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# Optimizing Knitwear Manufacturing: A Comparative Study of Computerized Knitting Software in Ludhiana

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**Abstract**
The present paper describes a comparative analysis of computerized weft knitting software's optimizing the knitwear manufacturing in Ludhiana. The knitwear industry's survival relies on constant innovation and renewal. To stay competitive, fashion designers leverage technologies like CAD/CAM. Computerized knitting software has become essential in fulfilling consumer demands for functionality, performance, and aesthetics. This study explores the application of listed data structures in CAD systems for knitting industry, enabling efficient representation of knitting patterns. The research aims to provide a novel approach to data representation in CAD/CAM systems, streamlining knitwear design and production. A comparative analysis of three computerized knitting softwares i.e. Stoll M1, Shima Seiki, and Heng Qiang systems are investigated for its business growth, highlighting the impact on the knitwear industry that meet the customer demand.

**Keywords:** Computerized knitting software, CAD/CAM, knitwear design, fashion technology.

## 1. Introduction:

Ludhiana, dubbed the "Manchester of India", is a city renowned for its thriving knitwear. Ludhiana, a leading industrial town in the north Indian state of Punjab, is a significant center for textile industries, particularly knitwear and hosiery (Kumar, 2017). The industry primarily caters to the domestic market, with some exports. Ludhiana, a hub for wool products, dominates India's woolen knitwear industry, accounting for a staggering 95% of national production. The city's hosiery industry boasts an impressive annual turnover of $40 million (Kapur Jyoti, 2003).

The study focuses on the weft knitting technique, a widely used method for fabric production (Kumar, 2018). Weft knitting dominates the industry, accounting for approximately one-quarter of total apparel fabric yardage, surpassing warp knitting's one-sixth share (Textile World, 2020). Weft knitting machines, particularly those designed for garment-length production, are appealing to small manufacturers due to their versatility, relatively low capital costs, compact floor space requirements, quick pattern and machine changing capabilities, suitability for short production runs, low yarn and fabric inventory requirements (Majumdar, 2015). A significant portion of the weft knitting industry is dedicated to garment assembly, utilizing specialized seaming and linking operations (IJCST, 2019).

Despite its significance, many units in Ludhiana still employ traditional methods, whereas the adoption of computer-aided design (CAD) and computer-aided manufacturing (CAM) systems can enhance productivity and efficiency (Gupta, 2019). The knitting industry in Ludhiana faces challenges such as labor scarcity and international competition (Kumar, 2017). However, the introduction of CAD/CAM systems has helped mitigate these issues. These systems have improved design capabilities, increased productivity, and reduced waste (Gupta, 2019). The evolution of flatbed knitting machines has enabled the production of complex pattern goods, including multi-colored jacquard patterns. However, the increasing demand for flat knitted products led to the development of computer-aided design (CAD) and computer-aided-manufacturing (CAM) systems. These advancements have given rise to high-precision, push-in type, computer-controlled flat knitting machines, which are now exported globally (Kazmi et al., 2017). These machines have revolutionized the industry by enabling the production of specialized clothing and adopting full-garment production technology. The computer control system has become a critical factor in the development of flat knitting machines, surpassing mechanical mechanisms in importance (Chen et al., 2020). The application of computer graphics in the knitting industry has two primary aspects: designing knitting structures and creating knitting pattern shapes. The former involves designing intricate structures such as Intarsia, Jacquard, Lace, and Arans, while the latter relates to the machine's capacity to produce fully-fashioned (FF) products (Xu et al., 2019).

The advent of automation in knitting machines has significantly enhanced production rates, mitigating design and operational issues that previously led to wasted time (Kumar, 2018). Automation has reduced the time required to alter knit designs from 3-4 seconds to under one second, allowing for real-time design changes during operation (Chen et al., 2020). Furthermore, computer-controlled machines enable efficient production, improved fabric quality, and reduced waste (Xu et al., 2019). The ever-changing demands of customers, who expect high-quality products at minimal cost and lead time, have compelled manufacturers to optimize production processes (Kazmi et al., 2017). This has led to the adoption of advanced CNC plants, new design software, and innovative manufacturing techniques. In Ludhiana, a hub for knitwear and fashion industries, most factories have transitioned or are transitioning to new design and manufacturing systems to remain competitive (Textile World, 2020).

