International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 4513-4517

A Development of Mechanical Arm for Weight Scale Calibration

Pattaraweerin Woraratsoontorn

Department of Industrial Physics and Medical Instrumentation, Faculty of Applied Science,
King Mongkut's University of Technology North Bangkok, Bangkok, 10800, Thailand.

Abstract

In weight scale calibration, the staff that carries the heavy standard weight can be possibly injured. For preventing that health problem, this research aims to design and construct the mechanical arm for the weight scale calibration that consists of the programmable logic controller (PLC) for controlling the operation and touch screen. Three stepping motors were used to control left-right movements on linear slide, up-down movements corresponding to moving of the spiral rod and forward-backward movements of all four wheels. The working of the solenoid valve caused the gripper in a hand section assembled on the mechanical arm that was able to hold or release the standard weight for the weight scale calibration. From the result of performance testing, the designed and constructed mechanical arm for weight scale calibration can carried maximum standard weight at 2 kilograms corresponding to the previous study. However, the movement was more efficient because all of the wheels have a smooth movement significantly. In addition, the mechanical arm developed was more convenient to use because of without air pump to control the gripper.

Keywords: mechanical arm, calibration, weight scale, PLC

INTRODUCTION

Calibration is a process in metrology; it is a set of operations under specific conditions to determine the correlation between a value from measuring instrument and a standard value [1]. The result from calibration can evaluate suitability in metrological characteristics of the measuring instrument. According to the standard, the calibration process and acceptable tolerance are defined. The calibrated measuring instrument will receive an inspection certificate or a calibration certificate [2]. In the certificate, there are some specific properties of the measuring instrument such as; range, resolution, accuracy, and suitable environment for working such as temperature and humidity. Therefore, the calibration is important for ensuring the results from all types of measuring instrument such as; production process measuring instrument, testing instrument, and analytical instrument. The most important factors that make the measuring result reliable are the correct and accuracy of measurement process, which suitable for working. In the first phase, the calibration cycle of a weight scale should be appointed in once a year or more. A changing rate of measurement value should not exceed the defined value.

Calibration of medical instrument is a standard of medical instrument quality enhancement, which provides the medical analysis, diagnosis, and treatment efficiently. Calibration of medical instrument ensures that the instrument can work properly quality and reliable. A weight scale is a type of medical instrument that need to be calibrated as well. Firstly, the weight scale is adjusted to be zero, then, put the standard weight at a middle point of the weight scale, and then, wait until a displayed value or a needle stop moving. Calibrate at least 3 times for each position including data record.

There are 3 steps of calibration method for medical weight scale as;

1. The standard weight preparation step, the standard weight is appropriately selected with a measurement range of the weight scale.
2. The weight scale preparation,
   - 2.1 Clean the weight scale, remove dusty by brush especially at the balance plate.
   - 2.2 Put the weight scale on a horizontal flat surface.
   - 2.3 Turn on and warming the weight scale for stable working.
   - 2.4 Set up working mode of the weight scale.
3. The repeatability step,
   - 3.1 Put the standard weight on the balance plate of the weight scale.
   - 3.2 Read the measured value of weight on the display.
   - 3.3 Repeat steps 3.1 – 3.2 twice, and collect the data in the recode sheet.

An acceptable value is based on the size and type of the weight scale as shown in Table 1. If the measured value does not correspond to the acceptable value, keep following an unexpected situation procedure.

Table 1 The acceptable values of the weight scale calibration

Medical instruments	Calibration range (g)	Acceptable value (g)
The weight scale for adults	1-1000	± 500
The weight scale for children	500 – 5000	± 100
The weight scale for objects	500 – 5000	± 10

The standard weight which is used for calibration has the maximum weight at 100 kg. If the medical staff or the calibration staff lifts it up for many times in wrong action or too quickly, maybe these cause them to be ergonomics and musculoskeletal disorders. This research aims to design and to construct a mechanical arm for weight scale calibration which can lift the standard weight up from one place to the weight scale according to the calibration position for preventing health problems of the staffs. Moreover, the mechanical arm may help hospitals in the case that they have enough budgets and ready to buy the standard weight for calibrating by them, but there are not enough staffs or the potential staff who can lift the heavy weight up. In previous investigation, there are many obstacles in the mechanical arm constructed. Especially, a large air pump was used to control the gripper in holding and releasing of the standard weight that caused to be complex to use and to remove; and costly. The forward-backward movements of all four wheels were not smooth and discontinuous. The entire component was controlled by mechanical system. Moreover, it was able to lift the maximum 2 kg weight up only. Consequently, discussed mechanical arm should be developed for more efficacy in this research.

