Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Mecánica

Tesis

Heavy object lifting platform to correct human balance and posture

Frank Reijkaro Raymundo Crisostomo

Para optar el Título Profesional de
Ingeniero Mecánico

Huancayo, 2019

Heavy Object Lifting Platform to Correct Human Balance and Posture

View the article online for updates and enhancements.

Heavy Object Lifting Platform to Correct Human Balance and Posture

F Raymundo[1], G Quispe[2], C Raymundo-Ibañez[3,*]

[1] Facultad de Ingeniería, Universidad Continental, Lima 15046, Perú.
[2] Ingeniería Industrial, Universidad Nacional Autónoma Altoandina de Tarma, Tarma 12651, Perú.
[3] Dirección de Investigación, Universidad Peruana de Ciencias Aplicadas (UPC), Lima 15023, Perú.

*carlos.raymundo@upc.edu.pe

Abstract. This research document on technological development is aimed at workers in small companies, those that are developing well and soon to emerge as companies that will be positioned at the top of their labor sector. Starting from the problem at present with respect to the bad manipulation of loads it is arranged to solve the problem with established objectives to try to correct the corporal posture at the time of lifting an object with a machine that replaces the functions of the worker. The design and the solution was made based on the requirements of the worker, workers who have the need to load objects at a certain height, here the man-machine relationship, demands and desires that help to achieve the general objective are analyzed. In addition, it has the main function of this machine: to lift heavy objects of up to 150 kg of mass, this due to the implementation of a hydraulic piston in the lifting platform. The appropriate solution is an adaptation of a platform in the form of a truck forming an angle of 47.17 between the structure of the truck and the horizontal surface, this position is the most adequate so that the back does not suffer injuries during the handling of loads at work. The results give assurance that it is a machine of reliability and easy handling since it only requires an operator to control the objects and a flat position on the back without damaging the spine.

1. Introduction

In certain work areas, lifting heavy objects require human effort, which may cause excessive damage to the lumbar area owing to the lack of knowledge and application of new technologies, particularly in small businesses (microenterprises). Therefore, this study aims to apply knowledge, skills, and techniques to address this issue and help workers at small booming companies, which may soon emerge as companies that will position themselves at the top of their industrial sector. Using the existing poor load handling issues as a point of departure for problem resolution, the objectives are set to correct body posture using a machine to perform all the heavy lifting tasks for the workers.

Therefore, this study uses the VDI 2221 methodology, which describes all the tools used to obtain one or multiple solutions, considers the list of requirements, explains their operation, and calculates the effort needed to lift objects and improve human work efficiencies. In the future work, this study will be responsible for implementing the technology and automation required for new jobs based on automatic control of lifting platforms, thereby replacing human effort with mechanical effort and preventing posture-related injuries resulting from lifting heavy objects.

2. State of the Art

2.1. Human posture analysis

2.1.1. Symmetry

To focus on poor posture acquired by workers when asymmetrically lifting heavy jobs at the work areas, previous studies addressed the lumbar spine compression and shear forces because of poor posture and determined that these forces majorly affect the lumbar spine during asymmetric lifting. [1] In storage, transportation, and logistics sites, where companies require workers to move, load, and lift heavy objects regularly without adequate rest, the asymmetric lifting or handling of loads helps them to reduce back pain. Assessing the relation between manual heavy object lifting and the stress exerted by compression and shear forces on the lumbar area revealed that the difference between a rookie and an experienced worker relies on knowledge, i.e., experienced workers have better knowledge; therefore, they assume better postures when loading objects. [2] (Fig.1).

The results have been measured and compared against each other, which indicated the symmetry model and angle when lifting heavy objects. Regarding the difference between the lifting techniques used by experienced workers and rookies, the rookies apply greater effort than experienced workers, which is a global issue. [3] Eventually, workers start understanding load differences, thereby performing healthy work particularly without accidents or lumbar injuries resulting from lifting heavy objects. [4] (Fig. 2).
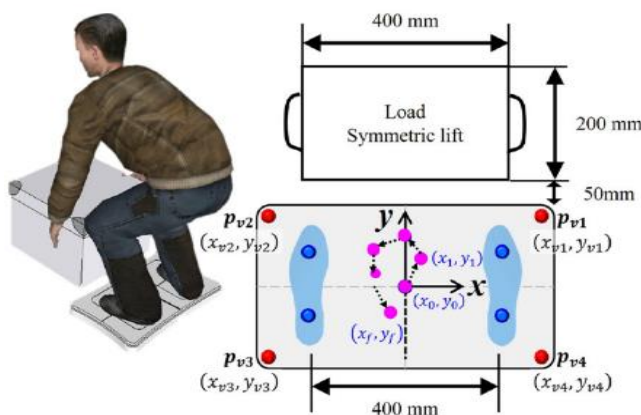

