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Adopting Technology System of an Innovated Dual-Sided Mechanical Tool Storage

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Abstract**—** *The research is a model-building study of mechanical tool storage that aimed to save time in storing and accessing tools, as well as improving space in the machine shop. A dual-sided mechanical tool storage was designed having manual automation in the overall storage system and was portable for mobility. Different compartments were installed and mounted to a bearing in connection to the sprocket and chain for smooth manual rotation. Furthermore, a wheel and lock system was added for movement and stability. The design was simulated in order to identify the amount of strain that the materials experienced during operation. A higher load was used to see if the projected design will be able to store the proposed weight of hand tools to be stored. The results showed that the strain experienced by the mechanical tool storage was concentrated in the section wherein the tools are being placed. It displayed a maximum deformation of 0.1891 mm with a load of 56.74 kg, torque of 100 N-m, and speed of rotation of 3 rpm. It was implied that the mechanical tool storage is more than able to store the proposed total weight of hand tools. Moreover, a survey was conducted for acceptability of the design to its users. It showed a satisfactory performance in the different factors and attributes of the design. The results inferred that the dual-sided mechanical tool storage can be an innovative way in safe keeping the hand tools. It was successful in preserving the integrity of hand tools against dirt, grime, and moisture. Moreover, the data implied that in terms of usefulness, the design was reliable in organizing tools thus reducing hazards in the machine shop. Based on the findings, the researcher concluded that the dual-sided mechanical tool storage yield significant changes in terms of work efficiency. It met its objectives in defining and determining the functionality of the dual-sided mechanical storage for safety of hand tools in the machine shop. Lastly, the researcher recommended to make the manual mechanism into automatic mechanism by accompanying switches in the design, as well as changing the dimensions in order to store heavy equipments such as power tools.*

Keywords**—** *Mechanical tools, tool storage, machine shop.*

I. INTRODUCTION

Rationale

Tools are devices used directly upon a piece of material to shape it into a desired form. They are usually found in machine shops where portable power tools and hand tools are used for making, finishing, or repairing machines or machine parts. Commonly used portable power tools and hand tools are screwdrivers, spanners, pliers and cutters, hammers and mallets, chisels, scribes and punches, hacksaws and files, vises and clamps, hand threading tools, hand drills and reamers, and hand grinder.

Proper storing of tools protect them from mishandling, dirt, grime, and moisture which promotes oxidation and rust. A toolbox is a metal or plastic which contains general tools that you need at home, for house and car repairs. For the workforce, machine shop, plumbing industry, and others, a toolbox is an important piece of equipment as it encloses their different necessities for work. Such storage will organize the different tools for easy access when needed.

Currently, industries used several storage devices in organizing there tools such as shelves, racks, drawers, and toolboxes. Moreover, some of these storage devices can be portable. However, though it aids in classifying and organizing those different tools, it has its limits specifically on its convenience on moving the needed set of tools to a specific area in the workshop. In some instances, these storage devices can be bulky and thus can be a cause of space congestion and an unorganized workplace.

So, the challenge now is to design and fabricate a mechanical tool storage that will not only organize the power tools and hand tools but also be portable enough for mobility. Different compartments will be installed, and be mounted to a bearing in connection to the sprocket and chain for manual rotation. The mechanical tool storage will be built from materials that can bear the combined weight of the tools being stored. Moreover, specification of such material must be able to withstand the stress caused not only by the weight of the tools but as well as the momentum during rotation of the storage. Furthermore, a wheel and lock system will be added for movement and stability.

Conceptual Background

The integration of innovative technologies provides automation in the flow of work and also lessens the consumed time per work while relatively increasing the efficiency in a job done. Reduced space used in storage, and less time consumed in the sorting of tools during work mean less hassle and create a better working environment. Having a better working environment can greatly contribute to having a better work process, thus, directly affecting the efficiency of work positively. Small leaps in technological advancements like this will not only have a high impact in the long run but also change how people work in their daily life, especially those who will benefit the most from this proposed study.

