SSRG International Journal of Electrical and Electronics Engineering
ISSN: 2348-8379/ https://doi.org/10.14445/23488379/IJEEE-V11I7P128

Volume 11 Issue 7, 312-316, July 2024
© 2024 Seventh Sense Research Group®

Original Article

Precision Measurement of Tablet Characteristics: A Digital Device Approach

Milind S. Narlawar[1], Reema Roychaudhary[2], Poorvi K. Joshi[3], Pradnya Morey[4], Vishal Yadav[5]

[1]*Yeshwantrao Chavan College of Engineering, Maharashtra, India.*
[2]*St. Vincent Pallotti College of Engineering and Technology, Maharashtra, India*
[3,5]*Shri Ramdeobaba College of Engineering and Management, Maharashtra, India.*

[3]*Corresponding Author : joshipk@rknec.edu*

Received: 13 May 2024 Revised: 16 June 2024 Accepted: 13 July 2024 Published: 26 July 2024

Abstract *- Accurate tablet hardness and diameter measurements are critical to pharmaceutical quality control. However, traditional weight-based calibration techniques faced considerable difficulties because of the built-in limitations of the tablet hardness tests that are now on the market, particularly the small size of the force sensor housing. The hardness, diameter, and thickness of tablets are the primary focus of this comprehensive analysis. A sophisticated arm-mounted force application system, powered by a 50 kg load cell, measures tablet hardness in newtons as force is incrementally increased until the tablet fractures. Precise tablet dimensions are captured using two potentiometers functioning as variable resistors, ensuring accurate measurements of thickness and diameter. The experimental process involves meticulous calibration followed by individual tablet testing to record tablet properties accurately. Validation against established benchmarks confirms the reliability and accuracy of this approach. This study offers a robust method for thorough tablet assessment, ensuring accuracy and consistency in evaluating tablet characteristics, particularly in hardness, diameter, and thickness. Accurate measurement of these properties is critical for pharmaceutical quality control, and this research introduces a novel strategy integrating innovative technology with precise procedures to ensure consistent and reliable evaluations.*

Keywords *- Tablet hardness tester, Thickness measurement device for tablets, Diameter measurement tool for tablets, Digital tablet characterization equipment.*

1. Introduction

The evaluation of tablet characteristics such as hardness, thickness, and diameter stands as a fundamental pillar in pharmaceutical quality assessment [1, 2]. An essential part of pharmaceutical quality control is the accurate assessment of tablet properties, which has a big impact on the stability, efficacy, and dependability of drugs [3, 4].

Assessing characteristics such as hardness, thickness, and diameter is essential because they are basic markers of a tablet's performance and quality [6]. However, due to limitations in current instrumentation and assessment tools, conventional ways to quantify these features have inherent problems [7]. This work presents a novel digital tool intended to transform the tablet property measurement procedure to overcome these constraints [8].

This cutting-edge tool's main goal is to improve assessments greatly. This novel instrument aims to greatly improve tablet hardness, thickness, and diameter measurements in terms of precision, speed, and dependability [8, 10].

Strict quality standards in the pharmaceutical production industry guarantee the reliable distribution of safe and efficient drugs across the globe [11]. Modern technology improvements could significantly enhance pharmaceutical quality control processes when used in tablet property evaluation [12].

The purpose of this study is to investigate the difficulties and complexities present in the tablet property evaluation techniques used today [13]. The goal is to address the drawbacks of conventional assessment tools by adding a state-of-the-art electronic device [14]. Through the use of precise measurement techniques and technological breakthroughs, this device aims to offer a comprehensive and reliable solution for accurate and efficient tablet property evaluation [15].

