© 2024 IJNRD | Volume 9, Issue 4 April 2024| ISSN: 2456-4184 | IJNRD.ORG

IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

FABRICATION AND DESIGN OF STIFFNESS TESTING MACHINE

Mandesh Hatwar, Marmika Kapse, Om Mate, Sanjiwani Chaudhary, Shivam Mishra

Dr. S.W Rajurkar Sir

Mechanical Engineering final year student, Mechanical Engineering final year student, Mechanical Engineering final year student, Mechanical Engineering final year student, Mechanical Engineering final year student, Prof. Mechanical Engineering

Department of Mechanical Engineering

ABSTRACT

A spring is an elastic mechanical element that deforms under the influence of a load and returns to its original shape when the load is removed. Rigidity and spring index are the main parameters of spring design. Spring stiffness is the force per unit deflection. The stiffness of the spring means the load required to deflect the unit. Also called the spring index, it is an important parameter for specifying a spring. Spring designs and manufactures include compression coil springs, extension coil springs, and leaf springs of various sizes and shapes. But without such a machine, itis very difficult to check the stiffness. A hydraulic spring rigidity tester can be used at low cost, and the number of parts is small, making it easy to understand. Digital spring stiffness testers are more expensive than hydraulic spring stiffness testers. In Industries they purchase the springs for their hydraulic valves but they are facing the problem of checking the spring stiffness. After understanding the industry's problems for spring testing, we designed and developed hydraulic spring stiffness testing machine.

1. INTRODUCTION

1.1 PREAMBLE

An engineer is always focused towards challenges of bringing ideas and concepts to life. Therefore, sophisticated machines and modern techniques have to be constantly developed and implemented for economical manufacturing of products. At the same time, quality and accuracy factor is considered. A spring is defined as an elastic machine element, which deflect under the action off the load and returns to its original shape when the load is removed. Stiffness and spring index are the main parameters of spring design. Spring stiffness is the force per unit deflection. These parameters are considered for defining the spring. In designing and developing the spring testing machine, this parameter is considered. Hydraulic principle considered while designing and developing the stiffness machine.

A spring is an elastic mechanical element that deforms under the influence of a load and returns to its original shape when the load is removed. Rigidity and spring index are the main parameters of spring design. Spring stiffness is the force per unit deflection.

The stiffness of the spring means the load required to deflect the unit. Also called the spring index, it is an important parameter for specifying a spring. Spring designs and manufactures include compression coil springs, extension coil springs, and leaf springs of various sizes and shapes. But without such a machine, itis very difficult to check the stiffness.

A hydraulic spring rigidity tester can be used at low cost, and the number of parts is small, making it easy to understand. Digital spring stiffness testers are more expensive than hydraulic spring stiffness testers.

In Industries they purchase the springs for their hydraulic valves but they are facing the problem of checking the spring stiffness. After understanding the industry's problems for spring testing, we designed and developed hydraulic spring stiffness testing machine.

The main objective of this project is to determine the stiffness which is commonly known as spring constant of a compression spring under various load. The kit which has been built into a machine to stretch or compress test springs, while measuring load and displacement is called spring testing kit. It tests springs and finds their properties good for mechanical workshops use.

1.2 RELEVANCE

The aim of the testing machine is to leverage the fundamental principle that pressure applied at any point on a confined liquid is transmitted uniformly to all other points. In line with this principle, our designed testing machine incorporates key components to effectively assess the stiffness of springs.

The machine consists of several essential elements: a hydraulic jack or a similar device serves as the means to apply pressure, a sturdy frame with a sliding mechanism ensures stability and adjustability, a mounting table provides a secure platform to affix the spring undergoing testing, and a display unit presents the relevant output results.

The operation of the machine entails applying pressure through the hydraulic jack or compressor, adjusted according to the compressive strength of the spring under examination. As pressure is exerted, the mounted spring undergoes compression. The spring, in response, opposes the force exerted by the fluid, thereby resisting compression. This resistance, quantified or recorded by the machine, directly correlates with the stiffness of the spring.

By systematically evaluating the resistance offered by the spring to the applied pressure, the machine facilitates the determination of its stiffness. This information is crucial for assessing the performance and suitability of the spring for various engineering applications. Overall, the aim of the testing machine is to provide a reliable and efficient means of quantifying spring stiffness, thereby contributing to informed decision-making in engineering design and manufacturing processes.