METHODOLOGY

A mechanical arm consists of many parts, which have different functions according to their features and purposes of works. Figure 1 shows a block diagram of the mechanical arm for lifting the standard weight up in the weight scale calibration that was designed and constructed in this research.

Considering the block diagram of a mechanism of the mechanical arm for lifting the standard weight up in the weight scale calibration, a 220 VAC main supply was used to apply the circuit board. Actually, the different circuits assembled in this system cannot be supplied 220 VAC directly, therefore, a regulator was needed to regulate 220 VAC to 24 VDC. There are 3 components which are supplied by 24 VDC as followed: the first, a touch screen display is an input component for user to command the mechanical arm movement. The second, PLC is a controller to control the stepping motor driver for driving the stepping motor that related to different directions of the mechanical arm motion. The third, a relay controls the on-off system of solenoid valve to hold and release the standard weight. Moreover, there is a transformer, which transforms 220 VAC to 110 VAC for supplying three stepping motors. The first stepping motor controls the forward-backward movement of the mechanical arm, and the another two control the upward-downward and leftward-rightward movement, respectively.

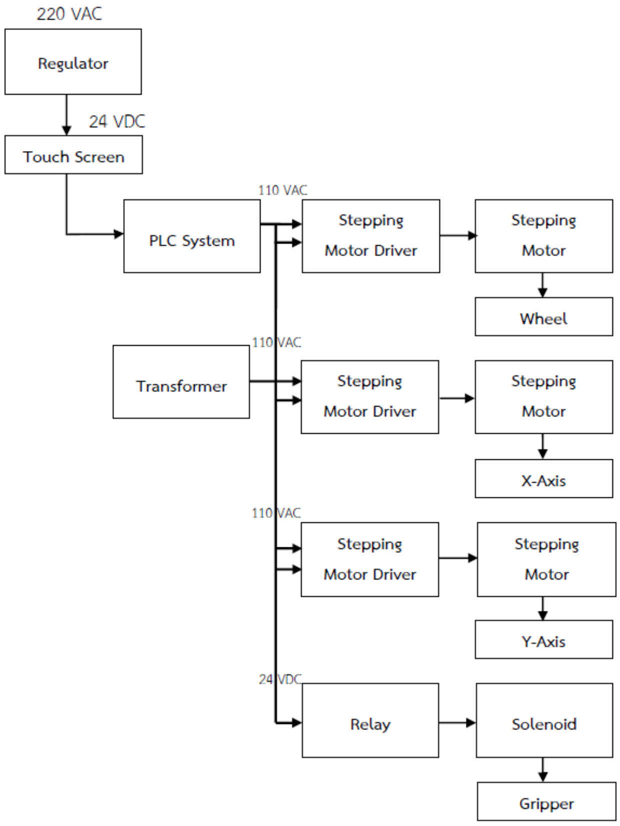

Figure 1: Block diagram of a mechanism of the mechanical arm for lifting the standard weight up in the weight scale calibration

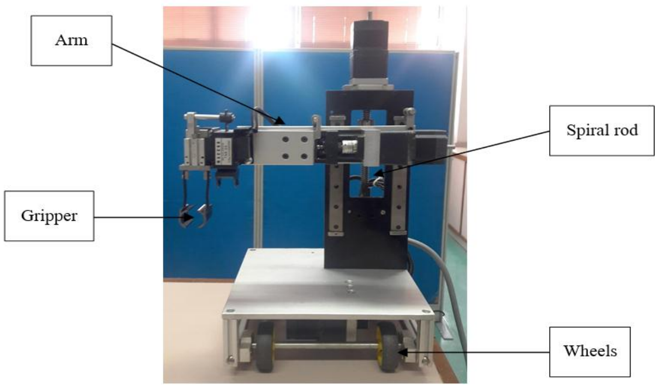

Figure 2: The components of the mechanical arm for lifting the standard weight up in the weight scale calibration task

Figure 2 shows the feature and components of the designed and constructed mechanical arm for weight scale calibration. There are four important parts as follows: The arm that moves along the X-axis (horizontal) as shown in Figure 3. The spiral rod that moves along the Y-axis (vertical) as shown in Figure 4, the gripper that holds and releases the standard weight as shown in Figure 5, and finally, the 4 wheels that were set up under the base of the mechanical arm for moving to other places.

