Conference Article

Manual Quick Coupler System at Earth Moving Machines

Fatma Öz[1*], Ferhan Fıçıcı[2]

[1] Hidromek A.Ş, Orcid ID: https://orcid.org/0009-0008-7920-1003, E-mail: fatma.yalcin@hidromek.com.tr

[2] Hidromek A.Ş, Orcid ID: https://orcid.org/ 0000-0002-4851-2342, E-mail: ferhan.ficici@hidromek.com.tr

[*] Correspondence: fatmayalcin@gmail.com; Tel.: +905332671239

4th International Conference on Access to Recent Advances in Engineering and Digitalization
May 27 - 28, 2024

Received 12 February 2024
In final form 25 May 2024

Reference: Öz, F., Fıçıcı, F. Manual Quick Coupler System at Earth Moving Machines. Orclever Proceedings of Research and Development, 4(1), 90-99.

Abstract

In order to quickly and safely disassemble and assemble attachments on earth moving machines, so-called "quick coupler" devices are used. Quick coupler devices provide ease of operation for the machine operator and also save time. The most important criterion in these devices is safety. Because if the attachment cannot be fully engaged or there is a malfunction in the locking system, it will be very dangerous. The systems of these apparatus are mentioned in the ISO 13031 standard. The equipment designed to meet all the requirements of the relevant standard has high costs because they have complex systems. For this reason, many machine operators, especially in our country, prefer to use quick coupler devices without any safety precautions. In this paper, the safety system used to make low-cost manual quick coupler devices more reliable will be discussed.

Keywords: Manual quick coupler, engagement locking

1. Introduction

Quick coupler is a device mounted on an earth-moving machine to allow the quick interchange of attachments [1]. According to the ISO 13031 standard, three types of quick couple types are determined.

1. Powered Quick Coupler: Quick coupler where the movement of at least one part of the engagement and locking system is actuating by a power source.

2. Manual Quick Coupler: Quick coupler where the movement of the engagement and locking systems is actuated by human effort at the quick coupler itself.

3. Mixed Quick Coupler: Quick coupler where engagement and locking are carried out from the operator's station but disengagement is carried out by human effort at the quick coupler itself.

Engagement system is mechanical system of quick coupler which engages with the attachment and retains the attachment in its working position. In this paper, a special design study on the force-locked engagement system with manual quick coupler will be discussed.

Force-locked engagement system is engagement system whereby continued engagement is dependent on the continues application of the engagement force as the working forces act in a direction to cause disengagement.

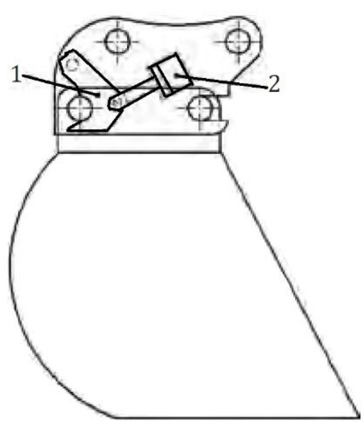

Figure 1: Force-Locked Engagement System

1- Engagement System

2- Engagement Force Device

Engagement force moves the engagement system to the engaged position and, if the design requires, retains it in that position. The engagement system shall be able to witstand the working forces applied to the attachment and hold the attachment in the working position.

2. Materials and Methods

A spring force is generally used as engagement force in manual quick couplers. With the spring force, the connection pin of the attachment is clamped between a jaw and the engagement process is performed. At the 2016 version of the ISO 13031 standard, it is stated that it is not enough for this system to just engage, but it must also be able to resist working forces and keep the attachment in the working position. In this case, quick coupler designs have become more complex. Quick coupler manufacturers have also concentrated their work on more automatic systems. However, this has increased quick coupler costs. A quick coupler design that is both low-cost and meets the requirements of the ISO 13031 standard, which is the subject of this paper, has been studied.