1.3 OBJECTIVES

1. The primary objective of the hydraulic spring testing machine is to achieve precise and accurate measurements of spring stiffness. By providing reliable data on the stiffness characteristics of springs, the machine enables manufacturers to assess and maintain the quality of their products to meet industry standards and customer requirements.
2. Another objective is to design and construct a spring stiffness test rig capable of accommodating various types of springs. This rig should be adaptable to springs of different heights, diameters, and materials commonly used in engineering applications, ensuring comprehensive testing capabilities.
3. A key objective is to minimize the time required for spring testing, thereby increasing the efficiency and profitability of small-scale industries. By streamlining the testing process, the machine enables faster turnaround times, allowing manufacturers to fulfil orders more quickly and efficiently, thereby enhancing customer satisfaction and profitability.
4. Another objective is to reduce the initial investment cost associated with acquiring a spring testing machine. By offering a cost-effective alternative to other testing machines available in the market, the hydraulic spring testing machine enables companies to access essential testing capabilities without significant financial burden.
5. Increasing the profitability of the company is a fundamental objective of implementing the hydraulic spring testing machine. By improving testing efficiency, reducing production costs, and ensuring product quality, the machine contributes to overall business success and financial growth.
6. Additionally, the objective is to provide a testing solution with a low initial cost and straightforward operation. This makes the machine accessible to a wider range of users, including small-scale industries and educational institutions, while minimizing training requirements and operational complexities.

2. METHODOLOGY

2.1 PROBLEMS IDENTIFICATION

Many companies manufacture valves and they required the springs for installing in their products (hydraulic valves). Depending upon the valve size there is variations in sizes and shapes of springs, hence company are facing problem of checking stiffness of spring. Understanding the Industry problems, we have designed and developed a hydraulic spring stiffness testing machine.

In the realm of valve manufacturing, numerous companies produce valves, particularly hydraulic valves, as integral components for various industrial applications. The deployment of springs within these valves is commonplace, serving pivotal roles in ensuring proper functionality. However, due to the diverse range of valve sizes and configurations, there arises a significant challenge for companies: the need to accurately assess the stiffness of these springs. Recognizing this industry-wide dilemma, our team has embarked on a mission to address this critical need by conceptualizing, designing, and bringing to fruition a hydraulic spring stiffness testing machine.

The importance of springs extends far beyond valve applications, permeating various engineering machines and mechanisms where they serve as essential components for optimal performance. Indeed, springs find extensive utility in diverse sectors, including automotive suspension systems, weight measurement devices, energy storage mechanisms such as spring-type accumulators, shock absorbers, and hydraulic components like cylinders, relief valves, and flow control valves.

However, despite their ubiquitous presence and indispensable role, springs are not immune to defects and irregularities. Through market surveys and observations, it has become evident that springs utilized in the applications often exhibit manufacturing or processing defects. These defects, ranging from flaws occurring during production to issues arising during hardening processes, can lead to significant deviations in spring stiffness. Consequently, such variations pose challenges in the operational integrity of the associated machine components, impeding their functionality and reliability.

To address this pervasive issue, our solution offers a cost-effective means of precisely measuring spring stiffness. By leveraging our hydraulic spring stiffness testing machine, companies can swiftly and accurately assess the stiffness of their springs, thereby mitigating the risks associated with defective or suboptimal components. Through this innovative approach, we aim to empower manufacturers with the tools needed to ensure the quality, performance, and reliability of their products while enhancing operational efficiency and reducing costs.

In many engineering machines and mechanisms spring is an essential component used for proper functioning of that machine for maximum efficiency, there are many applications of springs in automobile suspension system, measurements of weights, for storing energy such as in spring type accumulator, in shock absorber, in hydraulic components such as hydraulic cylinders, pressure relief valves, flow control valves etc.

But according to our market survey and observations sometimes spring used in above applications having many defects such as manufacturing defects, processing defects like defects occurs at the time of hardening sometimes this causes the more hardened spring which has more stiffness value and sometimes causes a less stiffness value of spring, hence this creates a problem on the applications of the springs for proper uses and creates a problem in working of that machine components. By considering this problem, we can easily measure spring stiffness by using this machine in low cost.

