Advancing Industrial Sustainability: A Multifunctional Ergonomic Sewing Machine Table for Enhanced Productivity and Worker Well-being

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Abstract

This study explores a new ergonomic sewing machine table designed for sustainability in industries. The table is made to fit how workers sit, prevent health issues, and decrease injuries. It uses a hydraulic system for easy adjustments and includes a vibration sensor for safety. Built with wood, plastic, and metal, the table aims to keep workers comfortable and help the environment. It's adjustable, user-friendly, and promotes high efficiency and productivity. Specifically, the table can be customized and adjusted vertically up to 32 feet. This flexibility allows workers to reach challenging spots easily, reducing tiredness. The table is cost-effective, uses minimal power, and is versatile compared to other options. It benefits workers' health and increases overall industry productivity. The ergonomic table is applicable in various industries, providing a comfortable working position through rotation and tilting features. With a tilt angle of up to 30 or 45 degrees, it improves efficiency in different operations. By reducing worker fatigue and the risk of accidents, it creates a safer and more productive industrial environment. In conclusion, the ergonomic sewing machine table offers a sustainable solution to enhance productivity and working conditions in industries.

1 Keywords:
Ergonomic furniture, garment manufacturing, Employee well-being, Workplace injuries, Productivity.

2 Introduction

An ergonomic sewing table stands as a pivotal workstation within the textile industry, offering a versatile platform equipped with a sophisticated scissors mechanism. This mechanism facilitates seamless adjustment of the sewing machine arrangement, allowing operators to tailor the setup to the specific requirements of their tasks. Central to the table's design are key components such as the sturdy platform, precision-engineered hydraulic arrangement, robust metal stands, maneuverable wheels, efficient sewing machine, and reliable motor. The hydraulic system empowers this table with effortless height adjustment capabilities, ensuring operators can easily customize the workstation to suit their ergonomic preferences. This feature not only enhances user comfort but also supports sustained focus and productivity during extended work sessions. Moreover, by providing an ergonomic solution, the table effectively addresses the prevalent health issues associated with prolonged sitting, thereby fostering a more comfortable and conducive working environment. One of the standout features of the ergonomic sewing table is its foolproof control system, which significantly reduces operator fatigue, particularly in environments where space is limited. This feature enhances operational efficiency and contributes to overall worker satisfaction. Additionally, the table's customizable features and compact lifting equipment make it a cost-effective and adaptable solution compared to alternative workstation setups.

With its minimal power consumption, the ergonomic sewing table not only delivers economic benefits but also prioritizes the well-being of workers by mitigating health-related concerns. Its versatility extends across various industrial domains, where it optimizes operational efficiency by facilitating seamless product handling. By raising, rotating, and tilting products as needed, the table streamlines critical processes such as manufacturing, packaging, and warehousing.

Furthermore, the table's design minimizes the need for strenuous reaching and bending motions, thereby reducing the risk of workplace accidents and injuries. This proactive approach to safety ensures a secure working environment and promotes employee welfare. Moreover, by enabling seamless connectivity between different stages of industrial processes, the ergonomic sewing table plays a vital role in enhancing overall productivity and operational effectiveness across diverse sectors. In essence, the integration of ergonomic sewing tables not only prioritizes the well-being of workers but also drives sustained growth and efficiency within the industrial landscape. Through its innovative design and multifunctional capabilities, this essential workstation contributes significantly to the success and competitiveness of businesses across various industries..