In manual quick couplers, during the assemble the attachment process, the operator usually positions the quick coupler close to the attachment from inside the cabin. The freely positioned front pin of the attachment inserts into the front pin channel of the attachment. Then he positions the attachment so that it hangs vertically in this channel. In order for the jaw to be rotated by human force, a lever is attached to the arm channel on the quick coupler. The arm is then pushed in a direction that compresses the engagement spring, thus overcoming the spring force and allowing the jaw to rotate around the rotation pin axis. With the rotational movement of the jaw and the force of gravity, the rear pin of the attachment fits into the jaw channel. The lever is removed from the quick coupler lever channel, the engagement spring pushes the jaw and the attachment pin is compressed. Finally, the attachment is secured by inserting the lock pin belonging to the locking system.

https://doi.org/10.56038/oprd.v4i1.468

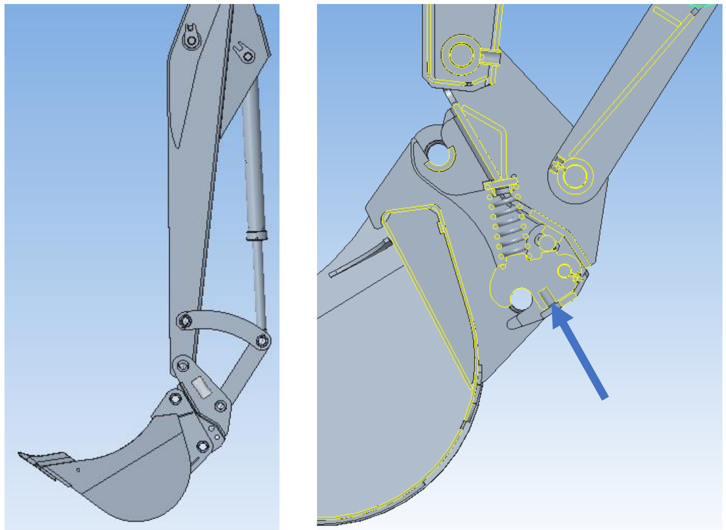

Figure 2: Assembly process of Classic Manual Quick Couplers

During the attachment disassembly process in manual quick couplers, the operator usually lifts the attachment slightly above the ground in a flat position. In order for the jaw to be rotated by human force, a lever is attached to the arm channel on the quick coupler. The arm is then pushed in a direction that compresses the engagement spring, thus overcoming the spring force and allowing the jaw to rotate around the rotation pin axis. With the rotating movement of the jaw and the force of gravity, the rear pin of the attachment is released from the jaw channel. The lever is removed from the quick coupler lever channel.

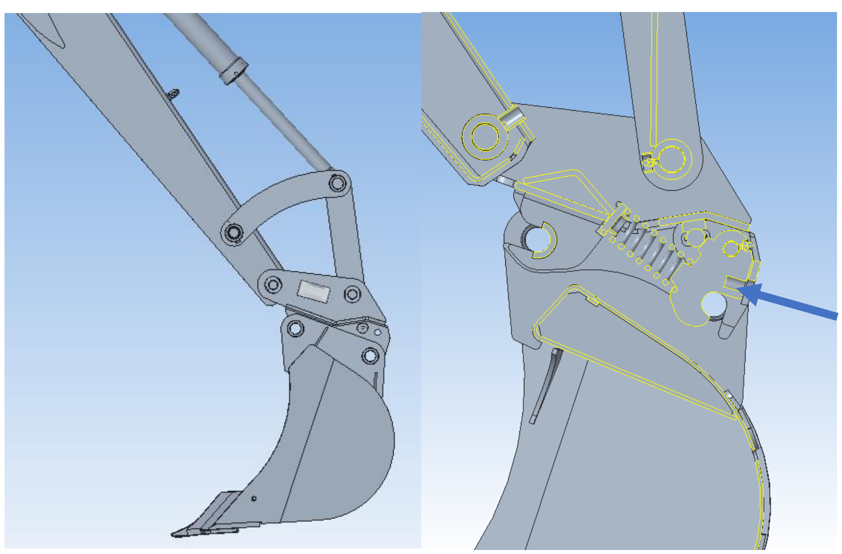

Figure 3: Disassembly process of Classic Manual Quick Couplers

In this type of quick couplers, spring force has the ability to perform the engagement process. However, while excavating with the attachment, the forces acting on the spring may cause the spring to compress and the attachment pin to be released. In order to perform the disassembly process, the same engagement spring is compressed by human force. Due to this situation, it is not possible to increase the spring force. Otherwise, the disassembly of the apparatus will not be possible.