Project construction is quick, manageable, and effective. The main construction requires a rigid body that can withstand an enormous amount of combined weight of tools and can be

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able to fit different compartments for tool storage. A chain and sprocket is also integrated into the part.

A 5S methodology is a systematic approach to workplace organization. This method comprises five steps; Sort, Set in order, Shine, Standardize, and Sustain. It is a framework that emphasizes the use of specific mindsets and tools to create efficiency and value in work. C. Veras et al. (2017) Lean Manufacturing is a method derived from Toyota Production System, which aims to eliminate losses and waste in all aspects, whether time, energy, or profit. The 5S method, a simple yet effective practice. It helps establish and sustain a productive and efficient working environment in industry or small-scale workshops.

The Lean Implementation or 5S method started in Japan and the United States of America in the automotive industry and became a necessity in this line of industry. In the past years, this concept has been continuously and constantly evolving due to its proven efficiency and effectiveness. A significant characteristic of Lean Implementation is its versatility in terms of application in various fields: healthcare, retail, IT, government, and manufacturing sector.

According to K. Shoemaker (2019), while a cluttered workplace can create physical hazards, it can also create personal hazards and problems for the business. A cluttered workplace can be related to increased levels of stress and anxiety that can have a negative in workflow, that also cause unnecessary obstructions. Having difficulty in finding the right tools especially when they are needed can cause increased stress. While it is understandable that a cluttered workplace cannot be easily avoided, it can pose a hazard to people or workers.

A tool organizer is an important piece of equipment, particularly in a machine shop or any workplace, as it helps in space-saving and organization of tools. Guirlinger (2005) defines tool organizers as disclosed material. Contains a frame and a plurality of wheels connected to the frame. It also includes a tool storage structure that strengthens the frame. The tool storage structure includes a majority of storage panels, all storage contains at least one fastener and associated tool indicia for ensuring and specifying specific tools. The plurality of storage panels is portable concerning one another between a closed configuration and an open configuration. A modular tool organizer, a toolset transportation system, a tool bag, and a method for examining a set of tools stored within a tool organizer are also disclosed. The numerous aspects of the current innovation are recommended for pushing carts and moving cart assemblies. One embodiment includes a moving cart assembly with a plurality of interlocking, vertically stackable, storage modules.

In addition, Ferraro and Murphy (2006) stated the modules of this embodiment include a frame, willingly having at least four sides, e.g., a top, a back, a right side, and a left side. Each module also includes something to encompass the interior area, such as a set of doors or a drawer that is selectively slidable into the frame. The requirements of a specific office can be readily adapted by using enormous or limited amounts of drawer modules and/or cabinet-type modules.

Moreover, Brunner (2020) stated, a compact assembly including a base cabinet in the shape of a bucket having an upper end and a top case assembly including at least one top cabinet. The top cabinet is slidable ensured to the base cabinet. The top cabinet is slidable between a closed standpoint in which it substantially wraps the upper end of the base cabinet and the open stance in which it exposes the base cabinet. The movable container assembly further comprises a locomotive assembly having a wheeling parliament and a handle parliament for locomotion the portable parliament.

The projected design of this research will be based on how to hold up the total weight of tools and their potential to be transported or moved around. The design incorporated several compartments to sort out different categories of the tool. According to Hovatter (1999), tool storage and transport system contain a tool storage box assembly ensured to remove dolly assembly. The tool storage box assembly contains various attachment bolts extending outwardly from a back wall of the storage box assembly, a like amount of fastener nuts threadable onto the threaded ends of the attachment bolts, a lifting plate obtaining slot formed into the bottom of the tool storage box assembly, and a magnetic cover surface ensured to an upper surface of the tool storage box assembly. The removable dolly assembly includes a couple of vertical supports, having numerous storage boxes securing slots and space there along a manner to enable the attachment bolts of the tool storage box to be arranged there through, and a lifting plate protected between the verticals supports and sized to match within the lifting plate receiving slot of the tool storage box assemble.