As per MRFR analysis, the knitting machine market size was estimated to be $12.71 billion in 2024. The knitting machine market industry is expected to grow from $13.61 billion in 2025 to $25.33 billion by 2034, at a CAGR (growth rate) of approximately 7.14% during the forecast period 2025-2034 (Gupta, Sakshi 2025). In this era of intense competition, only the most efficient and innovative manufacturers can survive. The study aims to explore the benefits and challenges of adopting CAD/CAM systems in the knitting industry. The present study focuses on a comparative analysis of computerized weft knitting software's optimizing the knitwear manufacturing of Shima Seiki, Stoll M1 and Heng Qiang technology in Ludhiana.

## 2. Gap of The Study:

The author would like to identify a production shortfall in response to the rising demand for flat knitted products. To address this issue, the researcher aimed to investigate the preferences of knitwear manufacturers in Ludhiana regarding the usage of computerized flat-bed knitting software. The tentative research gaps are described in below points:

- **Niche topic:** Computerized flat-bed weft knitting software's i.e. Stoll M1, Shima Seiki, and Heng Qiang are a specialized area with limited academic interest which need to be elaborated.
- **Emerging technology:** Computerized knitting software is a relatively new field, with limited research conducted to date.
- **Lack of standardized evaluation criteria:** There is no established framework for assessing the effectiveness and acceptability of computerized knitting software.
- **Limited understanding of user needs:** The specific requirements and challenges of manufacturers using computerized knitting software has not fully explored.
- **Insufficient investigation of software features:** The study of computerized knitting software features and their impact on manufacturing processes are underexplored.
- **Need for comparative analysis:** Research on comparative analysis for acceptability and effectiveness of different computerized knitting software solutions not yet done appropriately.
- **Gap in understanding the impact on productivity and quality:** The effects of computerized knitting software on manufacturing productivity, product quality, and overall business performance have not been thoroughly investigated.
- **Limited exploration of industry-specific challenges:** The unique challenges and opportunities faced by manufacturers in the knitwear and fashion industries has not been addressed meticulously.
- **Need for investigation of user training and support:** The study of user training and support requirements for computerized knitting software may be lacking.

In today's competitive market, customers demand high-quality products at minimal cost and lead time. To meet these demands, manufacturers in Ludhiana's knitwear and fashion industries must adopt advanced technologies. By addressing these research gaps, this study can contribute to a better understanding of computerized flat-bed weft knitting software and its applications.

## 3. Objectives:

The primary objectives of this study are:

- To conduct a comparative analysis of the features and capabilities of three prominent computerized flat knitting design software's i.e. STOLL M1, Shima Seiki, and Heng Qiang.
- To investigate the benefits of these computerized flat knitting software in six selected garment manufacturing units in Ludhiana, with a specific focus on their impact on design efficiency, production productivity, and overall business performance.

## 4. Scope of Study:

This research focuses on the application of software to investigate how technology can facilitate faster production of technical fabrics on computerized knitting machines within a limited timeframe, while achieving superior fabric quality compared to manual hand flat knitting machines. The scope of this study is limited to:

- Investigating the benefits of using computerized knitting software and machines in Ludhiana's knitwear industry.
- Identifying the best software and machines for factory entrepreneurs to purchase for business development.

- Analyzing the impact of upgrading from old production systems to new software on production, PPC control, quality systems, storage warehouse systems, and cost reduction.

This study aims to provide insights into the potential for technology adoption to drive growth and innovation in Ludhiana's knitwear manufacturing industry.

## 5. Limitations:

This study has several limitations, primarily due to its initial scope and limited resources. The key limitations are:

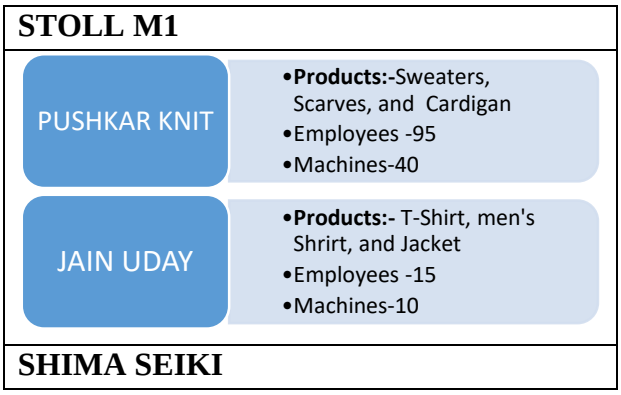
- **Focus on secondary data sources:** The study relies on secondary data sources, which may not provide the most up-to-date or accurate information.
- **Limited software scope:** The study only compares three design software's: Stoll M1, Shima Seiki, and Heng Qiang PDS.
- **Geographical limitation:** The study focuses on manufacturers in Ludhiana.
- **Domestic market focus:** The respondents and organizations chosen for the study primarily cater to the domestic market.