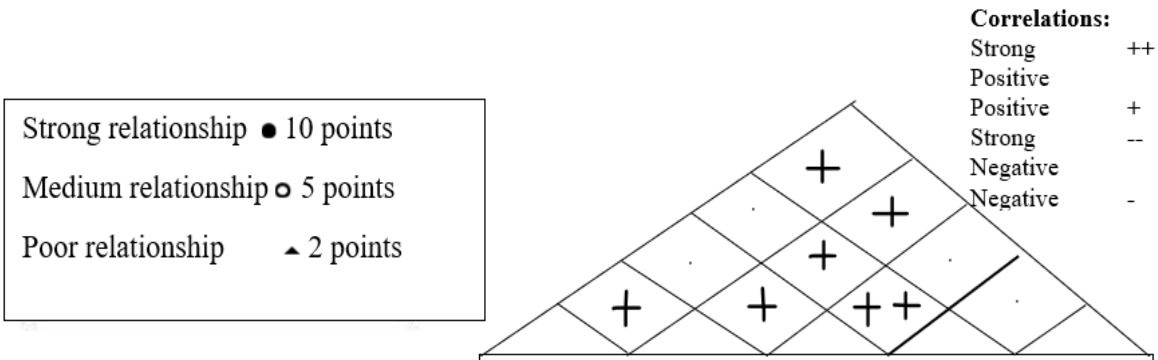
2 Literature Review

Foldable furniture is gaining prominence in modern furniture design, offering multifunctionality and space-saving solutions. However, comprehensive design documentation remains limited. This study aims to develop a space-saving multipurpose table with improved ergonomic performance, leveraging research articles and patents for concept generation. Mechanical simulations validate structural integrity, indicating enhanced task completion speed and reduced space occupancy compared to single-function furniture items. Survey analysis underscores a strong correlation between space-saving effectiveness and ergonomic performance, suggesting potential commercial viability (Cheng et al., 2021). Ergonomics is pivotal for industrial growth and sustainable manufacturing, ensuring efficient processes while prioritizing workforce well-being. This review emphasizes integrating human-centric ergonomics with sustainable practices to optimize efficiency and safeguard worker health. It highlights advancements in ergonomic design and the need for human-centered approaches to align with sustainability goals, underscoring the importance of cognitive variables such as situational awareness and decision-making abilities (Hasanain, 2024). In the context of China's furniture manufacturing industry, modular design principles are employed to enhance the sustainability of multifunctional furniture across the product life cycle. By analyzing the modular design of imitation solid wood frame cabinet furniture, the study proposes innovative approaches to produce versatile furniture styles. Redefining multifunctional furniture based on sustainability principles, the research offers insights into sustainable design processes and their application in furniture manufacturing (Wang, 2022). Integrating human factors and ergonomics (HFE) with lean principles enhances operational efficiency and worker well-being in industries such as textiles. Action research demonstrates the effectiveness of Ergo-VSM in identifying ergonomically critical activities and evaluating human factors alongside lean parameters. The study underscores the potential of an integrative approach to enhance worker satisfaction and operational performance (Sakthi Nagaraj et al., 2019). A case study focusing on improving the work environment of an informal apparel micro-enterprise highlights the significance of addressing working conditions to enhance worker health and productivity. Strategies based on ergonomic principles lead to improvements in worker comfort, well-being, and performance, contributing to sustainable development goals and serving as a valuable educational case study (Senayah and Appiadu, 2022). Product development reports detail the creation of an ergonomic iron designed to enhance user comfort and performance. Through literature review, user studies, and prototype development, the final product achieves ergonomic excellence and sustainability, integrating seamlessly into home interiors while prioritizing user comfort (Fredriksson and Österlind, 2018; Prashant, Gopinath, and Ravichandran, 2014). Exploring the integration of macro- and micro-ergonomic approaches in optimizing the worker-work environment interface for sustainable business practices, the study identifies ergonomic issues impacting employee well-being and operational efficiency. The findings underscore the importance of an integrative approach to address productivity, quality, and safety concerns effectively (Genaidy et al., 2009). A holistic approach to product design is exemplified in the development of a school bag convertible into a study table, addressing ergonomic concerns related to prolonged study sessions and poor posture. This innovative design contributes to educational sustainability and societal development goals (Sadasivan et al., 2021). The emergence of smart clothing presents opportunities and challenges for sustainable development in the apparel industry. This review explores sustainability issues throughout the smart clothing lifecycle, proposing strategies to address environmental concerns and promote industry sustainability (Li et al., 2022).

3 Methodology

4.1 Quality Function Deployment (QFD)

This research endeavors to apply Quality Function Deployment (QFD), also known as the House of Quality, to integrate customer requirements extracted from surveys with the technical attributes of our alert system within the context of an ergonomic sewing table. By leveraging the framework of the House of Quality, significant technical prerequisites were delineated. Particularly noteworthy were customer preferences for adjustable features, user-friendliness, durability, comfort, and cost-effectiveness. Consequently, these discerned design specifications have been designated as focal points in our developmental trajectory, directing resource allocation towards critical technical elements such as materials, hydraulic arms, sensors, microcontrollers, and metal components.