| Figure 1. Experimental Symmetry in Environments used in COP Measures | Figure 2. Symmetry Analysis through COP Locations |

2.1.2. Balance

Technological innovations have introduced robot prototypes for people with serious back issues resulting from poor lifting practices for heavy objects. Evidently, treatments had not been effective, although medicine and technology made several efforts to help the people who want to get up from bed through a metal robot support, which may understand and care for patients. This is a controversial issue because some people assert that robots must not take care of patients [5].

Back pain is the most frequent affliction in the world, often requiring a doctor or hospital care. Several doctors, employers, and employees have started using lumbar support belts to relieve some of these issues. However, the problem regarding the cost remains because numerous support belts are not very effective in eliminating or reducing back pain, particularly because employers often purchase the cheapest belt available owing to the lack of technical knowledge, which exposes them to being ripped off.

Further, assessments on the effects that are exerted on the waist by carrying heavy objects revealed that the balance is critical when moving objects, together with using adequate lumbar support belts while working. Moreover, the most affected workers, who are more likely to suffer back injuries due to poor balance and posture when loading heavy objects, are Wal-Mart employees. [6] (Fig. 3)

3. Contribution and proposed solution

This study proposes combining three machines in an unusual design to improve ergonomics and operator posture control. [7] Herein, hydraulic pistons are widely used in big cranes at work areas of large magnitude, and platforms serve to support and lift loads. Finally, the wheelbarrows currently used by microenterprises usually cause bad posture because they are used to move large and heavy objects, which eventually turn into additional weight. (Fig. 4)
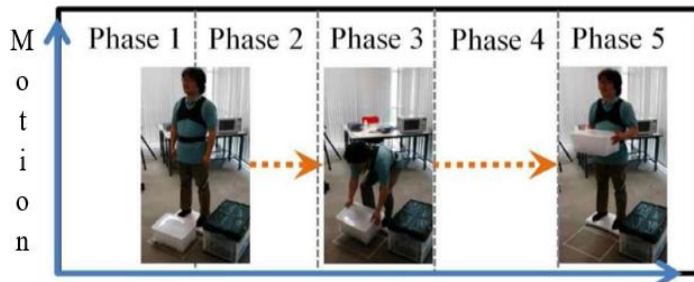

Figure 3. Experimental Study Process   **Figure 4.** Load Lifting Platform Design.

The alternative solution proposed herein is the design of a new lifting platform, which comprises three main components: wheels, metal structure, and a hydraulic piston. This new platform is collapsible, can reach up to 2 m in height, and provides stability to lift any type of heavy objects. Its design weight is 130 kg and comprises the aforementioned three components currently used. Additionally, the platform does not require much space and is the most suitable for working in small spaces. However, it requires an operator because it will be managed by a semi-automatic control guided by the operator, thereby replacing human force with hydraulic force.
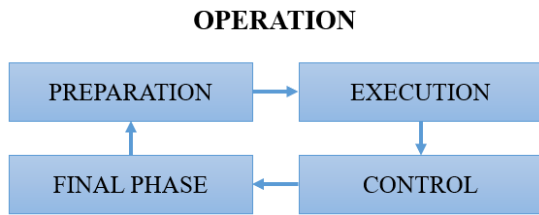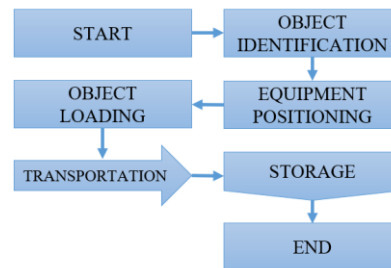
3.1. Operation

From Figure 5:

- Preparation: Object identification.
- Execution: Moving the object from point A to point B, as required by the programmer, such as operator and worker.
- Control: The procedure can be controlled through the buttons and command controls of the lifting machine.
- Final Phase: The work ends when the object is delivered to the target location.