2.1. Jaw Locking System

With a new design study, a system that locks the jaw and prevents working forces from acting on the engagement spring has been developed. While carrying out this study, a lock system that works perpendicular to the working forces was designed.

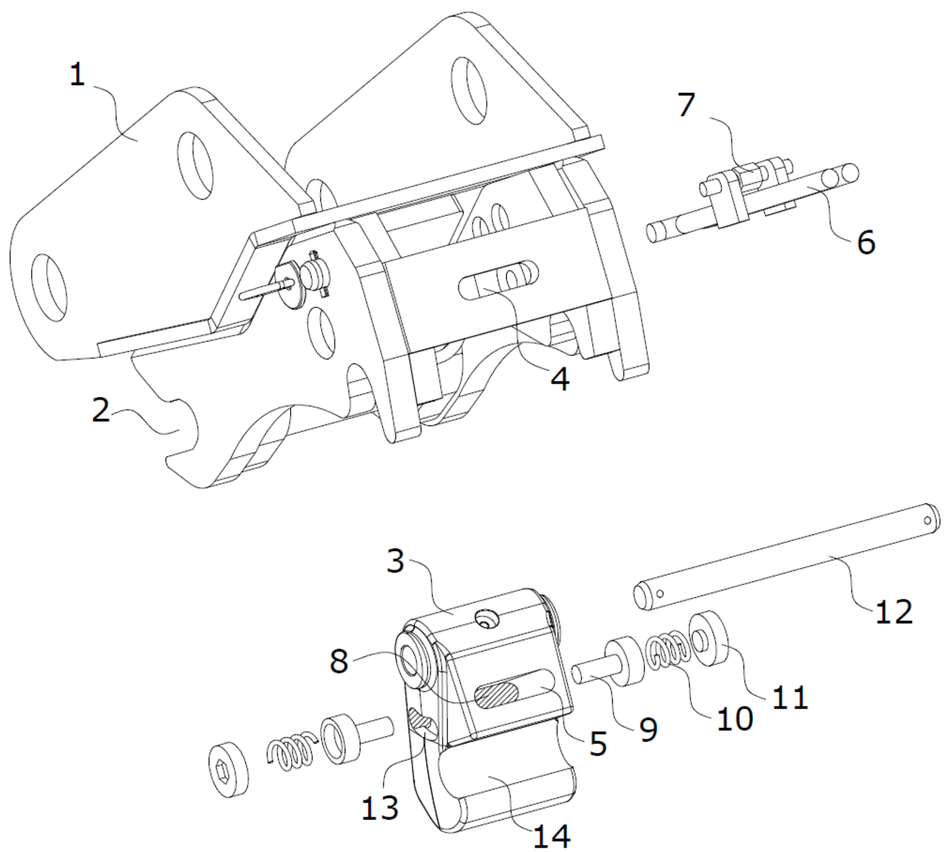

Figure 4: Jaw Locking System

Table 1: Jaw Locking System Components

No	Description
1	Quick coupler
2	Quick coupler free channel
3	Jaw
4	Quick coupler lever channel
5	Jaw lever channel
6	Lever
7	Lever adjustment mechanism
8	Pin seat
9	Lock pin
10	Spring
11	Cap
12	Rotary pin
13	Pin channel