Customer Important Rating	Customer Requirements	Functional Requirements				
		Materials (Wood)	**Hydraulic Arm**	**Sensor**	**Micro controller**	**Metal Parts**
5	Adjustable	○	●	●	●	○
4	Simplicity to use	●	●			▲
3	Durability	○				●
2	Comfort	●	●	○	○	▲
1	Low cost	●	▲	▲	▲	○
Technical Important Score		135	112	62	62	72
Importance%		30.4%	25.28%	13.99%	13.99%	16.25%
Priorities rank		1	2	4	5	3

Figure 1:QFD Chart

4.2 Functional Decomposition

This section delves into the functional decomposition of an ergonomic sewing table, elucidating its three primary units: the Main Body, Driven Unit, and Control Unit. The Main Body encompasses essential components such as a flat table made of wood or plastic, a vertical metal table stand, and adjustable wheels. Within the Driven Unit, pivotal elements comprise a hydraulic system, handle, and pressure arm. Meanwhile, the Control Unit encompasses sophisticated components including sensors, a microcontroller, and controlling devices. This systematic breakdown provides a comprehensive understanding of the interplay between the various units constituting the ergonomic sewing table, facilitating a structured approach towards its design, development, and optimization..

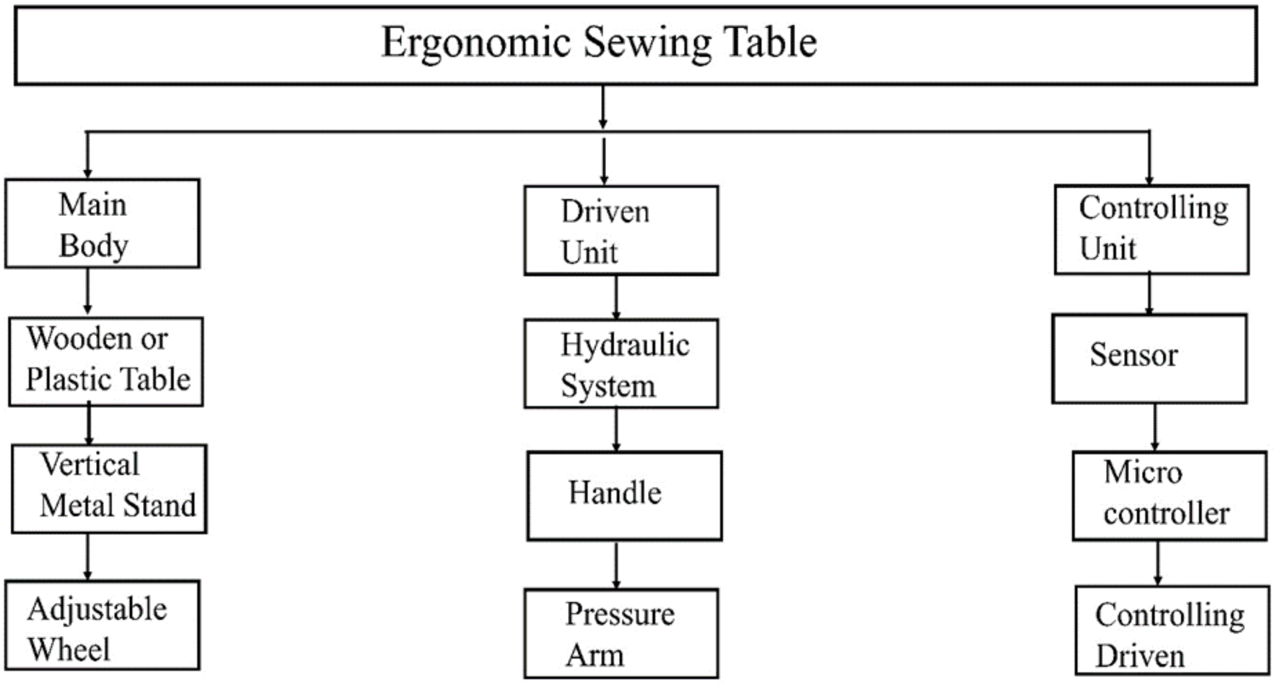


Figure 2: Functional Decomposition for Development of Multifunctional Uses of Ergonomic Sewing machine Table

4.3 Black Box

Black box is a model that receives input and produces output without revealing any information about its internal workings. The black box of an ergonomic sewing table is given below where we can see that an ergonomic sewing table receives energy and different information to produce results accordingly.