According to Anzivino (2014), equipment for organizing and storing tools, related work equipment, and comfort items such as a music system with speakers, a radio, a digital CD player, and an MP3 adapter, as well as a portable refrigerator and a water cooler in a tool cabinet that is modular and handily transportable between work sites. The portable modular tool cabinet contributes an electrical power system, shelving components, and sliding drawers for holding tools, and two lockable doors that fasten additional hand tools and can be protected when the user is ready to transport the portable modular tool cabinet to another worksite or workshop. The whole unit is transportable by operating two base wheels and a pivotable-dolly-system with telescoping rod and wheel combinations that sustain easy rolling to transport trucks such as for loading and transporting to another area.

This proposed study focuses not only on the equipment's capability or capacity to organize tools but also to be transported and be mobile for ease in place to place doing jobs. Furthermore, this study will concentrate on having the manual automation in the overall system of the tool organizer for it to be a beneficial tool organizer as well as its capability or overall body integrity to withhold the variety of tools weight.

The most important part of creating a designed project is illustrating and attaining a sufficient understanding of the design to be created. Figure 1 shows the conceptual framework of the study wherein it started by gathering information about the topics in line with the design project. It includes the following:

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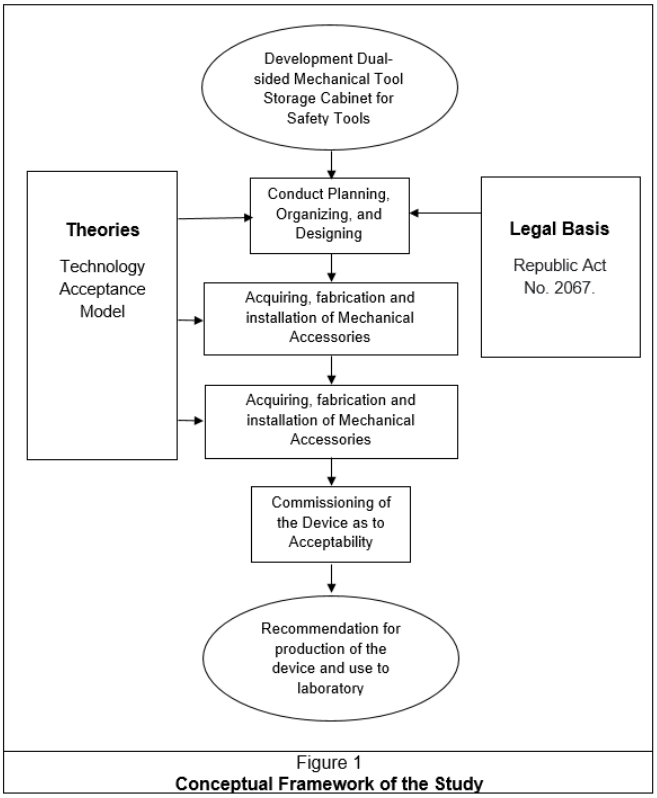

Figure 1
Conceptual Framework of the Study

Republic act no. 2067. An act to integrate, coordinate, and intensify scientific and technological research and development and to foster invention; to provide funds therefor; and for other purposes.

The technology acceptance model (Davis, 1989), or tam, it posits that there are two factors that determine whether a computer system will be accepted by its potential users: (1) perceived usefulness, and (2) perceived ease of use. The key feature of this model is its emphasis on the perceptions of the potential user.

Development dual-sided mechanical tool storage cabinet for safety tools. A cabinet structure stored with mechanical hand tools and other accessories display inside the mobile wooden cabinet. The development of this innovated device helps in the utilization in the laboratory as safety, ergonomics and storing tools.

Recommendation for production of the device and use to laboratory. This innovated device will adopt, shares and recommend to produce as a mobile tool cabinet in the technology laboratory.