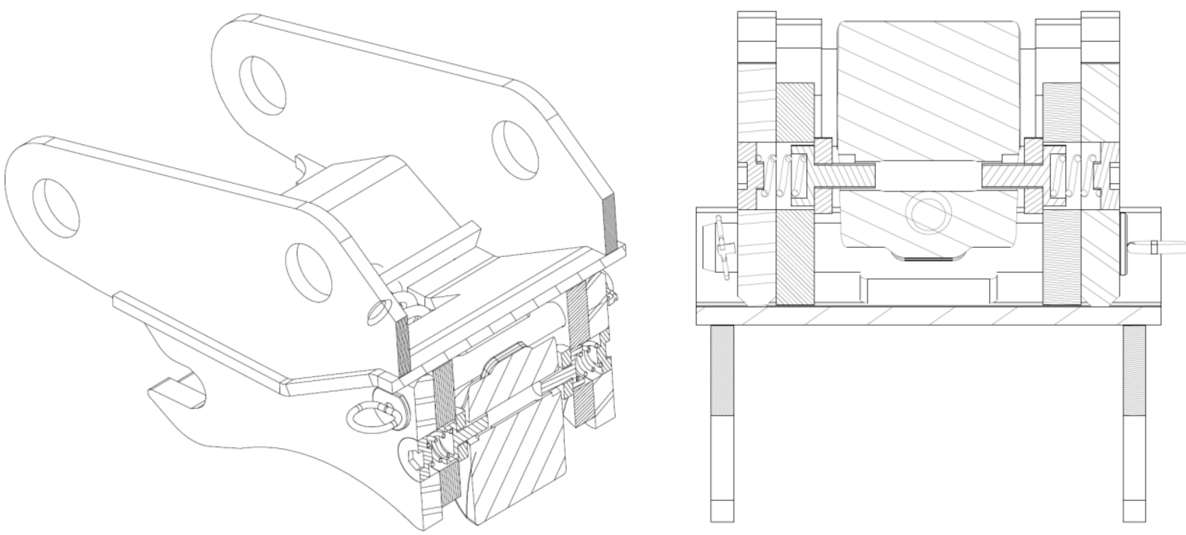

Figure 5: Jaw Locking System Section

The process of attaching attachments with the jaw-locking quick coupler apparatus is the same as the classical methods. However, the lever used during the attachment removal and installation process differs for this apparatus. With the adjustment mechanism on the lever, the arms of the lever are pushed towards the lock pin in the pin slot. Meanwhile, the spring is compressed and the lock pin moves outwards. Thanks to the cover, the lock pin is prevented from coming out of place.

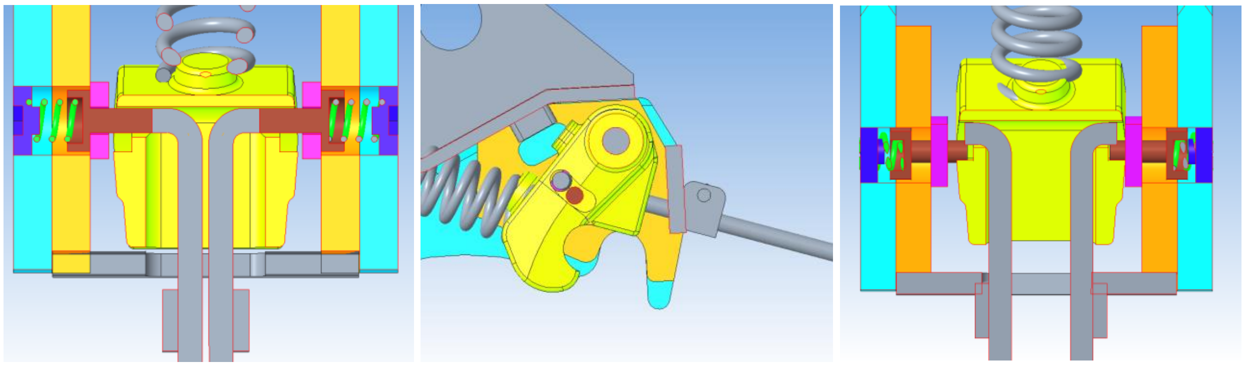

Figure 6: Disassembly at Jaw Locking System

The lever is then pushed downwards, causing the jaw to rotate around the rotation pin axis. Meanwhile, the lock pin can move freely within the pin channel. Thus, the lock is released. With the rotational movement of the jaw and the force of gravity, the rear pin of the attachment fits into the jaw channel. With the adjustment mechanism on the lever, the lever arms are moved away from the lock pin, allowing the lock pin to seat in the pin slot with the spring force. The lever is removed from the quick coupler lever channel. Finally, the attachment is secured by inserting the lock pin belonging to the locking system.