## 6. Research Methodology:

The research methodology employed in this study aims to effectively achieve its objectives. Research methodology refers to the systematic arrangement of conditions for collecting and analyzing data, balancing relevance to the research purpose with procedural efficiency (Kothari, 2004). In essence, research methodology outlines the approaches and techniques used to fulfill the study's objectives in a rigorous and effective manner (Creswell, 2014). This paper consists of following sections: Research Design, Sample Size & Selection, Research Tool, Data Collection, and Data Analysis.

**6.1 Research Design:** This study employed an exploratory and descriptive research design, utilizing both qualitative and quantitative techniques. The sampling technique used was purposive sampling.

**6.2 Sample Size & Selection:** A total of 18 respondents from six garment manufacturing units in Ludhiana city were selected for this study. The respondents included Managing Directors, Knitwear Designers, and Knitting CAD Masters from selected manufacturing units. The software usability of knitwear organizations described in below fig. -1.



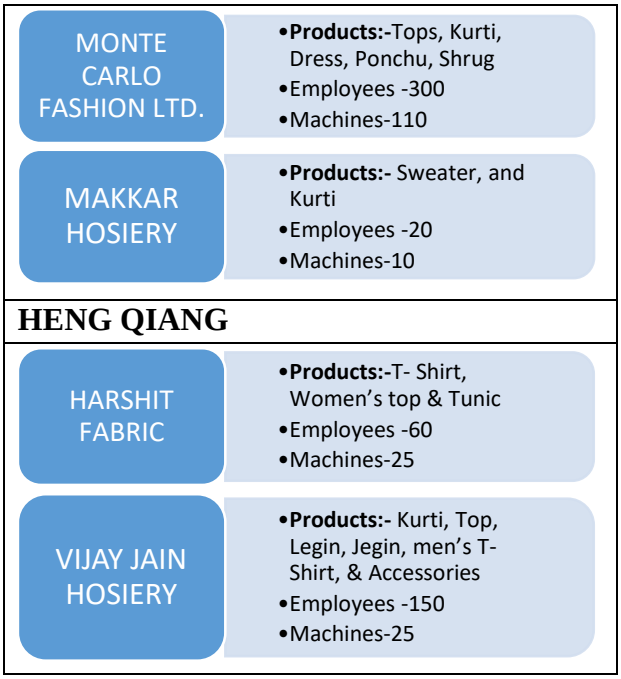



figure-1: Software's-Stoll M1, Shima Seiki & Heng Qiang machines usage by the manufacturers.

**6.3 Research Tool:** A questionnaire was used as the primary research tool, supplemented by observation methods. The books, magazine and websites as the secondary research tool

**6.4 Data Collection:** Pre-testing was conducted on a non-sampled garment manufacturing unit with 6 respondents. The questionnaire was revised based on the pre-testing results. Primary data was then collected from 18 respondents using the revised questionnaire and observation methods.

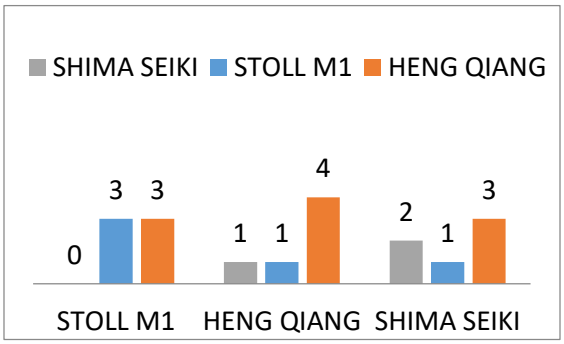
**6.5 Data Analysis:** The collected data was coded, tabulated, and analyzed manually using simple percentage calculations. The results were presented in tables, charts, and graphs. The actual data was compared with standard data to draw valid conclusions.