Statement of the Problem

This research defined and determined the functionality of the Dual-sided Mechanical Tool Storage Cabinet for Safety Tools at the machine shop at Cebu Technological University Pinamungajan Extension Campus School Year: 2022-2023 towards technology adoption.

Specifically, it sought answers of the following questions:

1. What are the existing designs of tool storage?
2. What is the technology system for designing the dual-sided mechanical tool storage as to:
   2.1 technical requirements,
   2.2 procedure;
   2.3 ergonomics and safety, and
   2.4 sustainability?
3. As perceived by the respondent groups, what is the acceptability of the developed mechanical tool storage as to:
   3.1 perceived usefulness,
   3.2 perceived ease of use,
   3.3 users' satisfaction?
4. Based on the findings, what enhanced technology system for innovated dual-sided mechanical tool storage can be developed?

Significance of the Study

Instructors/School Administrators

They are the ones with direct contact to students and disseminate the procedure. The school administration was benefit the outcome by means of organizing the tools inside the workshop.

Students

The skills and knowledge of the students were enhanced by the designing and fabricating the dual-sided tool storage.

Future Researchers

This study will be beneficial to the readers and future researchers because it will give important information on organizing the workplace.

Scope and Limitations

The study focuses on storing lightweight tools to be kept in the mechanical tool cabinet. Moreover, it can be operated manually.

II. Research Methodology

Flow of the Study

The study focused on the design and fabrication of a technology model of a dual-sided mechanical tool storage. Figure 2 presented the input, process, and output of the study. The inputs are the profile of the identified respondent groups. The data were gathered through descriptive survey questions, actual observations, administration of the questionnaire after which was treated with appropriate statistical tools, analysis of data carefully interpreted. These was the basis of findings, conclusion and recommendations. The expected output of this study is the dual-sided mechanical tool storage product developed by the researcher and will be used at CTU Pinamungajan Campus.

Research Design

The type of research obtained in this project is a model-building study. The research project proposes a dynamic model for research and a model of a dual-sided mechanical tool storage. The design of the tool storage was modelled using AutoCAD software. The material used for the frames and walls are angle bar and marine plywood, respectively.

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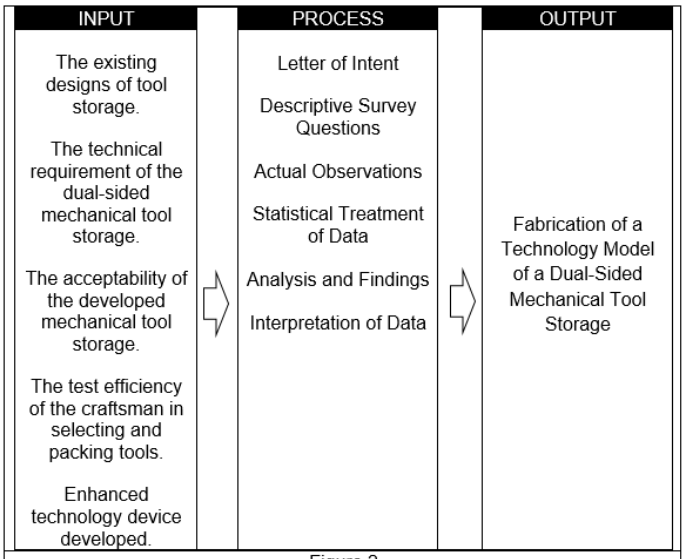

Figure 2
The Flow of the Study

Figure 3 showed the details of the mechanical tool storage design. The outside frame's width, length, and height are 650 mm × 550 mm × 1100 mm, respectively. Moreover, the inside frame (the rotating frame) measured 400 mm × 400 mm × 900 mm. At the lower part of the design, caster wheels with lock are attached for mobility of the storage. Each tool compartment had a width, length, and height of 400 mm × 400 mm × 300 mm, respectively.

The fabrication of the dual-sided mechanical tool storage conforms to the design shown in Figure 3. The materials to be used are presented in Appendix with its corresponding description.