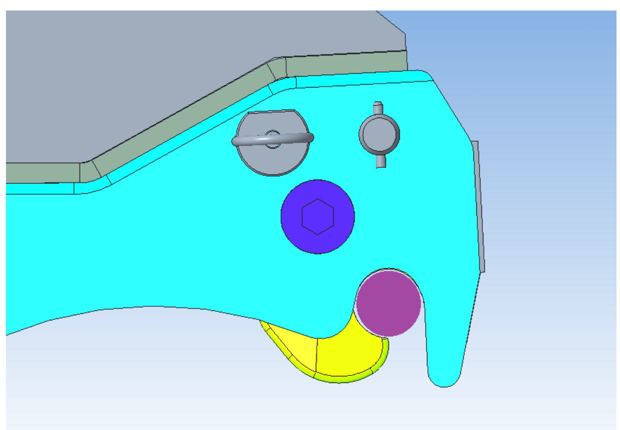

Figure 7: Assembly at Jaw Locking System

During the design study, the forces on the jaw locking pins were calculated. In the calculations, the position with the maximum bucket breakout force was taken as reference. To calculate the bucket breakout force, mechanism analyzes were made and position and force values were calculated.

https://doi.org/10.56038/oprd.v4i1.468

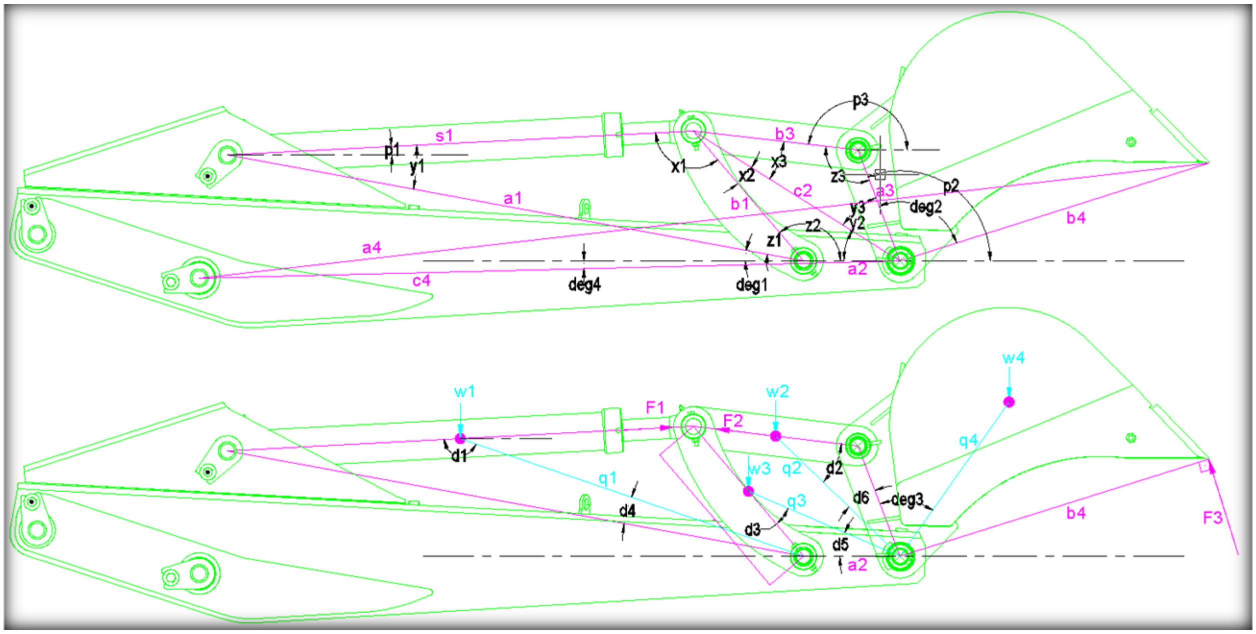

Figure 8: Calculation of force on quick coupler jaw

To determine the locking pin diameter and material, the shear force acting on the pin was calculated. There are no published standard values for shear strength like with tensile and yield strength. Instead, it is common for it to be estimated as 60% of the ultimate tensile strength [2].