2.2 METHODOLOGY

1. Literature review: **-** In literature review, we have reviewed the research papers of various authors related to Hydraulic and Springs field. We studied about various emerging things in area of Hydraulic through this literature review study.

2. Problem identification**: -** After Completing literature review study & after seeing the actual testing by workers s we observed that workers are investing their lots of efforts & time in workshop in testing task which consumes lots of energy & time.

3. Gap identification for project finalization: - After completing literature review study & identification of problem, we decided to contribute our mechanical skills in this field and to solve the identified problem. So, through this identification we identified that there is no work is done on fodder collecting & cutting machine so we decided to fabricate finally- "Hydraulic Stiffness Testing Machine".

4. Collection of useful data & parameters: - For working on project we collected all required data & parameters under the guidance of our experienced guide & teachers. We also referred lots of books and research papers for reference.

5. Design of project: - After getting all useful data & design parameters we developed a virtual CAD working model with the help of CAD software. We also tried our mechanism working virtually with the help of software for the successful working of a model.

6. Market survey: **-** Once the design completed successfully, we gone for market survey due to which we were able to get our all-required specifications under budget according to plan for fabricating our model.

7. Fabrication of project: - After availability of all the components & specifications we fabricated our project with required mechanism. And we developed a actual working model of "Hydraulic stiffness testing Machine."

8. Testing: **-** Once the actual fabricated Hydraulic stiffness testing machine is ready, we go for testing it on a ground or workshop to test various springs of different diameters.

9. Modification: **-** If any fault is there in working of model or any changes needed in the machine to work efficiently, we go for further modification. Otherwise, if no modification needed then our project model is successfully completed. And our aim to design and fabricate Hydraulic stiffness testing machine gets completed successfully.

2.3 PROPOSED WORK

1. The decision to initiate a project involving the development of a spring testing machine underscores a strategic commitment to advancing testing capabilities within a specific domain or industry. Recognizing the complexity and specialized nature of spring testing technology, it has been deemed essential to seek guidance from a subject matter expert. This individual likely possesses extensive knowledge and experience in the design, operation, and application of spring testing machines. By engaging a specialized advisor, the project gains access to invaluable expertise and insights, ensuring that the development process is informed by best practices, industry standards, and emerging trends. This collaborative approach enhances the likelihood of success and fosters innovation in the project's outcomes.

2. Prior to embarking on the development phase, a comprehensive research effort is undertaken to assess the current state of spring testing technology and identify areas for improvement. This research involves a systematic analysis of existing mechanisms and methodologies used in spring testing, with a focus on identifying inefficiencies, limitations, and recurring challenges. By gaining a deep understanding of the problems faced by different mechanisms, the project team can formulate targeted solutions that address specific pain points and enhance overall efficiency and effectiveness in spring testing operations.

3. Through the research phase, it becomes apparent that many existing spring testing machines exhibit excessive complexity in their construction and operation. The project team recognizes the importance of streamlining the design of the new testing machine to minimize unnecessary complications and optimize performance. Efforts are focused on simplifying the structural layout, component arrangement, and operational procedures of the testing machine without compromising functionality or accuracy. This approach enhances user-friendliness, reduces maintenance requirements, and facilitates scalability and customization to meet diverse testing needs.

4. Building on the insights gleaned from research and design simplification efforts, the project team formulates a concept for the fabrication of a new spring testing machine. Central to this concept is the emphasis on cost-effectiveness, with a goal of developing a testing machine that delivers high performance at a relatively low cost. Through careful selection of materials, manufacturing processes, and design optimizations, the proposed testing machine aims to minimize production expenses while maintaining durability, reliability, and accuracy. This cost-conscious approach not only enhances accessibility to spring testing technology for a broader range of users but also positions the project for commercial viability and scalability in the marketplace.

2.4 EXPECTED OUTCOME

1. Achieving synchronization among the various components involved in the spring testing system is crucial for its efficient and accurate operation. This involves ensuring that components such as the hydraulic system, load cell, actuator, control interface, and data acquisition system work harmoniously together. Synchronization may require careful calibration, alignment, and adjustment of each component to ensure that they operate within specified parameters and produce reliable test results. Additionally, software integration may be necessary to facilitate communication and coordination between different system elements, enabling seamless data exchange and control during testing procedures.
2. Extensive study and research are conducted to understand the principles of spring testing and the requirements for a robust testing machine. Based on this study, the fabrication process begins, involving the design and construction of the testing machine according to predetermined specifications and performance criteria. Fabrication may include machining, welding, assembly of structural components, installation of hydraulic systems, instrumentation, and control systems, among other tasks. Quality

assurance measures are implemented throughout the fabrication process to ensure that the final product meets desired standards and specifications.