2. Literature Review

Otsuka et al. (2006) investigate tablet hardness in pharmaceutical manufacture, predicting it based on raw mixed powder characteristics using chemometrics and NIR spectroscopy. They look at the effects of lubricants, which are essential to the production of tablets, and discover that longer

This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

mixing, particularly after lubricant addition, lessens the hardness of the tablets. Their research highlights the critical role of lubrication and the effectiveness of NIR spectroscopy in understanding tablet properties. It also sheds light on the critical mixing process, develops predictive models via principal component regression, and identifies ingredient patterns affecting tablet hardness [1].

Chaturvedi et al. (2017), maintaining tablet efficacy and quality depends critically on post-compression evaluation parameters. Their thorough analysis emphasizes how important it is to evaluate the chemical, physical, and bioavailability characteristics that are essential for pharmaceutical integrity. The study highlights the need to adhere to pharmacopeial criteria to ensure consistent tablet quality, highlighting important factors such as size, shape, weight, hardness, disintegration, and dissolving properties. It emphasizes how important it is to keep manufacturing uniformity between batches, particularly with regard to dimensions and form, in order to meet strict quality requirements all the way through the production process [2].

Ficzere et al. (2022) measured the thickness of film-coated tablets and looked for flaws using machine vision and deep learning. Their work showcased possible improvements in pharmaceutical quality control by demonstrating real-time capabilities in accurate measurement and defect recognition. Pharmaceutical formulations can be made with sustained quality by optimizing tablet manufacture and efficacy with further developments in analysis procedures [3].

Nurjanah et al. (2023) highlight the value of the direct compression method because of its affordability and ease of use in the manufacturing of Chlorpheniramine Maleate (CTM) tablets. Accurate excipient selection guarantees consistent drug dispersion, which is essential for effective compaction. In order to maximize tablet qualities, researchers investigate different excipients, with an emphasis on improving disintegration and dissolve rates. Important factors include quality, strength, dosing accuracy, and appearance (dimensions, weight consistency, tablet hardness, and friability). The goal of research on excipient selection and compression force modifications is to produce CTM tablets that are reliable and long-lasting [4].

Wang et al. (2021) work streamlines and simplifies the tablet hardness calibration procedure by using a unique counter-force calibration approach that uses a static standard dynamometer. It complies with traceability requirements and provides a workable answer to the challenges posed by conventional techniques. This breakthrough greatly enhances pharmaceutical quality control, reinventing the calibration of hardness testers and possibly elevating industry standards for tablet quality assurance [6].

Fell et al. (1965) use the diametral-compression test to examine tablet strength in order to control pharmaceutical quality. They emphasize optimal line loading for precision by analyzing the intricacies of stress distribution during compression. The study emphasizes the significance of visual inspection and outlines three forms of tablet failure. For accurate assessments of strength, it highlights the importance of carefully considering test conditions [7].

National Pharmacopoeia Commission wrote the "Pharmacopoeia of the People's Republic of China," which was released in (2015) by China Medical Science and Technology Press. It contains extensive guidelines for medications. It sets standards for the composition, potency, purity, and quality of drugs and acts as a cornerstone of Chinese healthcare regulations. By guiding manufacturers, regulators, and healthcare professionals, this reputable journal guarantees the safety, efficacy, and consistency of pharmaceutical products. Frequent revisions take into account new developments in science and technology, which have an impact on international pharmaceutical standards and practices [8].

3. Methodology

3.1. Tablet Hardness Measurement

The tablet hardness assessment involves an innovative arm-mounted force application system meticulously designed for controlled force application during tablet hardness evaluation. The system, as shown in Figure 1, precisely administers force to the tablet, incrementally increasing it until the tablet fractures. Throughout this process, a highly sensitive load cell, capable of detecting forces up to 50kg, precisely measures the applied force. The load cell readings are meticulously processed and prominently displayed on an LCD panel, providing an accurate and immediate indication of the force at which the tablet fractures. This meticulous process delivers a high-precision measurement of tablet hardness in newtons, as shown in Figure 2.