3.2. Operation sequence

From Figure 6:

- Start: The machine uses electronic, electric, and manual controls to lift and move objects.
- Object identification: The operator identifies the object that requires lifting and moving from a specific location to another location and identifies the type of platform (i.e., basket) required.
- Equipment positioning: The operator positions the machine using the command controls and then puts the platform in place to be used for the load.
- Object loading: The operator secures the load on the platform and then proceeds to operate the machine again.
- Transportation: Moves the object from the original location to another specific location.
- Storage: Drops the load safely in the desired location and starts returning the machine.

Figure 5. Operation

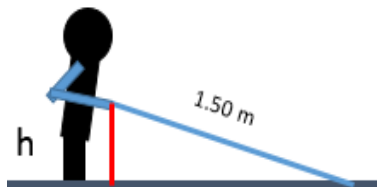**Figure 6.** Operation sequence

3.3. Calculations

3.3.1. Determination of the angle between the structure and horizontal surface
From Figure 7, herein, Structure Measurement = 1.50 m; Average people height = h = 1.10 m. Then:

$$Sin\beta = h/(Structure\ Measurement) = 1.10/1.50 ; \quad \beta = 47.17° \qquad (1)$$

3.3.2. Effort at maximum load
The calculations consider the maximum load to obtain favorable results (Fig. 8).

Figure 7. Angle between the structure and horizontal surface
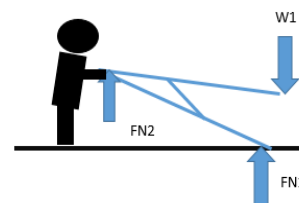
Figure 8. Effort at maximum load

Second Law of Newton: At equilibrium, the sum of the forces acting on the object equals zero.
$\sum F (Y)=0$; where W1 = 80 kg.; Then:

$$-Fw1-Fw2 + Fn1 + Fn2 = 0; \quad Fn1 + Fn2 = Fw1 + Fw2 \qquad (2)$$

$$F = m * g \qquad (3)$$

Replacing data:

$$Fw1 = 80\ kg * 9.8182\ m/s\char`^2 = 784,8\ N; \quad Fw2 = 50\ kg * 9.8182\ m/s\char`^2 = 490.91\ N \qquad (4)$$

Then, replacing in (2)

$$Fn1 + Fn2 = Fw1 + Fw2 = 784,8 + 490.91 = 1275.71\ N$$

To calculate the force exerted on the piston to reach equilibrium (Fig. 9),

$$\sum F(Y) = 0; \quad -Fw1-Fw2 + Fn1 + Fn2 + Fpsen30 = 0;$$
$$Fn1 + Fn2 + Fpsen30 = +Fw1 + Fw2 \qquad (5)$$

We will find the starting force to determine the force exerted on the piston:

$$\sum Fpw(Y) = 0 ; \quad Fpw = 7348;$$
$$\sum Fpipw(Y) = 0 \quad ; \quad -Fpwsen30-Fpsen45 = 0;$$
$$Fp\ sen45 = Fpwsen30; \quad Fp = 5195\ N;$$

Then, it is replaced in

$$Fn1 + Fn2 + Fpsen30 = +Fw1 + Fw2; \qquad (6)$$
$$Fn1 + Fn2 = -3920N$$

System of equations between (4) and (6)

$$Fn1 + Fn2 = 1275.71; -Fn1 + Fn2 = -3920N$$
$$F1 = -1322; F2 = 2597 \qquad (7)$$
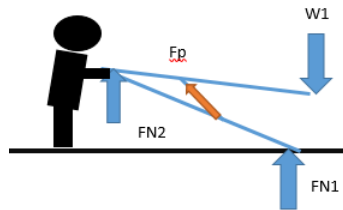
3.3.3. Piston speed in the cylinder