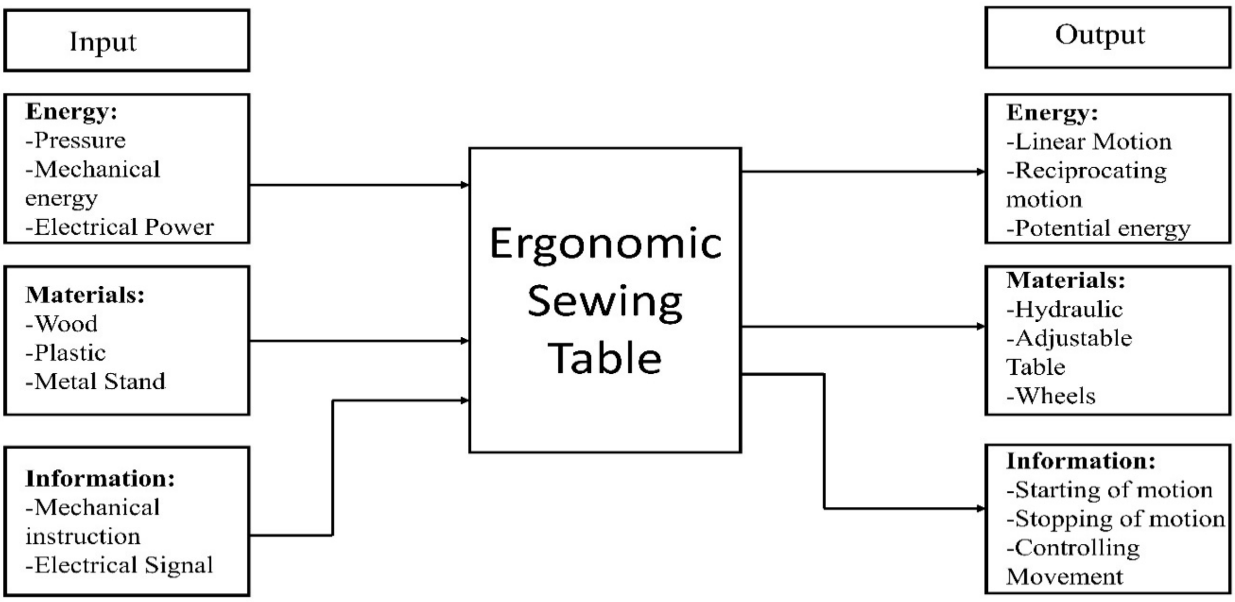


Figure 3:Black Box Diagram Development of Multifunctional Uses of Ergonomic Sewing machine Table

4.4 Cluster Diagram

In academic research aimed at enhancing the discourse surrounding ergonomic sewing tables, the utilization of a Cluster Diagram proves instrumental in structuring the ideation process and organizing pertinent information. Within this context, the Cluster Diagram serves as a visual representation offering an overview of the flow of