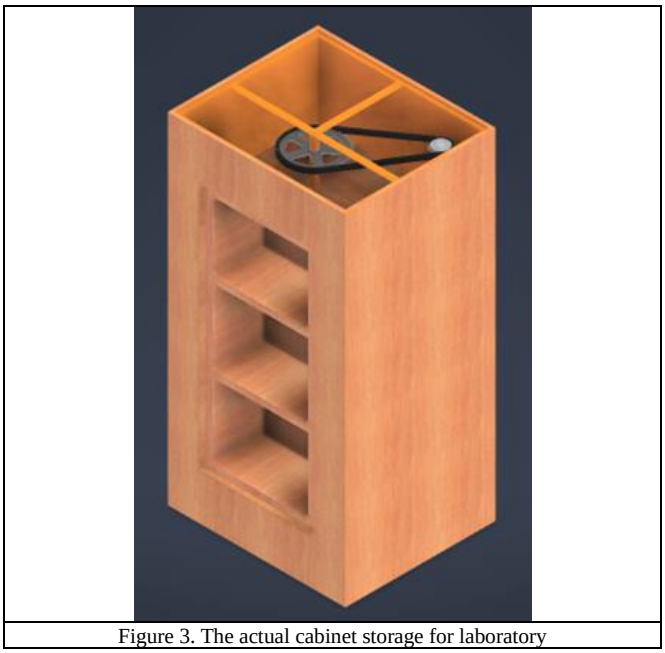

Figure 3. The actual cabinet storage for laboratory

Research Environment

The Cebu Technological University, Pinamungajan Campus was the research locale of the study. The university is located at the Municipality of Pinamungajan, province of Cebu. This was an extension campus of the Cebu Technological University and was converted into a regular campus under House Bill No. 9075 on March 2021. The CTU-Pinamungajan Campus primarily provide short-term technical-vocational, undergraduate, and graduate courses within its areas of competency and specialization pursuant to the mandate of the CTU. It is also mandated to undertake research and extension services, and provides progressive leadership in these areas.

Respondents

The respondents of the research are the instructors (10), chairpersons (5), and students (50) of the Welding and Fabrication Department in Cebu Technological University. The selected respondent groups will be rated based on the processes and the performance in Dual-sided Mechanical Tool Storage for Safety Tools.

Table 1. Distribution of Respondents

Respondents	Sample Respondents (N)	Percentage (%)
Instructors	10	15.39
Chairpersons	5	7.69
Students	50	76.92
TOTAL	**65**	**100.00**

Scoring Procedure

In the parameter of limits, the weighted, mean objectively described and the verbal descriptions of the ratings were shown.

Method and Techniques used on respondents

Weight	Range	Verbal Rating	Verbal Description
4	3.27 – 4.00	VHF	Very Highly Functional
3	2.52 – 3.26	HF	Highly Functional
2	1.76 – 2.51	LF	Less Functional
1	1.00 – 1.75	NF	Not Functional

Definition of Terms

Acceptability. It refers to the characteristics of the mechanical tool storage to fulfill its purpose in storing hand tools.
Caster. It refers to the wheeled device that is mounted to the mechanical tool storage which enables it to roll with ease.
Chain. It refers to the connected series of metal links that is used to fasten two-sprockets in order to transmit rotary motion to the mechanical tool storage.
Efficiency Testing. It refers to the process in testing the performance of the design.
Ergonomics. It refers to the optimization of the mechanical tool storage based on its accessibility and mobility.
Functionality. It refers to the quality of the design that was suited to serve its purpose.
Machine Shop Equipment. It refers to an equipment specifically used in a machine shop to cut, fabricate, etc.
Performance. It is the execution of the purpose of the mechanical tool storage.
Rotary Platform. It is a component of a motion system used to restrict an object to a single axis of rotation.
Safety. It is a condition that describes freedom from hazards that may cause injury.
Safety Tools. It means a tools or gadgets that are used for the protection of life and to avoid casualties and injuries.

