International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design of equipment to measure connecting/ Disconnecting Force As per ISO standard for QRC Testing

*Sagar Gaddamwar**[1], *Om Galande*[2], *Aniruddha Kamat*[3], *Ganesh Dudhade*[4], *Dr. A.V. Waghmare*[5], *Vijay Kumar Jain*[6]

*[1,2,3,4]Student, [5]Associate Professor, [6]Senior Design Engineer

Department of Mechanical Engineering, AISSMS College of Engineering ,Pune, Maharashtra, India

* *Corresponding author.* Phone: 9049707913; 9511653662; 7722048074; 7020004190

E-mail address: sagarsureshgaddamwarg@gmail.com; omgalande336@gmail.com ; aniruddha03.kamat@gmail.com; dudhadeganesh31@gmail.com

ABSTRACT:

Hydraulic quick-release couplings (QRCs) are important parts of industrial fluid power systems to connect and disconnect hydraulic lines quickly and securely. However, existing methods of testing hydraulic quick-release couplings are mainly analog and have limitations. They essentially measure the connecting force only; the disconnecting force is typically not measured, nor is the data stored in a digital format.

To address this limitation, a completely new digital force measurement machine was created. This machine is capable of measuring and record the connecting and disconnecting forces of hydraulic quick-release couplings with real-time, digital data that can be recorded. The machine uses a bi-directional mechanical apparatus and a calibrated load cell, which is displayed on a microcontroller output. The final configuration allowed for accurate force measurements throughout the entire connection and disconnection process.

The new digital testing machine was developed using the ISO 7241 testing protocols, which describes its interface dimensions and performance requirements for two hydraulic quick-acting coupling series - Series A and Series B. The standard lets couplings made by different manufacturers be interchangeable which makes them easier to maintain and reduces downtime.

Digital force measurement machines have the unique ability to test different sizes and types of QRCs allowing even more flexibility. In addition, it is the only machine that allows the user to measure both connection and disconnection force, allowing the user to objectively assess the complete performance of couplings. The user can view the result on a digital display which offers real-time results, and the optional data logging capabilities provides even greater comparisons, assessments, and trends; this is a great benefit for manufacturers and testing facilities that are tracking quality control or compliance to international standards.

Keywords: Quick Release Coupling (QRC),Force Measurement ,Hydraulic Couplings ,ISO,Industrial Automation ,Digital Readout

INTRODUCTION

Hydraulic quick-release couplings (QRCs) are an integral component of hydraulic systems in a wide range of industries such as manufacturing, construction, agriculture, and transportation. QRCs enable fluid lines to be connected or disconnected rapidly by hand and without the use of tools, reducing downtime, and improving efficiency. Their performance is critical in ensuring that the integrity of the system is maintained to prevent fluid leakage, and protect personnel and equipment.

With respect to QRCs, the force required to connect and disconnect the coupling under specified conditions is one of the key performance parameters that governs the effectiveness and/or safety of the QRC. The accurate measurement of both the connection and disconnection force of the QRC is necessary not only to assess if the QRC is easy to use, but also to ensure compliance with international standards such as ISO 7241 which specifies the test requirements for hydraulic QRCs. High connecting or disconnecting force can lead to mechanical failure of the QRC, cause an ergonomic issue for operators during operation, or not properly engage/release the QRC. Low connecting and disconnecting forces can adversely effect sealing capability and pressure handling capabilities.

Industries are still reliant on analog testing machines for force measurement that measure, at most, connecting force through a spring type or dial gauge methodology, which is not accurate, and also has no ability to test disconnecting force, in addition to having more human error involved with analog measurements and no written, digital traceability, which capabilities are required (at least) from a quality assurance system in modern day organizations).

The purpose of this applied research project, therefore is to redesign and upgrade the existing analog machine into a electronically controlled force measurement system capable of measuring (precisely), connecting and disconnecting forces. It was envisioned to measure connecting forces using load cell sensors, a microcontroller based system., mechanical improvements (to increase steady state duration), under Supress QRC standard (ISO 10012 leads). The superior performance of the upgraded electronic system will provide accuracy compared to the measuring systems used acheive ISO standard compliance for QRC testing of QRC in an industral setting.

LITERATURE SURVEY

Quick-release couplings (QRCs) are standard components heavily used in hydraulic systems as they allow fast leak free connections. The dimensional specification, performance parameters and testing methods for hydraulic QRCs in fluid power applications has been defined in ISO 7241 (Part A and B). The standards will also provide force levels for engagement and disengagement under specified conditions with the goal of safety, reliability and interchangeability.

Measurement of such force in order to conform to ISO compliance has to be precise. Conventional measurement systems used in industrial circumstance have historically been analog force indicators like spring-based dial gauges. While these are less expensive, they are inherently finite in terms of precision, repeatability and data; and often strictly one directional as they generally only support connecting force and neglect disconnecting force.