## 7. Result and Discussion:

An assessment of the CAD/CAM system for integral knitting revealed five primary knowledge areas essential for utilizing this technology: yarn, knit structure, garment development, fashioning, and machine programming. Identifying these areas enables academics to pinpoint the information required for new users of integral flat knitting technology and inform the development of training materials covering textiles, apparel, and design. Understanding these knowledge bases also aids organizations in selecting the most suitable employee to design knitwear when implementing integral flat knit technology, by evaluating their expertise in each area. Moreover, recognizing the five knowledge areas highlights the necessity for users to comprehend a broad range of information across various aspects of knitwear. The identified knowledge areas were subsequently used to create an evaluation instrument, comprising a grading rubric, preliminary and post-surveys for self-assessment, and a direction manual for task completion. Initially, the direction manual provided detailed instructions for creating an integral knit sweater. The original direction manual remains a valuable resource, offering comprehensive guidance on creating a flat knit sweater using the Heng Qiang PDS CAD/CAM system. Its level of detail makes it an ideal training material for new users. Answers of the questions are given below:

**Q-7.1:** The question one deals that -What is the adoption ratio of the computerized knitting software in Ludhiana?

Table-1: Results for the adoption ratio of computerized knitting software in Ludhiana.

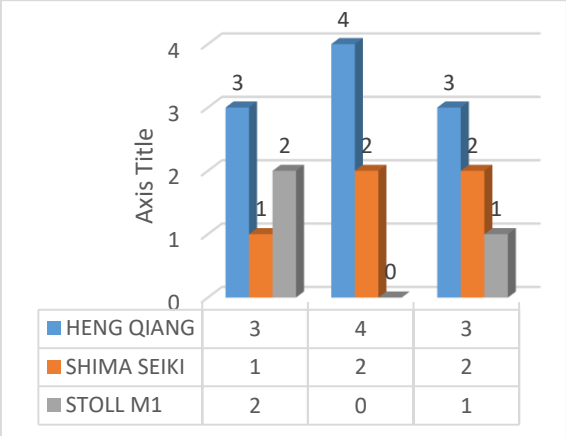



| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Stoll M1 | 3 | 16.7 | 16.7 | 16.7 |
| | Heng Qiang | 11 | 61.1 | 61.1 | 77.8 |
| | Shima Seiki | 4 | 22.2 | 22.2 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** It can be observed from the above table that, about 61.1% respondents have ranked best for its usage and performance of the Heng Qiang software. Whereas 22.2% respondents ranked for Shima Seiki and 16.7% ranked for Stoll M1 software's respectively.

**Q-7.2:** The question two deals that -Which software manual is easily available and how benefited this in programming?

Table-2: Results for the easy availability of software manual and its benefits during programming.

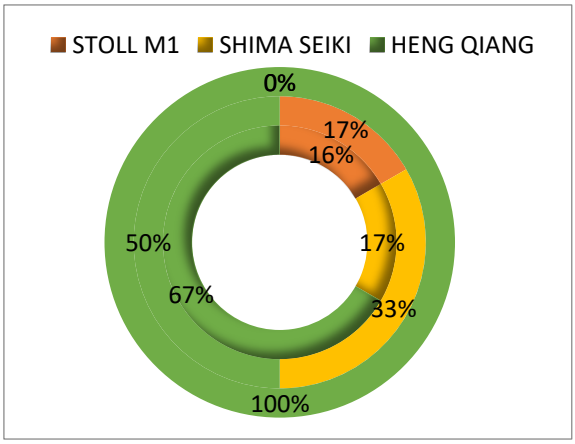



| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Heng Qiang | 10 | 55.5 | 55.5 | 55.5 |
| | Shima Seiki | 5 | 27.8 | 27.8 | 83.3 |
| | Stoll M1 | 3 | 16.7 | 16.7 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** It can be observed from the above table, about 55.5% of respondents concurred that the manual is highly beneficial and useful for its programming in Heng Qiang software, particularly once the machine is sold. Whereas 27.8% respondents agreed for Shima Seiki and 16.7% deemed it beneficial for Stoll M1 software's respectively.

**Q-7.3:** The question three deals that -Which software agency provides better training provision?

Table-3: Results for the software agency that provides the best training provisions.