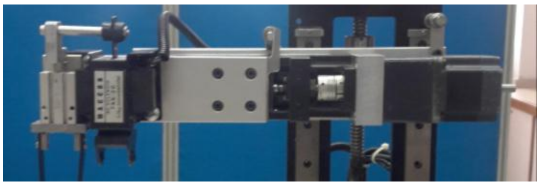

Figure 3: The arm rod or linear slide for leftward-rightward movement of the mechanical arm for seeking the standard weight in the weight scale calibration

Figure 4: The spiral rod for upward-downward movement of the mechanical arm for lifting the standard weight up in the weight scale calibration

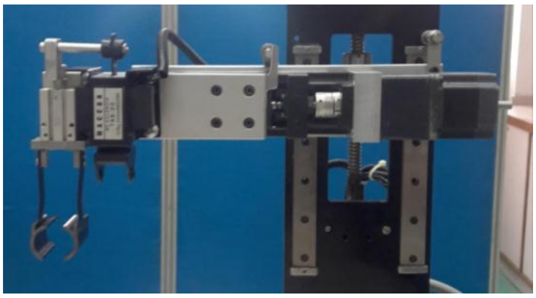

Figure 5: The gripper of the mechanical arm for holding and releasing of the standard weight in the weight scale calibration

Each component can be controlled by a command from the touch screen display. The control program was designed into four instruction sets as followed; Manual, Automatic, Setting, and Monitor as shown in Figure 6.

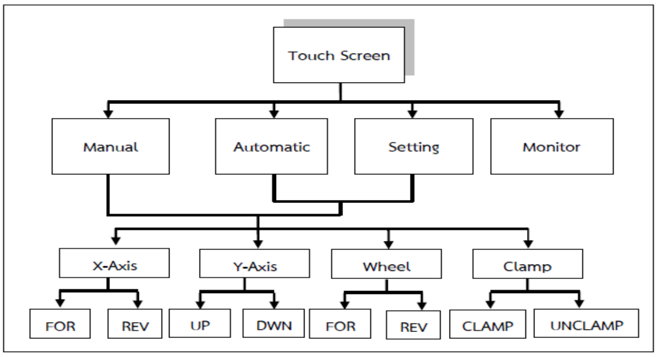

Figure 6: The instruction diagram of the touch screen monitor

When the switch in the control box is turned on, the touch screen display shows the four instruction sets (Manual, Automatic, Setting, and Monitor) as shown in Figure 7. The mechanical arm can operate with command in two instruction sets as Manual Mode and Auto Mode.

Figure 7: Instruction set on the touch screen display

Considering in Manual Mode, when tapping the manual mode function, the mechanical arm control window will appear as shown in Figure 8. The mechanical arm movement can be controlled from this window. The control functions were created on the PLC system for controlling each stepping motor in order that relate to movement of the mechanical arm. Therefore, each function on the screen can control each movement part such as; the movement along the X-axis, the Y-Axis, the movement of wheels and hand (gripper).

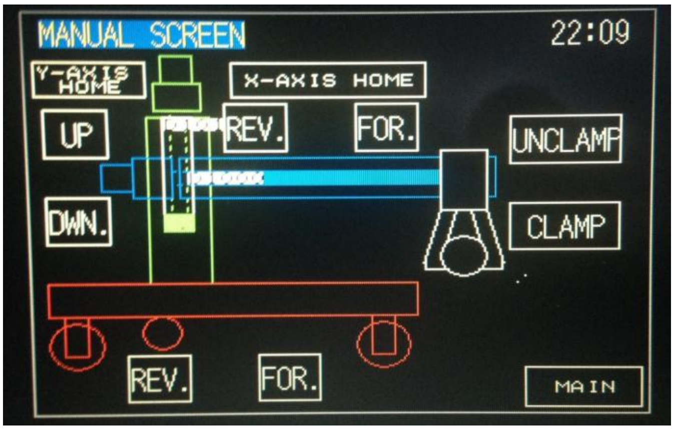

Figure 8: The Manual Mode window of the mechanical arm for lifting the standard weight up

The operation control procedures of mechanical arm for lifting the standard weight up in the weight scale calibration are;

a) Tapping “FOR” function at the X-AXIS zone for moving the arm forward,

b) Tapping “REV” function at the X-AXIS zone for moving the arm backward,

c) Tapping "UP" function at the Y-AXIS zone for moving the arm upward,

d) Tapping "DWN" function at the Y-AXIS zone for moving the arm downward,

e) Tapping "FOR" function at the WHEEL zone for moving the system forward,

f) Tapping "REV" function at the WHEEL zone for moving the system backward,

g) Tapping "CLAMP" function at the GRIPPER zone for controlling the hand to hold an object, and

h) Tapping "UNCLAMP" function at the GRIPPER zone for controlling the hand to release an object.