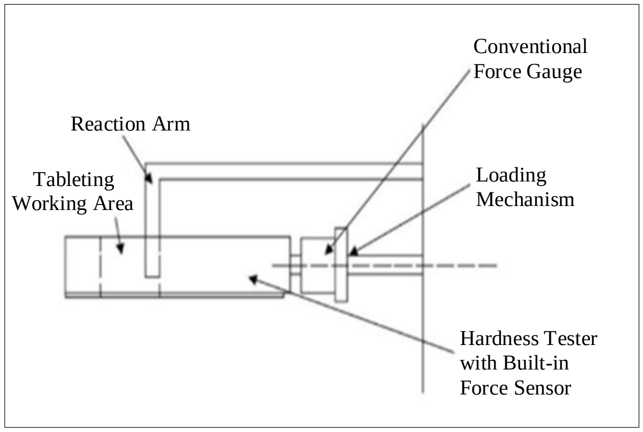

Fig. 1 Tablet hardness measurement principle

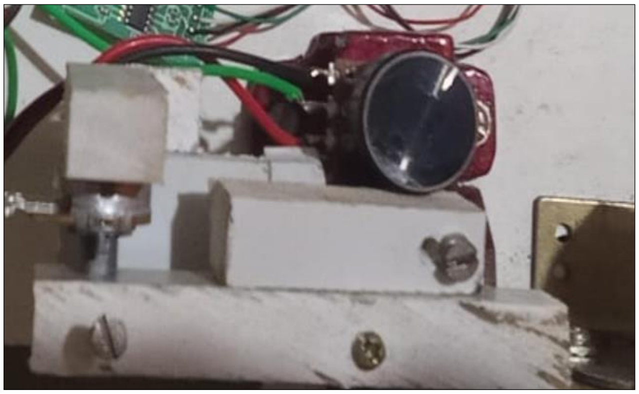

Fig. 2 Tablet hardness measurement system

3.2. Measurement of Tablet Diameter and Thickness

The determination of tablet dimensions-diameter and thickness-utilizes a unique approach employing two potentiometers operating as variable resistors. Strategically positioned around the tablet, these potentiometers rotate to measure the distances corresponding to the tablet's dimensions. To determine the tablet's diameter, one potentiometer captures the circular perimeter of the tablet, as shown in Figure 3.

Simultaneously, the other potentiometer, moving linearly across the tablet's surface, measures its thickness. These potentiometers undergo meticulous calibration to ensure precise distance measurement as they rotate around the tablet. The acquired data from these potentiometers is then meticulously processed to calculate the tablet's diameter and thickness with exceptional accuracy.

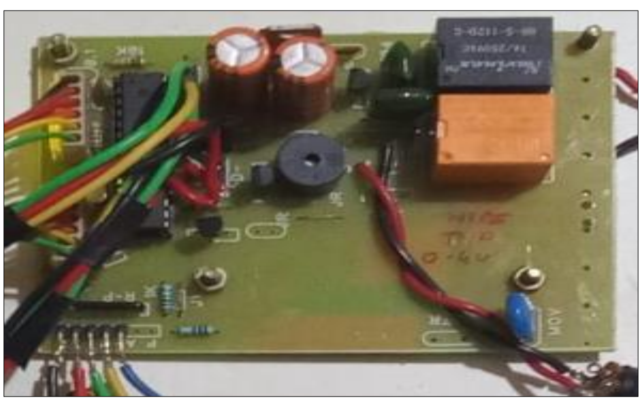

Fig. 3 Tablet diameter and thickness measurement system

3.3. Hardware Configuration

During the trial run deployment, accurate tablet evaluation necessitates a meticulous approach. Initially, individual tablets undergo hardness tests using the arm-mounted force application equipment. Gradually applied force continues until tablet fracture, meticulously documented through simultaneous LCDs and precise load cell measurements. Strategically positioning potentiometers around tablets initiates the measurement process for tablet thickness and diameter. These potentiometers methodically execute rotations and linear movements to measure distances. One potentiometer's rotation captures tablet diameter, while the other's linear movement evaluates thickness.