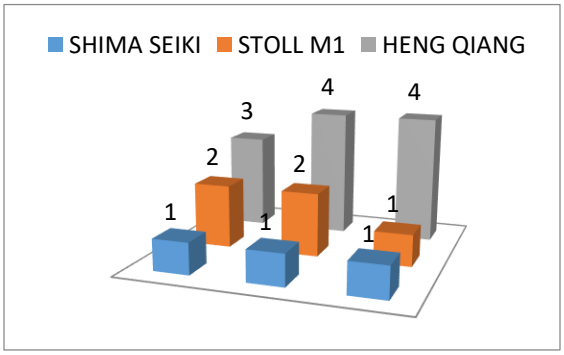



| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Stoll M1 | 2 | 11.1 | 11.1 | 11.1 |
| | Shima Seiki | 3 | 16.7 | 16.7 | 27.8 |
| | Heng Qiang | 13 | 72.2 | 72.2 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** The question three pertains to the training provision facilities offered better by the software agencies. As indicated in the table, about 72.2% respondents agreed that Heng Qiang software agencies provide superior training provisions, which are highly beneficial for operating the software. In comparison, 16.7% of respondents preferred Shima Seiki's, while 11.1% opted for Stoll M1 software's training facilities respectively.

**Q-7.4:** The question four deals that - In which software can knitting speed be controlled easily?

Table-4: Results for the software that allows easy control of knitting speed.



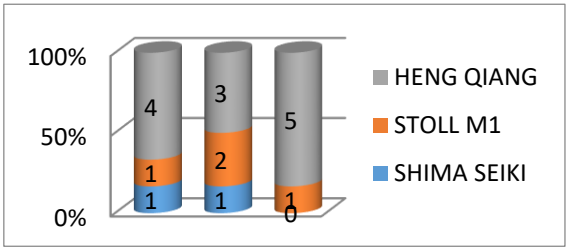

| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| V | Shima Seiki | 3 | 16.7 | 16.7 | 16.7 |

| | | | | | |
|---|---|---|---|---|---|
| | Stoll M1 | 5 | 27.8 | 27.8 | 44.5 |
| | HengQiang | 10 | 55.5 | 55.5 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** The question four investigates the capability to randomly control machine knitting speed according to different materials and knitting widths. As indicated in the figure, approximately 55.5% of respondents confirmed that Heng Qiang software offers a random controlling facility for knitting speed and adaptable to increase & decrease the productivity easily as per requirements. In contrast, 27.8% of respondents agreed for Stoll M1 software possesses this capability, while 16.7% opted for Shima Seiki software respectively.

**Q-7.5:** The question five deals that - In which software can pattern design be easily simulated?

Table-5: Results for the software in which pattern design can be easily simulated.

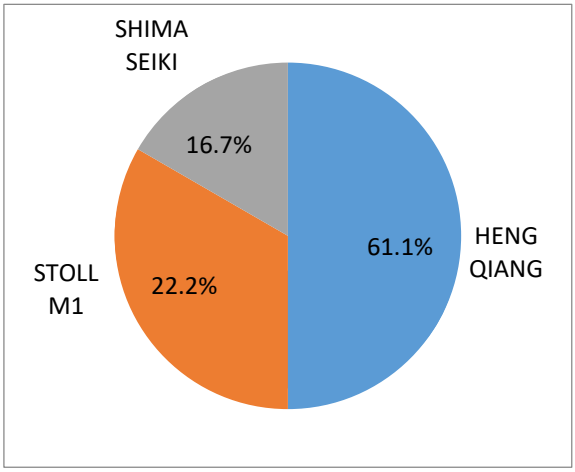



| | | **Frequ ency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
|---|---|---|---|---|---|
| Valid | HengQiang | 12 | 66.7 | 66.7 | 66.7 |
| | Stoll M1 | 4 | 22.2 | 22.2 | 88.9 |
| | Shima Seiki | 2 | 11.1 | 11.1 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** The question five examines the software capability for easy pattern design simulation. The collected data reveals that about 66.7% respondents agreed for Heng Qiang software excels in pattern design simulation, particularly in auto mode, with the simulation repeating up to 15 times. In comparison, 22.2% of respondents affirmed that Stoll M1 software possesses this capability, while 11.1% preferred Shima Seiki software respectively.

**Q-7.6:** The question six deals that -Which software is easier for connectivity to the hardware?

Table-6: Results for software that stands out for its easy connectivity to hardware.