Table 2: Guide relating tensile, yield, and shear strengths [3]

Material	Ultimate Strength Relationship	Yield Strength Relationship
Steels	USS = approx. 0.75*UTS	SYS = approx. 0.58*TYS
Ductile Iron	USS = approx. 0.9*UTS	SYS = approx. 0.75*TYS
Malleable Iron	USS = approx. 1.0*UTS	
Wrought Iron	USS = approx. 0.83*UTS	
Cast Iron	USS = approx. 1.3*UTS	
Aluminums	USS = approx. 0.65*UTS	SYS = approx. 0.55*TYS

USS: Ultimate Shear Strength, UTS: Ultimate Tensile Strength,

SYS: Shear Yield Stress, TYS: Tensile Yield Stress

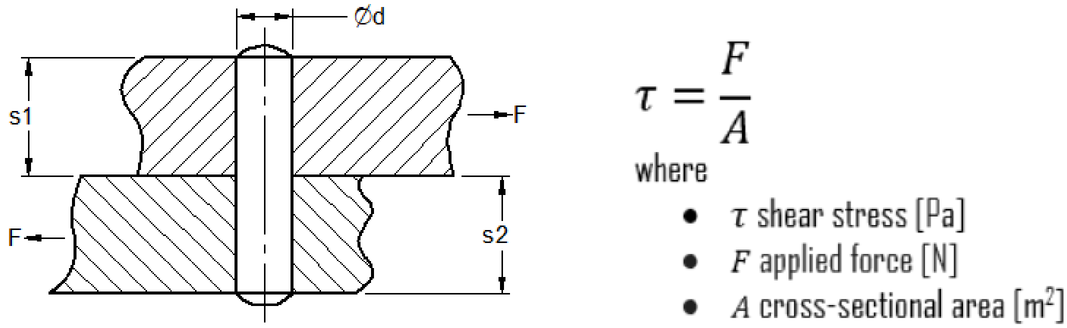

Figure 9: Shear Stress on the lock pin [4], [5].

Material mechanical properties in the EN 10277-5 standard were used for pin material selection.

Table 3: Material Selection [6]

Grade :	42CrMoS4					
Number:	1.7227					
Classification:	Alloy special steel					
Standard:	EN 10277-5: 2008 Bright steel products. Technical delivery conditions. Steels for quenching and tempering					
	EN 10083-3: 2006 Steels for quenching and tempering. Technical delivery conditions for alloy steels					
	EN 10263-4: 2001 Steel rod, bars and wire for cold heading and cold extrusion. Technical delivery conditions for steels for quenching and tempering					
Chemical composition % of steel 42CrMoS4 (1.7227): EN 10277-5-2008						
C	Si	Mn	P	S	Cr	Mo
0.38 - 0.45	max 0.4	0.6 - 0.9	max 0.025	0.02 - 0.04	0.9 - 1.2	0.15 - 0.3
Mechanical properties of steel 42CrMoS4 (1.7227)						
Nominal diameter (mm):	to 16	16 - 40	40 - 100	100 - 160	160 - 250	
Rm - Tensile strength (MPa) (+QT)	1100-1300	1000-1200	900-1100	800-950	750-900	
Rm - Tensile strength (MPa) (+AC)	630					

Nominal diameter(mm): or for flat products thickness: to 8; 8-20; 20-60; 60-100; 100-160;	to 16	16 - 40	40 - 100	100 - 160	160 - 250	
Re - Upper yield strength or	900	750	650	550	500	
$R_{p0.2}$ - 0.2% proof strength (MPa) (+QT)						

3. Result

With the relevant design, a safe, practical and less costly product will be obtained.

4. Discussion and Conclusion

The design has been protected by applying for a patent for the relevant design. Studies are continuing to make the system a commercial product.

5. Acknowledge

HİDROMEK A.Ş supported this study. I would like to thank HİDROMEK.

References

[1] *Earth-moving machinery — Quick couplers — Safety*, ISO 13031, 2016-05-01.
[2] Anthony Porreco. (2023, January, 27), *Calculating Yield and Tensile Strenght* [Online]. Available: https://www.portlandbolt.com/technical/faqs/calculating-strength/
[3] *Shear Strength of Metals* [Online]. Available: https://roymech.org/Useful_Tables/Matter/shear_tensile.html
[4] *Dovel Pin Shear Load Stress Equations and Calculator* [Online]. Available: https://www.engineersedge.com/calculators/dowel_pin_shear_load__15407.htm.
[5] *Shear Stress – Materials* [Online]. Available: https://www.nuclear-power.com/nuclear-engineering/materials-science/material-properties/strength/shear-stress-materials/
[6] *European Steel and Alloy Grades/Numbers* [Online]. Available: https://www.steelnumber.com/en/steel_composition_eu.php?name_id=195