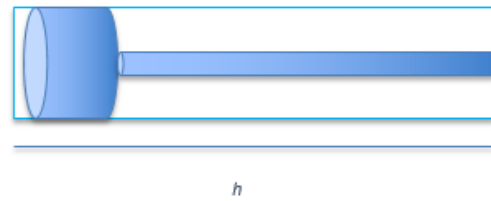**Figure 9.** Force exerted on the piston to reach equilibrium

Figure 10. Piston speed in the cylinder

$$P = F/A \qquad (8)$$

Development of pressure in the cylinder: F = 2550N; A=2pulg <> 0,0508

$$F = P * A \quad ; \quad 2550 = P * (\pi * d^2)/4 \quad ; \quad P = 12\,4827,05 \approx 20PSI \qquad (9)$$

NOTE. This is the piston pressure at equilibrium. For upwards movements, an additional 25% pressure must be supplied so that the piston may move the load. We will use the simple rule of three:

$$X = (2550N * 25)/100 = 637,5 \; N \qquad (10)$$

Total force required to lift 80 kg in weight: F = 3187.5 N at P = 40 PSI

Finally, the speed of a cylinder

$$V = v/A \qquad (11)$$

Where: V = Speed (m/min); v = Volume (m^3); A = Area (m^2)

$$V = \frac{\pi * r^2 * h}{\frac{\pi * d^2}{4}} \qquad (12)$$

h = 50 cm <> 0.5 m ; dp = 2pulg <> 0.0508

$$V = \frac{\pi * \left(\frac{0.051}{2}\right)^2 * 0.5}{\frac{\pi * 0.051^2}{4}} = 0.5 \frac{m}{min} <> 50 \; cm/min$$

The calculated speed is as expected because as engagement time decreases for the workers, productivity increases.