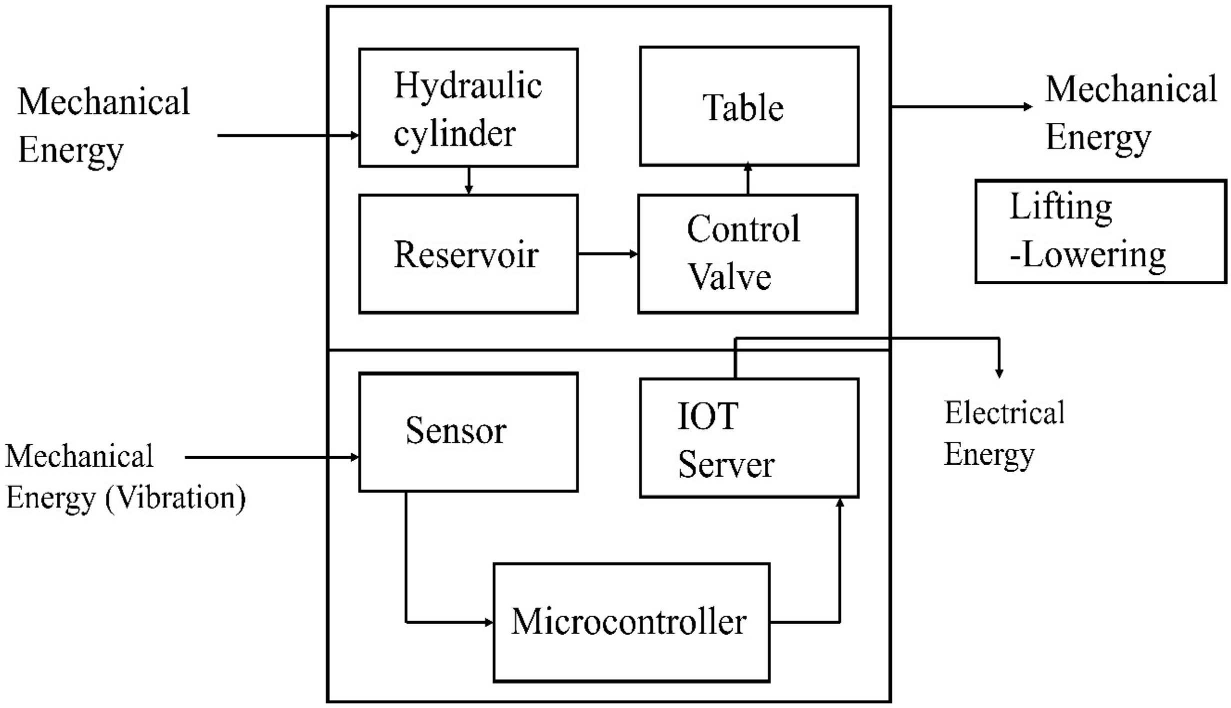


Figure 4:Cluster diagram for Development of Multifunctional Uses of Ergonomic Sewing machine Table

energy and signals throughout the entire system, culminating in the conversion to the final output. This analytical tool not only aids in conceptualizing the intricate dynamics within the ergonomic sewing table but also facilitates a comprehensive understanding of its operational mechanisms, thereby contributing to informed decision-making and innovative advancements in the field.

5 Material Selection

5.1 Flat Table

In the material selection process for an ergonomic sewing table, paramount consideration is accorded to criteria such as strength and vibration resistance. Consequently, additional factors including durability and cost are also evaluated to ascertain the most suitable material. Through comparative analysis of these criteria, weighted factors or relative emphasis coefficients are determined based on priority and the number of favorable decisions for each criterion. This methodical approach ensures the selection of materials that not only meet essential performance requirements but also align with overarching design objectives and cost considerations for the ergonomic sewing table.

Table 1:Determination of Relative Importance of Goals Using Digital Logic Method

Selection Criteria	Weighted Factor, α	Wood		Stainless Steel	
		Scaled Property, β	Weighted property, αβ	Scaled Property, β	Weighted property, αβ
Strength	0.3	30	9	100	30
Durability	0.2	60	12	100	20
Vibration resistance	0.3	75	22.5	100	30
Availability	0.1	100	10	60	6
Cost	0.1	100	10	60	6
Material Performance Index, **ϒ = ∑ αβ**			63.5		92

Table 2:Preferred material's properties and selection criteria of the product

Selection Criteria	**Wood**	**Stainless Steel**
Strength	15000	50000
Durability	3	5
Vibration resistance	3	4
Availability	5	3
Cost	5	3

Table 3:Numerical Value (Rating)

Very High	5
High	4
Medium	3
Low	2
Very Low	1

Table 3 delineates a systematic ranking system devised for the selected criteria. While certain criteria, such as strength, lend themselves to straightforward numerical comparison between materials, others like durability, vibration resistance, cost, and availability lack specific numerical values. To address this, a rating system derived from Table 3 is employed for comparing candidate materials across these criteria. Each material is assessed and assigned a rating from 1 to 5 based on its performance relative to a predetermined benchmark for the specific criterion under consideration. This structured approach facilitates a comprehensive evaluation of candidate materials, enabling informed decision-making in the material selection process for the ergonomic sewing table.