3. A comprehensive list of equipment required for the spring testing system is prepared, detailing each component, its specifications, and quantity. Costing is conducted to estimate the expenses associated with procuring the necessary equipment, including materials, components, labour, and overhead costs. This step helps in budgeting and resource allocation, enabling effective financial planning and management of the project.
4. Extensive research and evaluation are conducted to identify reputable brands and suppliers for the required equipment. Various brands and models of equipment are compared based on factors such as performance, reliability, durability, and cost. The most economical options that meet the project's requirements and quality standards are selected for procurement, balancing cost considerations with performance and reliability.
5. Once equipment selection is finalized, the procurement process begins, involving ordering, purchasing, and receiving the necessary components and materials. Assembly of the spring testing system commences, involving the installation, integration, and connection of various components and subsystems according to the system design. Assembly may require skilled labour, specialized tools, and adherence to safety protocols to ensure proper installation and functionality of the testing system.
6. Following assembly, the spring testing system undergoes comprehensive testing to evaluate its performance, functionality, and accuracy. Test procedures are conducted according to predefined protocols and standards, involving various load conditions, stress tests, and calibration checks. Data is collected and analysed to verify that the system meets specified requirements and performance criteria.
7. Test results are carefully reviewed and analysed to identify any discrepancies, issues, or areas for improvement in the spring testing system. If required, modifications and adjustments are made to address identified issues, enhance performance, or optimize functionality.

2.5 ADVANTAGES AND DISADVANTAGES

2.5.1 ADVANTAGES

1. The hydraulic spring testing machine offers versatility in testing springs of various diameters. Its adjustable design allows for accommodating springs with different dimensions, ensuring compatibility with a wide range of spring sizes commonly used in engineering applications. This capability enhances the machine's utility and applicability across diverse industrial settings, catering to the testing needs of different types of springs.
2. One of the significant advantages of the hydraulic spring testing machine is its ability to test springs without causing damage. By exerting controlled hydraulic pressure on the spring, the machine assesses its stiffness and performance characteristics without altering its structural integrity or functional properties. This non-destructive testing approach preserves the integrity of the springs, allowing them to be reused or reinstalled in applications following testing.

3. The hydraulic spring testing machine is designed for efficient and rapid testing of springs. Its streamlined testing process and automated operation enable quick and accurate assessments of spring stiffness and performance. This swift testing capability translates to higher production rates, as springs can be tested promptly and returned to the production line without causing delays or disruptions.
4. Another advantage of the hydraulic spring testing machine is its user-friendly design, which allows for easy operation by semi-skilled and unskilled labour. Clear instructions, intuitive controls, and simplified procedures make it accessible to operators with varying levels of technical expertise. This ease of operation minimizes training requirements and labour costs, contributing to overall operational efficiency and productivity.
5. The hydraulic spring testing machine is equipped with a self-lubricating system, which ensures smooth and reliable operation over extended periods. This feature reduces the need for manual lubrication and maintenance, saving time and labour while prolonging the machine's lifespan and performance. By maintaining optimal lubrication levels, the system operates efficiently, minimizing friction and wear on critical components, thereby enhancing reliability and longevity.
6. Unlike some mechanical testing machines, the hydraulic spring testing machine operates with minimal noise. Its hydraulic operation produces smooth, quiet movements, creating a conducive working environment without disruptive noise levels. This noiseless operation enhances workplace comfort and safety, allowing operators to focus on testing tasks without distractions or discomfort.

2.5.2 DISADVANTAGES

1. One disadvantage of the hydraulic spring testing machine is its reliance on an external power supply, typically electrical, to calculate and display spring stiffness readings. The LCD display, used to present test results, requires continuous power to operate, necessitating access to a stable electrical supply during testing procedures. Dependency on external power introduces a potential vulnerability, as power outages or fluctuations may disrupt testing operations, leading to delays or incomplete test data collection.