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Sprocket. It refers to the mechanical element in which the chain is connected for smooth rotation of the mechanical tool storage.
Storage Cabinet. It refers to the device in which the hand tools are stored.
Tool Compartments. It is a part of a piece of furniture, equipment, or a container with a particular purpose of storing different kinds of tools.
Welding. It refers to the process that the metals are connected.
Work Efficiency. It means a workers carry out the tasks in the right with the least time and effort.

III. Presentation, Interpretation, And Analysis Of The Study

The Existing Designs of Tool Storage

Tool storage had long been part of the engineering industry especially in machine shops. The different designs ensured the storing of mechanical tools and preserve the integrity of such stored tools. A number of design emerges such as metal and wood storage cabinets (Figure 5), perforated display board and rack (Figure 6), and mechanical tool storage with wheels (Figure 7).

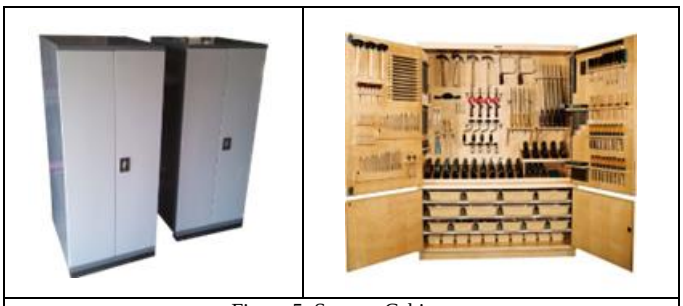

Figure 5. Storage Cabinet

Figure 6. Perforated Display Board and Rack

The metal and wood storage cabinets, and perforated display board and rack were generally used for storing mechanical tools. Though Figure 5 ensured that tools were safe from dust and moisture, it is limited in terms of mobility. Moreover, in Figure 6, tools were exposed in the environment causing oxidation to metals from the moisture in the surroundings. The mechanical tool storage with wheels in Figure 7 had its advantage from the previous designs in terms of its mobility. However, it is limited only to the specific lathe accessories that it was designed. Also, the storage compartment won't be rotated, thus there's a need to rotate the entire tool storage to have access on the other side.

Figure 7. Mechanical Tool Storage with Wheels

The Technical Requirements of the Dual-Sided Mechanical Tool Storage

The technical requirement of the Dual-Sided Mechanical Tool Storage has the capacity to hold mechanical hand tools and accessories. The design has features to utilize as to mobility from one place to another, it turned 360 degrees and has shelves that stores tools

Design

The design of the innovated device has illustrated and labeled with two dimensional measurements. It illustrates the views as to: Top View, Front View and the Right-side View.

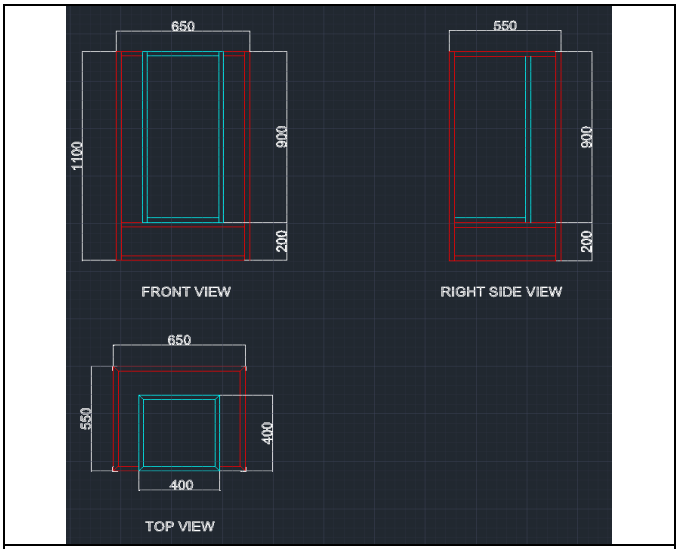

Figure 8. Orthographic Drawing of the Dual-Sided Mechanical Tool Storage

The figure 8 presents the required views in order that the users understand the position of the cabinet before used.