RESULTS

Considering in the control testing, each function on the screen was touched, and then, the responsibility on the mechanical arm was observed. According to all of the mechanical arm movements as Manual Mode, Auto Mode, Setting, and Monitor were considered. Table 2 shows that all modes on touch screen display could operate normally.

Table 2 The results obtained from touch screen responsibility testing on the different modes of the designed and constructed mechanical arm

Control Testing	**Touch Screen Responsibility**		
	Number of Testing		
	1	2	3
Tapping Manual Mode functions	✓	✓	✓
Tapping Auto Mode functions	✓	✓	✓
Tapping Setting functions	✓	✓	✓
Tapping Monitor functions	✓	✓	✓

Considering the movement capabilities of the mechanical arm, each function on the screen was touched, and then, the responsibility on the mechanical arm was observed. According to all of the mechanical arm movements as X-axis, Y-axis, wheel, and holding-releasing the object were considered; the results are shown in Table 3. It revealed that the designed and constructed mechanical arm were able to move with all on-screen instructions and holding-releasing the standard weight.

Table 3 The results obtained from movement capabilities testing along different axes and holding-releasing the standard weight of the designed and constructed mechanical arm

Movement Testing	**Capabilities**		
	Number of testing		
	1	**2**	**3**
Movement along the X-axis	✓	✓	✓
Movement along the Y-axis	✓	✓	✓
Movement along the Z-axis (Wheel)	✓	✓	✓
Holding-Releasing the standard weight	✓	✓	✓

Considering the lifting up efficiency, the standard weights of 1 to 3,000 grams (3 kg) were used for the lift up testing, each weight was tested for 3 times, and the results are shown in Table 4.

Table 4 The results from lift up efficiency testing of the designed and constructed mechanical arm

Weight (gram)	**Lift up efficiency**		
	Number of Testing		
	1	**2**	**3**
1	✓	✓	✓
5	✓	✓	✓
10	✓	✓	✓
20	✓	✓	✓
50	✓	✓	✓
100	✓	✓	✓
200	✓	✓	✓
500	✓	✓	✓
1000	✓	✓	✓
2000	✓	✓	✓
3000	✗	✗	✗

From the lift up efficiency testing results, it was found that the maximum weight of the designed and constructed mechanical arm can lift up was 2 kg.

CONCLUSION

The performance of designed and constructed mechanical arm in this investigation has more powerful than in the past research. Obviously, it was more compact and convenient to use because of the PLC was used instead of a large air pump to control the gripper in holding and releasing of the standard weight. The forward-backward movements of all four wheels were smooth and continuous. In addition, it can move along the X-axis, Y-axis, including Z-axis. Their movements can be controlled by the commands from the touch screen display which can operate two modes (Manual Mode and Auto Mode). All of control devices were contained in the control box. In contrast, the lifting efficiency the standard weight up in the weight scale calibration was not improved, it could lift the 2-kg weight up only like the previous investigation due to not change the gripper structure.

DISCUSSION

This designed and constructed mechanical arm for lifting the standard weight up in the weight scale calibration can be considered as a prototype system. However, there are many disadvantages of mechanical arm in this study that would be studied in the future work. The lifting up efficiency should be improved first. The gripper structure may be developed for carrying a heavy load. Furthermore, the movement around the Y-axis for flexibility in searching the standard weight, construction of the smaller control device and the mechanical arm should be improved for more convenient to use and move.

REFERENCES

[1] Medical Engineering Division. (2013). [Online]. The meaning of Calibration. [Retrieved on May 20, 2017]. From http://medi.moph. go.th/ system2533/Masses-Calibration.pdf.

[2] Tanyarat, and Anusorn Tonmuanwai. (2013). [Online]. Why does it have to calibrate? [Retrieved on April 25, 2017]. From http://www.mi t.in.th/htmlthai/knowledge/detail/index.php?kn=8.