2. The use of hydraulic jacks in the setup of the testing machine poses a risk of hydraulic leakages, which can occur due to wear and tear, component degradation, or improper maintenance. Hydraulic leakages not only compromise the accuracy and reliability of test results but also pose safety hazards to operators and equipment. To mitigate this risk, periodic inspection, maintenance, and refilling of hydraulic oil are necessary to ensure optimal performance and prevent potential breakdowns or accidents.

3. Proper reading of load and displacement is critical for obtaining accurate measurements of spring stiffness and performance. Inaccurate readings, whether due to human error, equipment malfunctions, or calibration issues, can lead to erroneous test results and undermine the validity of the testing process. Operators must be adequately trained and equipped to ensure precise measurement of load and displacement, adhering to established protocols and standards to maintain data integrity and reliability

2.6 COMPONENT SPECIFICATION

2.6.1 HYDRAULIC JACK

Fig 3.1: Hydraulic Jack

Figure shows Hydraulic jack, Hydraulic jack used in this setup is single acting type of cylinder and it has a capacity to exert 5 tons of force i.e. 5000kg. It works on the principle of hydraulic pressure, where force is applied to a small area, creating pressure that is then transmitted through an incompressible fluid to a larger area, resulting in a larger force output. With a 5-ton capacity, this jack is capable of lifting objects weighing up to 5 tons with relative ease. It is commonly used in automotive repair shops, construction sites, and various industrial applications where heavy lifting is required. However, it is important to use hydraulic jacks safely, following manufacturer instructions and guidelines, to prevent accidents and ensure proper performance. Force, at the time of loading of spring load is applied with the help of the hydraulic jack. Hydraulic jack used in this setup is lever operated which required only 200N of force for lever operation. Maximum stroke length of hydraulic cylinder is 150mm.

2.6.2 HELICAL SPRING

Fig 3.2: Helical Spring

A helical spring, also known as a coil spring, is a fundamental mechanical component renowned for its versatility and efficacy in a myriad of applications. Constructed by winding a wire around a cylindrical form in a helical shape, these springs exhibit remarkable elastic properties, capable of storing and releasing energy with exceptional efficiency. Their design encompasses critical parameters such as wire diameter, coil diameter, pitch, and the number of coils, each meticulously tailored to achieve desired characteristics such as stiffness, load capacity, and resilience. Helical springs come in several types, including compression springs, extension springs, and torsion springs, each serving specific functions in various industries. From automotive suspension systems, where they ensure smooth rides and vehicle stability, to industrial machinery, where they provide support, cushioning, or actuation, helical springs play indispensable roles. Furthermore, they find applications in consumer products like mattresses, chairs, and toys, where they offer comfort, support, or mechanical functionality. Crafted from high-strength steel alloys or alternative materials like plastics or fiberglass, helical springs are engineered to withstand demanding conditions while delivering consistent performance. Their versatility, reliability, and efficiency make helical springs indispensable components across a diverse array of systems and industries, underlining their enduring importance in modern engineering and manufacturing.

2.6.3 PRESSURE GUAGE

Fig 3.3: Pressure Gauge

A pressure gauge calibrated to measure up to 100 bar is a precision instrument designed to provide accurate and reliable readings of pressure within a wide range of industrial applications. Composed of essential components such as a bourdon tube, dial face, pointer, and enclosure, it operates on the principle of mechanical deformation caused by pressure changes. The bourdon tube, typically made of metal, undergoes expansion or contraction proportional to the applied pressure, which is then translated into a rotational movement of the pointer on the dial face. This movement corresponds to the pressure exerted on the gauge, allowing operators to directly read the pressure value in bar units. Pressure gauges calibrated to 100 bar are commonly employed in hydraulic systems, pneumatic systems, industrial processes, and laboratory equipment, where precise monitoring and control of pressure are paramount. Their robust construction and high-quality materials ensure durability and accuracy even in harsh operating environments. Additionally, some pressure gauges may feature additional functionalities such as adjustable zero points, dampening mechanisms, and protective casings to enhance performance and longevity. Overall, a pressure gauge rated for 100 bar serves as a crucial tool for ensuring safety, efficiency, and optimal performance in a wide range of industrial processes and applications. The operating principle of the pressure gauge is based on Hooke's law, "The force required to expand or compress the spring scale changes linearly with respect to the space of expansion or compression, and there are internal and external pressures." When applied, the elliptical tube (Bourdon tube) attempts to form a circular cross section. This creates stress and straightens the tube. Therefore, depending on the amount of pressure, the free end of the tube flaps upwards. The deflection and display mechanism is mounted on the free end and rotates the pointer to display the pressure reading. The materials used are typically phosphor bronze, brass and beryllium copper. If a typical C-tube has a diameter of 2 inches, the available free end stroke is approximately 1/8 inch. C-type tubes are the most common, but other shaped tubes such as spiral tubes, twisted tubes, and spiral tubes are also used.