The precision of tablet dimension measurements is ensured by carefully calibrated potentiometers, guaranteeing accurate future calculations. Integral to the procedure is the extensive data collection facilitated by the micro-controller. This system records and processes measurements from potentiometers, load cells, and related sensors. Real-time display on the LCD enables immediate observation, while concurrent data storage allows comprehensive examination later.

Calibration and validation phases are vital to ensure measurement precision and reliability. The entire system undergoes rigorous calibration before experimentation to ensure utmost accuracy. Post-experiment measurements undergo careful validation by comparing them to established methods or values. This methodical process substantiates the reliability, validity, and precision of the obtained measures, affirming the integrity of the assessment process.

3.4. Tablet Hardness Measurement

In the process of tablet hardness measurement, the hardware setup is meticulously designed to ensure accurate and reliable results, as shown in Figure 4. Integrating a load cell capable of detecting forces up to 50kg into the arm-mounted force application system forms the crux of this setup.

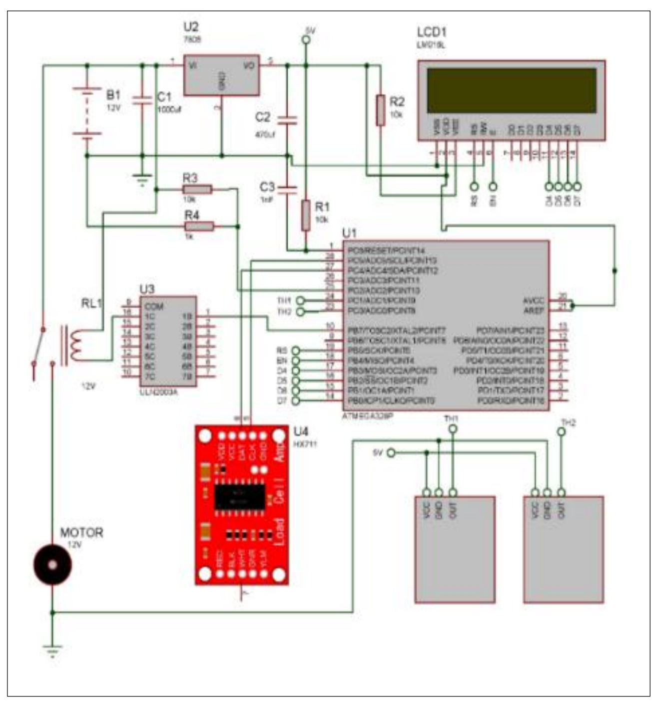

Fig. 4 Tablet hardness measurement circuit diagram

This load cell is seamlessly connected to a micro-controller, specifically the Atmega 328, enabling precise measurement of the applied force. To provide real-time insights, an LCD Display 16x2 is intricately linked to the micro-controller, offering instantaneous readings of the force exerted during tablet hardness testing. Execution of the hardness measurement process involves several key steps.

Initially, the arm-mounted system undergoes meticulous calibration to ascertain the accuracy of force application. Subsequently, individual tablets are placed beneath the arm for testing. The system systematically applies controlled force in incremental steps until the tablet fractures. Throughout this process, the load cell continuously records and transmits force data to the micro-controller, ensuring accurate measurements.

The culmination of the process lies in the data output phase. The micro-controller processes the load cell data and promptly showcases the applied force on the LCD panel in newtons. This real-time display represents the precise hardness value at which the tablet fractures, offering valuable insights into the tablet's structural integrity and strength.

3.5. Measurement of Tablet Diameter and Thickness

The accurate measurement of tablet dimensions, specifically diameter and thickness, relies on a methodical process and precise hardware configuration. This measurement setup involves two potentiometers meticulously positioned around the tablet. These potentiometers, functioning as variable resistors, undergo meticulous calibration to ensure their accuracy in measuring distances. In the execution phase, the measurement process unfolds systematically. One of the potentiometers executes rotational movements around the tablet's circular perimeter, capturing the tablet's diameter accurately.