Table 4 : Calculation of the Material Performance Index:

Selection Criteria	Weighted Factor, α	Wood		Stainless Steel	
		Scaled Property, β	Weighted property, αβ	Scaled Property, β	Weighted property, αβ
Strength	0.3	30	9	100	30
Durability	0.2	60	12	100	20

Vibration resistance	0.3	75	22.5	100	30
Availability	0.1	100	10	60	6
Cost	0.1	100	10	60	6
Material Performance Index, **ϒ = ∑ αβ**			63.5		92

Table 4 exhibits the conclusive outcome in the form of a performance index for the candidate materials. Through meticulous examination of the ratings attributed to selected criteria alongside their respective weighted factors, the performance index for both materials is computed. Specifically, wood garners a performance index of 63.5, while stainless steel achieves a score of 92. Wood emerges as the preferred material choice based on this analysis..

5.1 Wheel

Table 5: Determination of Relative Importance of Goals Using Digital Logic Method:

	Total number of positive decision = 3(3-1)/2				
Selection criteria	1	2	3	Positive Decisions	Repetitive emphasis co- efficient
Ultimate tensile strength	1	1		2	.67
Cost	0		1	1	.33
Availability		0	0	0	0
Total number of positive decisions = 3					∑α= 1

In the process of material selection for the wheel of an ergonomic sewing table, the foremost criterion of consideration is the ultimate tensile strength. In addition to this critical factor, other criteria such as cost and availability are also taken into account to determine the most suitable material. A comparative analysis is conducted across all criteria, followed by the calculation of weighted factors or relative emphasis coefficients. These calculations are based on priority ranking and the number of affirmative decisions for each criterion. This systematic approach ensures the selection of a material that not only meets the essential requirement of ultimate tensile strength but also aligns with considerations of cost and availability for the wheel of the ergonomic sewing table.

Table 6 : Preferred material's properties and selection criteria of the product

Selection Criteria	**Plain Carbon Steel**	**Stainless Steel**
Ultimate tensile strength	850	1200
Cost	5	3
Availability	4	3

Table 7: Numerical Value (Rating)

Very High	5
High	4
Medium	3
Low	2
Very Low	1

Certain criteria, such as ultimate tensile strength, possess quantifiable numerical values, simplifying the comparison between materials for this particular criterion. However, other factors like cost and availability lack specific numerical metrics. To address this challenge, a rating system derived from Table 7 is utilized for comparing candidate materials across these criteria. Each material is assessed and assigned a rating ranging from 1 to 5 based on its performance relative to a predetermined benchmark for the specific criterion under consideration. This structured approach facilitates a comprehensive evaluation of candidate materials, enabling informed decision-making in the material selection process for the ergonomic sewing table.

Table 8: Calculation of the Material Performance Index

Selection Criteria	Weighted Factor, α	**Plain Carbon Steel**		**Stainless Steel**	
		Scaled Property, β	Weighted property, αβ	Scaled Property, β	Weighted property, αβ
Ultimate tensile strength	.67	71	47.57	100	67
Cost	.33	100	33	60	19.8
Availability	0	100	0	75	7
Material Performance Index, **ϒ = ∑ αβ**			**80.57**		**83.8**

Table 8 presents the conclusive outcome in the form of a performance index for the candidate materials. Following a comprehensive analysis of the ratings attributed to selected criteria and their corresponding weighted factors, the performance index is calculated for both plain carbon steel and stainless steel. Notably, plain carbon steel achieves a performance index of 80.57, while stainless steel attains a higher score of 83.8. Based on this analysis, stainless steel emerges as the preferred material choice for the ergonomic sewing table.

5.1 Metal Stand

Table 9: Determination of Relative Importance of Goals Using Digital Logic Method:

	Total no of positive decision = 5(5-1)/2											
Selection criteria	1	2	3	4	5	6	7	8	9	10	Positive Decision	**Relative emphasis co-efficient**
Tensile strength	1	1	1	1							4	**4**
Hardness	0				1	0	0				1	**1**
Availability		0			0			1	0		1	**1**
Cost			0			1		0		1	2	**2**
Durability				0			1		1	0	2	**2**
Total number of positive decisions =10												∑α= 1

In the process of material selection for a metal stand, the primary criterion of consideration is the tensile strength, given its critical role in ensuring structural integrity. Alongside this pivotal factor, additional criteria such as cost, availability, durability, and hardness are taken into consideration to identify the most suitable material. A comprehensive comparative analysis is conducted across all criteria, followed by the calculation of weighted factors or relative emphasis coefficients. These calculations are performed based on priority ranking and the number of affirmative decisions for each criterion. This systematic approach ensures the selection of a material that not only meets the essential requirement of tensile strength but also aligns with considerations of cost, availability, durability, and hardness for the metal stand of the ergonomic sewing table.

