customers are surprised at the durability and ease of use of the K100 system, this can be attributed to extensive testing both at KUK and on site with a seeding customer. **Figure 15** shows the development machine undergoing changeover testing with the ground condition of the jobsite.

Fig. 15 Jobsite changeover testing

The K100 system has also expanded potential markets for KUK with increased sales of machines in the last 2 years to North America. The ease of work equipment disconnection for transportation that the K100 system provides combined with the quality and support of an OEM High Reach Demolition solution provides unique selling opportunities to Komatsu within North America.

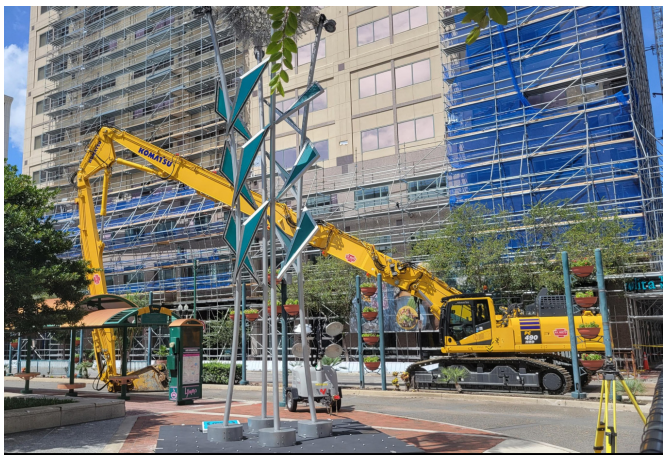

Fig. 16 PC490HRD-11E0 K100 specification on site in Florida, United States of America

The K100 was designed with other model compatibility considered, in 2024 the K100 quick boom change system was released for the PC390HRD-11E0 model offering the same functional benefits to customers in a smaller machine.

Fig. 17 PC390HRD-11E0 K100 press release

Acknowledgements

We would like to express our gratitude to all those that contributed to the development of this system, significant effort was made by many at KUK and KUK's suppliers to develop and deliver this project. Without the commitment and expertise of these people the project would not have been successful.

Introduction of the authors

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Joined Komatsu UK in 1998.

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Joined Komatsu UK in 2011.

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[A comment from the authors]

Whilst this development was very challenging, we have successfully delivered a product with true market potential are very proud to meet the demands of our customers. We are sure that future expansion is possible expand this system or incorporate it into future models.