Simultaneously, the second potentiometer moves linearly across the tablet's surface, providing precise measurements of its thickness. The crux of the process lies in the data acquisition phase. The rotational and linear movements executed by the potentiometers are meticulously recorded and captured. Subsequently, this data undergoes comprehensive processing to calculate the tablet's diameter and thickness with exceptional precision and accuracy. This method offers a thorough and reliable means to ascertain crucial tablet dimensions, ensuring that pharmaceutical researchers and manufacturers acquire precise information regarding the tablet's structural attributes.

3.6. Calibration and Data Collection

The calibration process stands as a foundational step, subjecting the entire hardware setup to rigorous calibration before any experimental execution commences. This meticulous calibration guarantees that the measurements obtained are precise and align with the desired accuracy standards. Following the experiment, the acquired data undergoes a thorough validation procedure. This involves cross-referencing the collected data against established standards or known values to authenticate its accuracy and reliability.

This step ensures that the measurements obtained are consistent and align with accepted norms, bolstering the credibility of the results. In the realm of data collection and analysis, a systematic approach is employed. The micro-controller serves as the central hub, diligently collecting and processing data from various sources such as load cells, potentiometers, and other sensors.

This comprehensive data collection enables a holistic understanding of the experimental parameters. The real-time display feature integrated into the system promptly showcases all processed data on the LCD screen. This real-time monitoring capability facilitates immediate observations and records of ongoing measurements.

Furthermore, the micro-controller undertakes the responsibility of data storage, archiving all acquired data for in-depth analysis and subsequent scientific interpretation. This archived data serves as a valuable resource for comprehensive post-experiment analysis, allowing researchers to derive meaningful insights and draw accurate conclusions from the experimental findings.

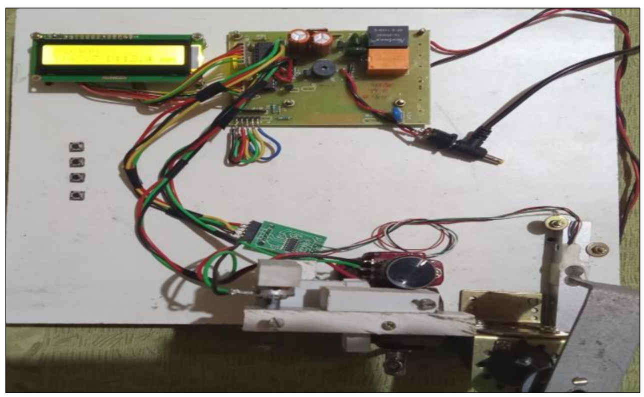

Fig. 5 Hardware implementation of device

Fig. 6 Output of device

4. Result and Conclusion

A tablet evaluation system with substantial hardware improvements was developed (Figures 5 and 6 shows the real-time output of the system. Precise potentiometers on the accompanying arm-mounted force application equipment allowed for thorough tablet property measurements.

A 50 kg load cell and an Atmega 328 micro-controller were used to provide real-time controlled force measurement for tablet hardness. Potentiometers, which were then verified by calibration processes, guaranteed precise tablet dimension readings. Measurement reliability was strengthened during the calibration and validation processes. Multiple sensor data sets were processed by the central micro-controller, allowing for both in-the-moment observations and comprehensive post-experiment analysis. The study presents a sophisticated hardware setup and methodology for accurate tablet evaluation, including thickness, hardness, and diameter measurements. To overcome the shortcomings of traditional pharmaceutical quality control, this integrated system showed incredible accuracy and dependability.

Both the arm-mounted force application tool and the potentiometer-based equipment produced consistently accurate tablet property measurements. Prompt observations and thorough post-experiment analysis were made possible by real-time data display (Figure 6), greatly increasing their utility in pharmaceutical research.