Table 10 : Preferred material's properties and selection criteria of the product

Selection Criteria	Plain Carbon Steel	Stainless Steel
Tensile Strength	4	5
Hardness	4	5
Availability	4	3
Cost	5	3
Durability	3	4

Table 11: Numerical Value (Rating)

Very High	5
High	4
Medium	3
Low	2
Very Low	1

Table 11 delineates a structured ranking system devised for the selected criteria. While certain criteria, such as tensile strength, can be quantified with specific numerical values, others like cost, availability, hardness, and durability lack such precise metrics. To address this variability, a rating system derived from Table 11 is utilized for comparing candidate materials across these criteria. Each material is evaluated and assigned a rating from 1 to 5 based on its performance relative to a predefined benchmark for the specific criterion under consideration. This systematic approach facilitates a comprehensive evaluation of candidate materials, enabling informed decision-making in the material selection process for the ergonomic sewing table.

Table 12 : Calculation of the Material Performance Index:

Selection Criteria	Weighted Factor, α	**Plain Carbon Steel**		**Stainless Steel**	
		Scaled Property, β	Weighted property, αβ	Scaled Property, β	Weighted property, αβ
Tensile Strength	.4	80	32	100	40
Hardness	.1	80	8	100	10
Availability	.1	100	10	75	7.5
Cost	.2	100	20	60	12
Durability	.2	75	15	100	20
Material Performance Index, **ϒ = ∑ αβ**			85		**89.5**

Table 12 illustrates the conclusive findings in the form of a performance index for the candidate materials. Following a meticulous examination of the ratings assigned to selected criteria and their corresponding weighted factors, the performance index is computed for both plain carbon steel and stainless steel. Specifically, the performance index is determined to be 80.57 for plain carbon steel and 83.8 for stainless steel. These numerical representations provide insights into the comparative performance of the materials under consideration, aiding in the informed selection process for the ergonomic sewing table. Based on this analysis, stainless steel emerges as the preferred material choice for the ergonomic sewing table.

6 Result and Discussion

The textile industry stands as a linchpin in fostering economic development across nations, with sewing constituting a pivotal sector within the garment manufacturing domain. Within this context, the sewing section holds paramount importance for garment manufacturing companies. This research delves into the ergonomic sewing table, aimed at addressing health concerns among workers while enhancing the overall working environment within such companies.

Over prolonged periods of work, individuals often encounter various health issues, including muscle pain and injuries. The implementation of an ergonomic sewing table offers a viable solution to mitigate such challenges. Leveraging hydraulic arms and vibration sensors, this innovative design ensures ergonomic adjustability and promotes safety through vibration detection. Through meticulous material selection, wood and stainless steel emerge as optimal choices for constructing this product, owing to their favorable characteristics and ready availability. The integration of this equipment into industrial settings promises to safeguard workers' health while bolstering productivity within a conducive working environment. By addressing health concerns and fostering a safe and efficient workspace, the ergonomic sewing table stands poised to make significant contributions to the well-being and productivity of workers in the garment manufacturing industry.

Conclusion:

This paper explores the implications of an ergonomic sewing table, designed to safeguard workers' health and enhance industrial productivity. By mitigating back problems and preventing chronic ailments, this innovative solution significantly improves worker comfort and reduces muscle strain. However, the cost of this product is relatively high due to the incorporation of sensors and hydraulic components. Looking ahead, the potential applications of the ergonomic sewing table extend beyond industrial settings to various facets of daily life. Its compact design makes it an attractive option for space-saving solutions. Furthermore, with the integration of additional features, such as convertible functionalities, the table holds promise as a versatile piece of furniture capable of serving multiple purposes, ranging from a workstation to a chair or even a baby's bed. As advancements continue, the versatility and adaptability of the ergonomic sewing table position it as a valuable asset in both industrial and domestic environments, offering enhanced functionality while promoting health and well-being.

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