The testing landscape has also moved towards automated and precision measurement systems that incorporate load cells and load sensors. Load cells are predominately strain gauge-based measurement devices that convert mechanical force into an electrical signal and that are commonly used in material testing, structural health monitoring and industrial automation systems. When combined with microcontrollers or a data acquisition system, load cells allow for digital signal measurement and logging for improved accuracy and traceability.

Various studies have used sensor-based systems towards hydro mechanical and hydraulic test for components. Several investigations on digitally controlled hydraulic test benches have shown that the digitization of the performance of a valve and a hose is accurate and efficient. Nevertheless, there exists a notable gap in the literature and in industry practice because there is not an integrated system to digitally measure connecting and disconnecting forces of QRCs according to ISO standards. There are a plethora of applications available to measure the required forces, however most do not provide bidirectional testing and/or they do not provide a digital output to adapt to ongoing modern quality assurance requirements.

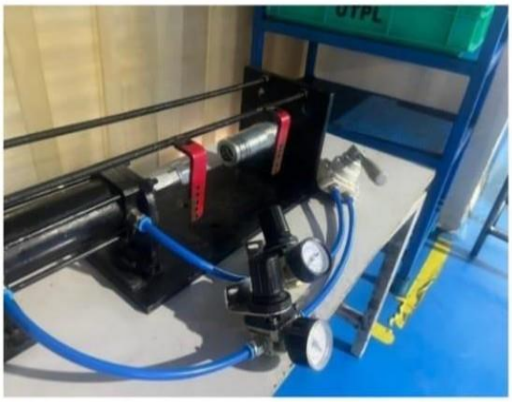
METHODOLOGY

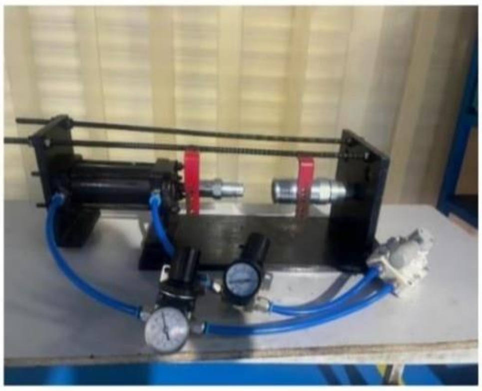
Before Modification – Existing Manual Model: Working:

- Mechanism: Manual spring-loaded lever.
- Measurement: Analog dial to indicate connecting force only.
- Operation: Manual pressing and reading.

Limitations:

- Only insertion force is measured.
- No data logging/digital output.
- No disconnecting force measured.
- Human error due to analog reading.



After Modification : <u>Components & Design:</u>

- Frame: Steel base with fixed and sliding clamps to hold male & female QRC halves.
- Actuation: Pneumatic cylinder (double acting) for bi-directional motion.
- Sensors: Load cell (compression & tension) to measure force during:
- Insertion
- Withdrawal

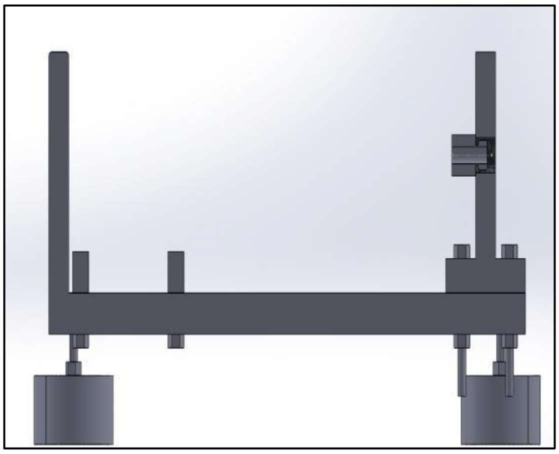
Control:

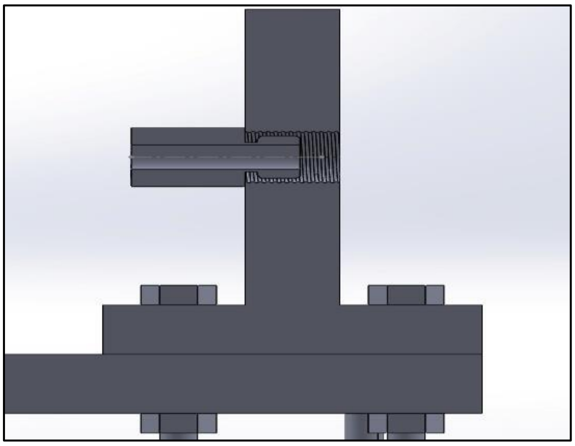
- Pressure regulator
- Digital pressure gauge
- Microcontroller for automation
- Optional: HMI display, SD logging, or PC serial output