References

[1] Makoto Otsuka, and Ikuro Yamane, “Prediction of Tablet Hardness Based on Near Infrared Spectra of Raw Mixed Powders by Chemometrics,” *Journal of Pharmaceutical Sciences*, vol. 95, no. 7, pp. 1425-1433, 2006. [CrossRef] [Google Scholar] [Publisher Link]

[2] Hitesh Chaturvedi, Ayush Garg, and Udaibhan Singh Rathore, “Post-Compression Evaluation Parameters for Tablets-An Overview,” *European Journal of Pharmaceutical and Medical Research*, vol. 4, no. 11, pp. 526-530, 2017. [Google Scholar] [Publisher Link]

[3] Mate Ficzere et al., “Real-Time Coating Thickness Measurement and Defect Recognition of Film Coated Tablets with Machine Vision and Deep Learning,” *International Journal of Pharmaceutics*, vol. 623, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[4] Nurjanah, and N. Nurlelah, “Formulation and Physical Evaluation of CTM Tablets by Direct Compression Method: A Systematic Literature Review,” *Eureka Herba Indonesia*, vol. 4, no. 4, pp. 305-309, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[5] Michal Meisner et al., “Characteristics of Commercial Effervescent Tablets Using Selected Pharmacopeial and Novel Analytical Methods,” *Applied Sciences*, vol. 13, no. 5, pp. 1-13, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[6] Zhenyu Wang et al., “Research on the Counter-Force Calibration Method of Tablet Hardness Tester,” *Measurement: Sensors*, vol. 18, pp. 1-3, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[7] J.T. Fell, and J.M. Newton, “Determination of Tablet Strength by the Diametral-Compression Test,” *Journal of Pharmaceutical Sciences*, vol. 59, no. 5, pp. 688-691, 1970. [CrossRef] [Google Scholar] [Publisher Link]

[8] Haichi Li et al., “A Rapid and Simple Quantitative Method for the Active Ingredients of Aescin in the Extraction Process Using Near Infrared spectroscopy,” *American Journal of Analytical Chemistry*, vol. 9, no. 10, pp. 500-513, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[9] Ali Nokhodchi, and Yousef Javadzadeh, “The Effect of Storage Conditions on the Physical Stability of Tablets,” *Pharmaceutical Technology Europe*, vol. 19, no. 1, pp. 1-5, 2007. [Google Scholar] [Publisher Link]

[10] Yi Liu et al., “A Chinese Medicine Formula (Jinqi Jiangtang Tablet): A Review on Its Chemical Constituents, Quality Control, Pharmacokinetics Studies, Pharmacological Properties and Clinical Applications,” *Journal of Ethnopharmacology*, vol. 236, pp. 1-8, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[11] Tavva Naga Panindra Kumar et al., “A Review on in Process and Finished Products Quality Control Tests for Tablets According to Pharmacopoeias,” *Indo American Journal of Pharmaceutical Sciences*, vol. 9, no. 5, pp. 30-36, 2022. [Publisher Link]

[12] Thibault Vallet et al., “Acceptability in the Older Population: The Importance of an Appropriate Tablet Size,” *Pharmaceutics*, vol. 12, no. 8, pp. 1-11, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[13] Sarsvat Patel, and Changquan Calvin Sun, “Macroindentation Hardness Measurement-Modernization and Applications,” *International Journal of Pharmaceutics*, vol. 506, no. 1-2, pp. 262-267, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[14] Jiaxiang Zhang et al., “Coupling 3D Printing with Hot-Melt Extrusion to Produce Controlled-Release Tablets,” *International Journal of Pharmaceutics*, vol. 519, no. 12, pp. 186-197, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[15] Ilgaz Akseli, and Cetin Cetinkaya, “Drug Tablet Thickness Estimations Using Air-Coupled Acoustics,” *International Journal of Pharmaceutics*, vol. 351, no. 1-2, pp. 165-173, 2008. [CrossRef] [Google Scholar] [Publisher Link]