4. Simulation

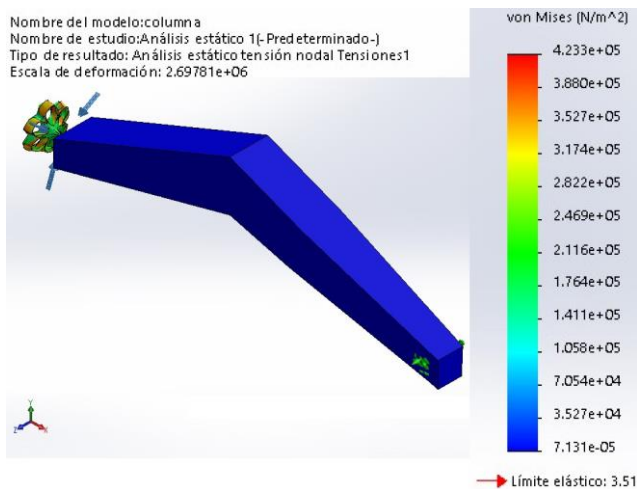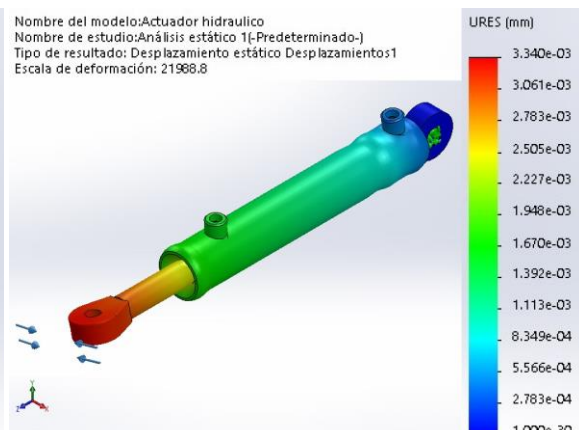

Figure 11. Simulation - Columna

Figure 12. Simulation – Actuador hidraulico
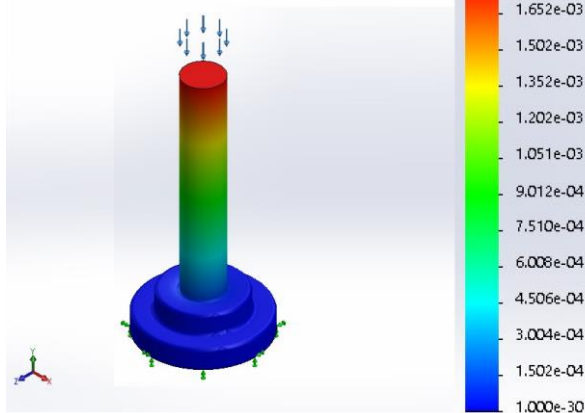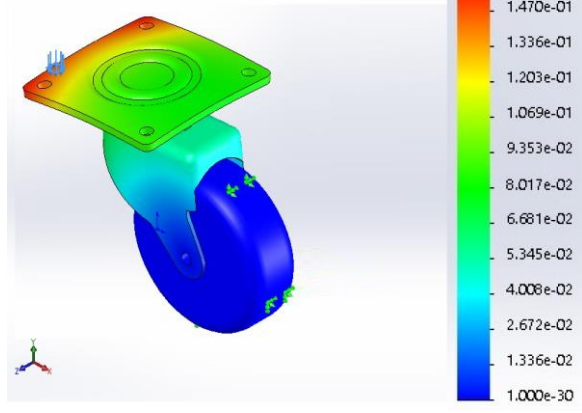
Figure 13. Simulation - Soporte

Figure 14. Simulation - Llanta

5. Conclusions

- The best lifting mechanisms are operated at high pressure, whether hydraulic or pneumatic, using extremely high compressed pressure to lift heavy objects to a certain height, thereby reducing engagement time for workers.
- Warehouse dimensions are often restricted in microenterprises, which prompted the design of a machine with specific dimensions that can replace one of the workers.
- The material used to store heavy objects is wood because its Britney hardness is 1 to 7 HB. However, this material is weak during several environmental conditions, such as rain. Additionally, it bumps when moving loads, thereby causing it to lose its original properties.

References

[1] JEONG, H. y OHNO, Y., 2017. Symmetric lifting posture recognition of skilled experts with linear discriminant analysis by center-of-pressure velocity. Intelligent Service Robotics, vol. 10, no. 4, pp. 323-332. ISSN 18612784. DOI 10.1007/s11370-017-0227-8.

[2] JEONG, H., YAMADA, K., KIDO, M., OHNO, Y., WATANABE, S. y NOMURA, T., 2016. Analysis of Center of Pressure Location during Asymmetric Lifting. Proceedings - 2015 IEEE International Conference on Systems, Man, and Cybernetics, SMC 2015, pp. 2471-2474. DOI 10.1109/SMC.2015.432.

[3] WATANABE, S., TORIGAI, K., HAYASHI, M., JEONG, H., SHIMIZU, S., KIDO, M., NOMURA, T., MIYOSHI, E., YAMADA, K. y OHNO, Y., 2015. A difference of human posture between beginner and expert during lifting a heavy load. BMEiCON 2014 - 7th Biomedical Engineering International Conference, pp. 1-5. DOI 10.1109/BMEiCON.2014.7017388.

[4] JEONG, H., YAMADA, K., KIDO, M., OKADA, S., NOMURA, T. y OHNO, Y., 2016. Analysis of Difference in Center-of-Pressure Positions between Experts and Novices during Asymmetric Lifting. IEEE Journal of Translational Engineering in Health and Medicine, vol. 4, no. August 2015. ISSN 21682372. DOI 10.1109/JTEHM.2016.2599185.

[5] WANG, T., JEONG, H. y OHNO, Y., 2017. Evaluation of Self-Reliance Support Robot Through Relative Phase. IEEE Access, vol. 5, pp. 17816-17823. ISSN 21693536. DOI 10.1109/ACCESS.2017.2747841.

[6] SHIMIZU, S., JEONG, H., KIDO, M., MIYOSHI, E., YAMADA, K., OHNO, Y., NOMURA, T., WATANABE, S., TORIGAI, K. y HAYASHI, M., 2015. Effectiveness evaluation of waist support tool through human posture balance. BMEiCON 2014 - 7th Biomedical Engineering International Conference, DOI 10.1109/BMEiCON.2014.7017387.

[7] VASQUEZ TORRES, E.L., 2013. SAE 1020 y SAE 1045. [en línea], pp. 6. Disponible en: https://repository.unilibre.edu.co/bitstream/handle/10901/7826/VasquezTorresEdwinLibardo2013 Anexos.pdf?sequence=2.