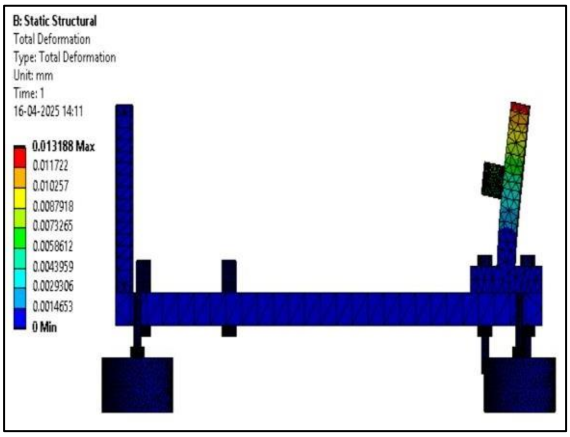
Working:

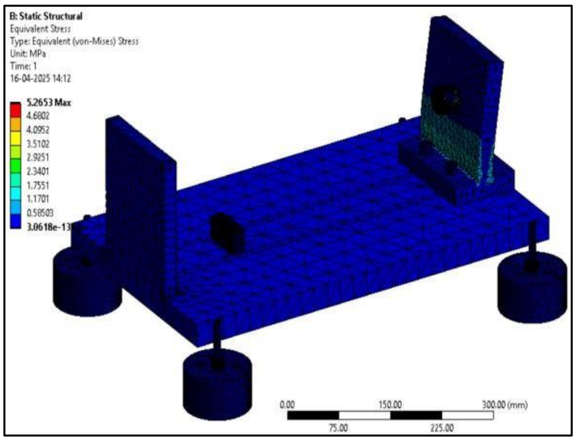
- QRC is mounted in the fixture (male in fixed end, female on movable).
- Pneumatic cylinder is actuated (forward) → insertion force recorded.
- Pneumatic cylinder retracted → withdrawal force recorded.
- Load cell sends real-time data to the microcontroller.
- Display and/or logging system stores data.

- Test repeated 3 times → average value used for result.









ANALYSIS AND IMPLICATIONS

The design and development of the digital force measurement machine for hydraulic quick-release couplings (QRCs) highlights many improvements not available in traditional analog systems. Fortunate, the following features outline how beneficial this advancement is for existing industrial testing environments:

Bi-Directional Force Measurement:

This system accurately measures both connection and disconnection forces. This feat greatly improves upon legacy machines which only measure the connection force. Measuring both forces is vital to fully understand the coupling's mechanical response; therefore improving safety, usability, and conformance to product regulations.

Digital Data Log and Traceability:

The machine employs load cells which connect to the digital microcontroller interface to measure the connection and disconnection force, and logs instantaneous force values in real-time. The text log can be sourced with various tests, and saved digitally for immediate analysis, future audits or compliance. It also allows for the traceability of raw data and can easily be exported to software tools to support quality assurance tools.

Easy Calibration - High Repeatability:

With new digital systems calibration is typically as simple as applying known weights using calibration weights or using industry standard calibration tools. Furthermore, the load cell will consistently provide initial output levels, making accurate and repeatably measurements achievable, making measurable outcomes less dependent on operator input and bias across production runs or shifts in a production environment.

ISO 7241 Compliant:

The machine has been developed to meet the approaches and test environments of ISO 7241, the standard that governs hydraulic QRCs. Meeting these standards ensured that the test configuration would deliver bona fide and recognized results contributing to the precious world driven supply chains.

No Subjective Error:

Analog force gauges rely on human interpretation and are subject to subjective error through a range of parallax or simple misreading. With the digital system each gauge captures its exact value in numeric form, eliminating all of the associated errors thus improving the measures reliability.

Functional to Industry:

This machine is inherently valuable to the R&D, QC, and Maintenance departments. R&D teams are able to use it to assist with product testing in controlled conditions. The QC department will be able to test accurate batches of products and maintain records. Maintenance teams will be able to assess wear and tear of components by observing increasing force in a coupling over time.

CHALLENGES FACED

Even though there can be rewards, designing and implementing the system introduced numerous engineering challenges.

Sensor Alignment and Electronic Noise:

To achieve accurate and repeatable force readings, the load cell must be aligned to the force of the applied load very accurately. If there is any misalignment between the load cell and the force applied there will be poor readings or inconsistencies in readings. Also, being very sensitive to electronic noise from motors and general noise in an industrial environment would hinder both the quality and stability of the readings. There were some additional design choices that needed to be made with properly grounded shielded cables with filtering and/or low pass filters to stabilize the signal.