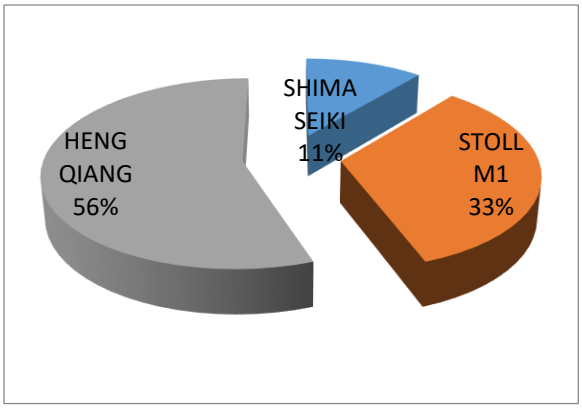



| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | HengQiang | 11 | 61.1 | 61.1 | 61.1 |
| | Stoll M1 | 4 | 22.2 | 22.2 | 83.3 |
| | Shima Seiki | 3 | 16.7 | 16.7 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** The question six examines the software stands easier for its connectivity to the hardware so that dispute should not vary once connected machine. Approximately 61.1% respondents agreed that Heng Qiang software has the ability to easy connectivity to the hardware. In contrast, 22.2% of respondents think for Stoll M1 software, while 16.7% opted for Shima Seiki software respectively.

**Q-7.7:** The question seven deals that -How adaptable of the input device to the software?

Table-7: Results for adaptability of input device to the software.

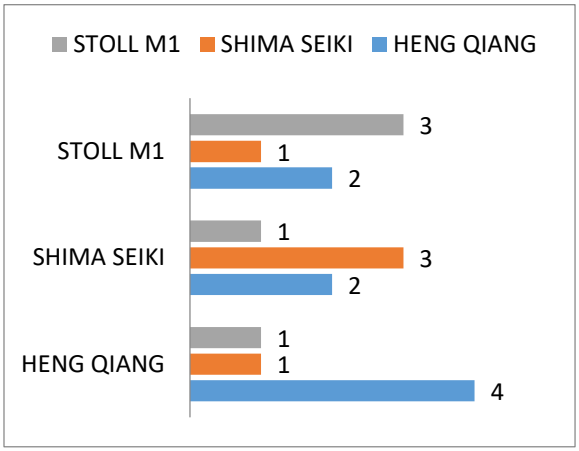



| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Shima Seiki | 2 | 11.1 | 11.1 | 11.1 |
| | Stoll M1 | 6 | 33.3 | 33.3 | 44.4 |
| | HengQiang | 10 | 55.6 | 55.6 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** The question seven examines the adaptability of input device to the software. The research clearly depicts while the data collection that approximately 55.6% respondents believed Heng Qiang software is adaptable to the input device like USB, Floppy and Card reader. Whereas, 33.3% of respondents think for Stoll M1 software, while 11.1% opted for Shima Seiki software respectively.

**Q-7.8:** The question eight deals that -Which software produce best quality knit product?

Table-8: Results for the software that produces the best quality knit products.




| | | Frequ ency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | HengQiang | 8 | 44.4 | 44.4 | 44.4 |
| | Shima Seiki | 5 | 27.8 | 27.8 | 72.2 |
| | Stoll M1 | 5 | 27.8 | 27.8 | 100.0 |
| Total | | 18 | 100.0 | 100.0 | |

**Interpretation:** The question eight investigates the quality of knit products when comes to choice Heng Qiang software. About 44.4% respondents agreed that benefits of Heng Qiang produce good quality product include not only optimum wear properties but also an improved, uniform standard of quality for each and every manufactured article, particularly where complex knitting process are involved. Whereas 27.8% each opted for Shima Seiki and Stoll M1 software's.

## 8. Findings:

The respondents were included Managing Directors, Knitwear Designers, and Knitting CAD Masters from selected manufacturing units. Out of it 72.7% Male and 27.3% female respondents. About 79.5% were from 29 to 39 years age group, 13.7% from 40 to 49 years, and 6.8% from below 28 years. About 60.5% were Managing Director, 20.5% Knitwear Designer, 10% CAD Masters and 9% Employees and Freelancers. The responses are briefly described in below points;

- **Adoption of Computerized Knitting Software:** Ludhiana manufacturers predominantly use Chinese machines, citing superior quality of heavy knitted fabrics produced. Domestic-oriented units in the region prefer this software and machine due to its optimal balance of quality and average cost.
- **Software Manual and its Benefit:** Heng Qiang software stands out for its ease of use and accessibility. The manual is readily available with local agents, and the software supports 13 languages, making it user-friendly for a global audience. In contrast, manuals of Stoll M1 and Shima Seiki not available and their language options are limited.