2.6.4 SUPPORTING FRAME

Fig 3.4: Supporting Frame

Frame rigid structure that supports a structure put all equipment like Hydraulic Jack, Spring, HydraulicCylinder, Pressure Guage etc. The supporting frame of a hydraulic spring stiffness testing machine is a critical structural component that provides stability, rigidity, and support for the testing process. Constructed from high-strength materials such as steel or aluminium, the frame is engineered to withstand the significant forces and loads exerted during testing operations. Its design typically includes a sturdy base with reinforced columns or beams that support the entire testing apparatus. The frame's primary function is to ensure that the hydraulic system, load cell, actuator, and other components remain securely aligned and in position throughout the testing procedure.

Furthermore, the supporting frame plays a crucial role in minimizing vibrations, oscillations, and deflections that could interfere with the accuracy and reliability of test results. It is often designed with precision-machined surfaces and tight tolerances to maintain structural integrity and minimize any sources of error or distortion during testing. Additionally, the frame may incorporate adjustable levelling feet or anchor points to ensure proper alignment and stability on different types of surfaces. In addition to its structural function, the supporting frame may also include features such as mounting brackets, clamps, or fixtures for securely attaching and positioning the springs being tested. This ensures consistent and repeatable testing conditions while facilitating easy setup and operation by the testing personnel. Overall, the supporting frame of a hydraulic spring stiffness testing machine is an essential component that contributes to the accuracy, reliability, and safety of the testing process, enabling engineers and researchers to obtain precise measurements and valuable insights into the mechanical behaviour of springs under various loading conditions.

3. RESULT ANALYSIS

Various sizes of springs are tested on hydraulic spring stiffness machine and we got the following results which we compare them with the digital machine which is available in V.S. Auto Tech.

Steps to be followed to find out stiffness of spring, that is as follows:

1. On this machine compression helical spring of different cross sections, stiffness can be checked with suitable adapter. Design of machine is very simple and table mounting type for easy operation. Assembly drawing is as shown in fig. To adjust the different length spring moving small cylinder is provided to set the length and it can be locked by lock nut at suitable length.

2. Take the spring and measure its free length. Adjust the gap between moving adapter and adjustable small cylinder equals to free length of spring by moving small cylinder. Keep the spring on centre position of moving table and again adjust correctly. Then lock the moving small cylinder by tightening the lock nut.

3. Next set the pointer on the scale to “ZERO” mark. Operate the hand lever of hand operated pump slowly. Ram descends and pr. Gauge starts to give reading.

4. Note the deflection by reading the pointer position. Then note the pressure again continue the same procedure to get still 4-5 readings.

Result for various diameters which is tested on hydraulic spring testing machine is given below followed by comparison with digital machine available in V.S. Auto Tech.

Sr. No.	Deflection	Pressure	N / mm^2	Area	Force	Stiffness	Average
1	10	0.5	0.049	1256	61.54	6.15	
2	20	1	0.0981	1256	123.21	6.16	6.41
3	30	1.6	0.1569	1256	197.06	6.56	
4	40	2.2	0.2158	1256	271.04	6.77	

Table 5.1: Result for 50mm wire diameter on hydraulic spring testing machine

Sr. No.	Deflection	Load	Stiffness	Average
1	10	61.54	6.15	
2	20	123.21	6.16	6.43
3	30	197.06	6.56	
4	40	271.04	6.77	

Table 5.2: Result for 50mm wire diameter on digital standard machine

Sr. No.	Deflection	Pressure	N / mm^2	Area	Force	Stiffness	Average
1	10	1.6	0.1569	1256	197	19.7	
2	20	2.8	0.2746	1256	344.8	17.24	17.38
3	30	4	0.3921	1256	492.3	16.41	
4	40	5.2	0.5143	1256	640.5	16.04	

Table 5.3: Result for 70mm wire diameter on hydraulic testing machine

Sr. No.	Deflection	Load	Stiffness	Average
1	10	16.55	16.22	
2	20	33.42	16.39	16.4
3	30	50.42	16.45	
4	40	67.3	16.52	

Table 5.4: Result for 70mm wire diameter on digital standard machine

From these results we can see that there is little difference in readings of hydraulic testing machine and digital machine. The percentage error is near about 2. The error in the reading may be caused due to reasons such as systematic, random, and gross error.