Mechanical Backlash on Actuator Travel:

All mechanical motion includes some degree of mechanical backlash, which is as follows: intended movement creates some amount of unwanted movement of mechanical components due to a change in the direction of the force. This is is especially pronounced for each peak of load sourcing when changing quickly from a different force transfer from the actuator. To reduce the effects of backlash, the machine was specially designed with preloaded components and with use of precision linear guides.

Real-Use Condition Simulation:

Another design challenge was designing fixtures to replicate and represent real-use scenarios of QRC operation. It was essential for the test fixture to simulate the actual conditions of their hydraulic system and configurations, i.e., alignment, grip pressure and insertion angles, to prevent comparing test results to their real performance. A number of iterations were performed to ensure that the mounting mechanism would allow for natural coupling behaviour without adding resistance or reducing resistance in some way.

CONCLUSION

This study has shown the design and development of a new digital force measurement machine specifically developed for use in testing hydraulic quick-release coupling (QRC). The digital measurement machine has overcome some of the key limitations of the current analog design as it is able to measure the connecting and disconnecting forces both of which have not been feasible in most industrial testing devices. The design of the digital device includes the load cell sensing mechanism that was complemented by a microcontroller mechanism linking a digital edge-based user interface and actuator system.

The intent of the normal hydraulic or mechanical loading acts to generate actual forces along the axis of the device which enable digital capture of force measurement in real time. The design enables ease in establishing basic test protocols and procedures with very limited noise while providing more controlled setups in assessing repeatability and identifying actual measurements to establish better traceability and standardization for organizational quality and system acceptance processes. The machine was developed in the spirit of ISO 7241 with the design intent to assist in the identification of QRC performance and provide means of QC and Q&A for global use in industry.

The machine has been developed with ampliability in design. The design and test device would be easily adapted to different QRC sizes and designs, and would enable manufacturers, missions and labs, and QC departments to employ the machine and data capabilities for a variety of applications. The digital logging of data provides manufacturers opportunities for implementing automated means of identifying quality assurance issues, monitoring life cycle trends, and even possible predictive maintenance for hydraulic systems.

As the technology flows a great deal of improvement and progress has come to the current state of testing, it has filled a major gap and it represents a move forward meaningfully in terms of modernizing approaches to hydraulic component testing. All of this is promising and paves the way for even more advancement in terms of full automation, remote call monitoring, and host or part of the overall Industry 4.0 landscape -- all of which can contribute to the development of safer, more efficient, and more reliable hydraulic systems in numerous industrial applications.

REFERENCES

1. ISO 7241-1:2014, Hydraulic Fluid Power – Dimensions and Requirements of Quick-Action Couplings, International Organization for Standardization, Geneva, Switzerland, 2014.
2. Omega Engineering, Load Cell Selection Guide, [Online]. Available: https://www.omega.com
3. Open Source Hardware Lab, Arduino-Based Load Cell Measurement Using HX711 Module, 2022. [Online]. Available: https://www.opensourcehardwarelab.com
4. Parker Hannifin Corp., Quick Coupling Division – ISO 7241 Series A and B Hydraulic Couplings Catalogue, Parker Industrial Catalogue 3800, 2020.
5. S. Kumar, R. Gupta, and A. Patil, Design and Validation of Hydraulic Testing Rigs for Industrial Couplings, International Journal of Mechanical Engineering & Technology (IJMET), vol. 11, no. 3, pp. 456–463, 2020.
6. Interface Inc., Load Cell Technical Reference Manual, Interface Engineering Resources, 2021. [Online]. Available: https://www.interfaceforce.com
7. Y. Zhao and W. Zhou, Sensor-Based Testing of Hydraulic Components in Industry 4.0 Framework, Procedia Manufacturing, vol. 49, pp. 157–164, 2020.
8. Bosch Rexroth AG, Hydraulic Systems Design Guide, Bosch Engineering Manual, 2021.
9. H. Singh and V. Desai, "Development of a Mechatronic Test Rig for Hydraulic Connectors," International Journal of Advanced Engineering Research and Science (IJAERS), vol. 8, no. 5, pp. 10-16, May 2021.
10. National Instruments, Strain Gauge and Bridge-Based Sensors Application Guide, 2021. available online on https://www.ni.com
11. D. Patel and S. Rao, "Digitalization of Mechanical Testing Using Load Cells and Microcontrollers," IEEE Transactions on Instrumentation and Measurement, vol. 70, pp. 1-8, 2021.
12. Norgren Ltd, Hydraulic QRC Installation and Performance Guide, 2020. available online on https://www.norgren.com
13. HX711 Load Cell Amplifier Datasheet - Avia Semiconductor Ltd, 2021. available online on https://cdn.sparkfun.com