- **Training Endowment by Agency:** Heng Qiang agency provides free and comprehensive training enables users to quickly grasp the software, unlike paid training offered by other companies. This in-depth training fosters a user-friendly experience with both software and machine, setting it apart from competitors.
- **Knitting Speed Controlling:** Heng Qiang software boasts advanced automation features, including: Automatic knitting speed controlling, Yarn color changing, Tension adjustment, Needle control, Transposition of needle bed, Automatic knitting setup, Yarn cutting and nipping, Batching and draw-off, Piece counting, Automatic stop for errors. These features enhance efficiency, productivity, and quality.
- **Pattern Design Simulation:** Heng Qiang's order-made whole-garment co-design system, best simulation feature facility in the machine, provided a more streamlined and efficient design experience. Notably, in auto mode, the software repeated simulations 15 times, ensuring optimal design outcomes.
- **Connectivity with Hardware:** Heng Qiang software boasts seamless connectivity with its hardware, offering: Remote access to machine displays from any PC, Remote technical assistance and support, Clear graphic presentations and real-time machine status updates, Reduced downtime through easy connectivity, Additionally, the Heng Qiang Name Server provides a centralized database for managing networked machines, enabling convenient data sharing and pattern loading.
- **Input Device Adaptability:** Heng Qiang software facilitates seamless data import via input devices without interrupting the knitting process. The USB port enables effortless data communication using external devices like thumb drives and hard disks. Additionally, the centralized database offers: Easy web-based access, Editable server access, Convenient pattern and file sharing across the network.
- **Producing Quality Knitwear:** Heng Qiang technology ensures high-quality products with: Optimum wear properties, Uniform quality standards, Seamless construction for improved fit. Even Haute Couture brands and designers recognize its importance, increasingly requiring suppliers to use optimized Heng Qiang technology. Heng Qiang software reduces supervision workload, allowing one technician to oversee multiple machines.

## 9. Conclusion:

This study examines the application of computer-aided design (CAD) and computer-aided manufacturing (CAM) systems in the knitwear industry, focusing on Ludhiana, India. The study compares three computerized flat-bed weft knitting software's: Heng Qiang, Shima Seiki, and Stoll M1. The results show that Heng Qiang software is the most preferred among entrepreneurs in Ludhiana due to its quality, cost-effectiveness, connectivity, and productivity.

The study highlights the importance of CAD/CAM systems in optimizing knitwear manufacturing. The use of computerized knitting software can improve design efficiency, reduce production costs, and enhance product quality. The results also suggest that Heng Qiang software is well-suited to meet the needs of Ludhiana's knitwear industry, offering new possibilities for complete garment knitting and seamless garment production.

Overall, the study demonstrates the significance of computerized knitting software in optimizing knitwear manufacturing. The findings suggest that Heng Qiang software is the most preferred among entrepreneurs in Ludhiana, offering a cost-effective and productive solution for knitwear design and manufacturing.

According to recent data, global imports of computerized knitting machines totaled 728 shipments (24%) from March 2023 to February 2024, with China, Japan, and Germany being the top suppliers. The leading importers were India (2,379), Peru (1,040), and Vietnam (302). Notably, global growth in this sector increased by 39% to 58% from February 2023 to January 2024, with 27 shipments.

India's knitwear industry, particularly in Ludhiana, plays a vital role in the country's economy. According to the Apparel Export Promotion Council (AEPC), the industry produces 95% of woolen and acrylic products. The sector generates significant revenue, with 30% of products exported internationally and 70% distributed domestically. Key products include woolen shirts, pullovers, cardigans, and other apparel items.

This study recognizes the substantial contribution of Ludhiana's knitting industry to India's economic growth. The entrepreneurs in this sector have ambitious plans to achieve higher targets, and this research aims to support their endeavors by providing insights into the effective adoption of CAD/CAM systems and software.

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