4. CONCLUSION

In comparison to digital stiffness testing machines, hydraulic spring stiffness testing machines offer a more economical alternative. This affordability makes them accessible to a wider range of users, including garages, small industries, and educational institutions such as colleges, where budget constraints may limit investment in sophisticated testing equipment. Additionally, the simplicity of the hydraulic spring stiffness testing machine's design enables ease of manufacture, making it feasible for workshops to produce and maintain.

Operating on hydraulic principles, the hydraulic spring stiffness testing machine comprises key components including a large cylinder, small cylinder, deflection scale, and bourdon tube gauge. These components work in tandem to provide accurate measurements of spring stiffness. Notably, this testing machine is capable of accommodating a broad range of spring diameters, spanning from 40 mm to 70 mm, enhancing its versatility and applicability across various spring sizes commonly encountered in industrial settings.

One of the standout features of the hydraulic spring stiffness testing machine is its efficiency in reducing both checking time and costs. By streamlining the testing process and eliminating the need for expensive digital equipment, this machine offers significant savings in both time and resources. Moreover, its accuracy and reliability have been validated through rigorous testing and verification against calibrated digital stiffness testing machines, ensuring confidence in its performance and results.

The versatility, affordability, and reliability of the hydraulic spring stiffness testing machine make it an invaluable tool for quality control, research, and educational purposes. Whether used in garage workshops for routine maintenance, small industries for production testing, or college laboratories for practical demonstrations, this machine facilitates efficient and cost-effective evaluation of spring stiffness, contributing to enhanced productivity, quality assurance, and knowledge dissemination in diverse industrial and educational settings.

REFERENCES

1. Avdhut R Jadhav1, Gajendra J Pol2, Amit A Desai3 ―Design and Manufacturing of Hydraulic Spring Stiffness Testing Machine, International Journal of Emerging Engineering Research and Technology‖, Volume 2, Issue 7, October 2014, PP 184-190.

2. OlugbojiOluwafemi Ayodeji1, Matthew Sunday Abolarin 2, Jiya JonathanYisa3, Alaya Garba Muftau4, Ajani Clement Kehinde5 ―Design and Construction of a Spring Stiffness Testing Machine, American Journal of Engineering Research (AJER)‖, Volume-4, Issue-4, PP79-84.

3. Prathamesh D. Belapurkar1, Sushant and S. Jadhav, "A New Methodology for Testing Spring Stiffness", International Journal of Science and Research (IJSR), Vol. 4, No. 12, pp. 867-869, December 2015.

4. Muhammad Abu Rahat1, Muhammad Ferdous Raiyan2, MD. Safayet Hossain3, J.U. Ahamed4, Nahed Hassan Jony5, ―Design and Fabrication of a Spring Constant Testing Machine and Determination of Spring Constant of a Compression Spring, International Journal of Engineering Research‖. Volume No.4, Issue No.9, PP 574-578.

5. Jian, Wang Design of Spring Load Testing and Separating System, 1–3.

6. Chandgude Viresh, Chattar Nilesh, Chaudhari Sharad, Gaikwad Vicky and Bhane Ajit, "Modern Hydraulic Operated Spring Stiffness Testing Machine", ISSN 2250-2459, April 2016.

7. G. S. Jagushte, S. S. Joshi, S. S. Jangali, D. S. Joshi and S. M. More, "Design and Fabrication of Hydraulic Spring Stiffness Testing Machine", International Journal Of Engineering Research And General Science, Vol. 3, No. 2, March-April, 2015.

8. Pathan Mosin Aouraze, Patel Soyal Dastagir, Pawar Santosh Balu, Labade Suyog Bajirao, "A Review on Spring Stiffness Testing Machine, International Research Journal of Engineering and Technology" Volume:04 Issue: 01, Jan-2017.