Isometric View

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The isometric view presents the whole picture of the innovated device and illustrated the rotary shelves and wheel mechanical gears. The Figure 9 represents the isometric view of the proposed design as well as the cross-sectional view of the swivel plate in order to have a better perspective of the fabricated design. The Figure 10 represents the exploded view of the whole design so as to give identification and location of parts in the design mechanism.

Cross-sectional view of the 10-inch Swivel Plate

Figure 9. Isometric View of the of the Dual-Sided Mechanical Tool Storage

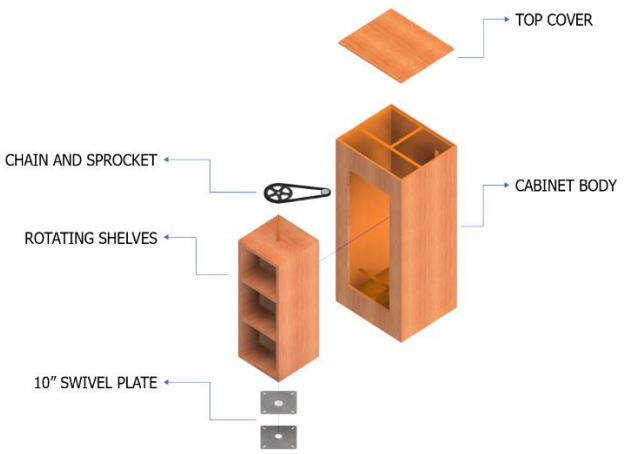

Figure 10. Exploded Drawing of the of the Dual-Sided Mechanical Tool Storage

Ergonomics

Ergonomics is the study of people in their working environment. More specifically, an ergonomist (pronounced like economist) designs or modifies the work to fit the worker, not the other way around. The goal is to eliminate discomfort and risk of injury due to work. Applying ergonomics principles to the workplace can reduce fatalities, injuries and health disorders, as well as improve productivity and quality of work.

The design encompass the ergonomic factors in terms of design dimensions, and mobility. It considered the average height of the person that will be using the storage, so that it won't be too short nor too high when storing the different mechanical tools. Moreover, it gave ease to the machinist when moving the tool storage from one place to another due to the heavy duty caster wheels attached to it. Lifting can be prevented, therefore ensuring safety to the machinist.

Figure 11. Ergonomics of the Dual-Sided Mechanical Tool Storage

Safety

Using a toolbox and tossing tools in there with no organization plan will not only waste resources, but could lead managers to reordering unnecessary replacement tools, or workers getting injured. Purchasing a toolbox is a good step in the right direction of tool organization, but it shouldn't stop there. Many toolboxes lacking an organization strategy may start off somewhat logically organized, but it won't take long before the drawers are cluttered, tools are missing, and workers can't find the tool they're looking for.

Many managers and employees may think if they can't see the problem, a mess of tools in a toolbox or tool chest, then the problem doesn't need to be solved.

A cluttered and unorganized toolbox, however, will waste time, result in unnecessary motion, and can even pose safety risks to those working in the facility.

Toolboxes and chests that have tools thrown in them with no organization method can be heard to search through. If a worker puts their hand in a drawer and is blindly digging around searching for a tool, sharp objects or items can pose a hazard. Time is also wasted when workers cannot find the tool they're searching for and they have to check multiple different areas around the facility. Workers going around the floor to search for tools can also waste movement, ultimately resulting in customers not receiving their purchase as quickly as they could.

A good alternative to the toolbox or tool chest is using a pegboard for tool organization. Although they take up a considerable amount of space, workers have the advantage of seeing every tool. Pegboards also offer a level of customization. A combination of hooks, pegs, shelves, and bins can be used to hold a variety of tools and materials. Using vinyl shadow tape also ensures workers know where to return tools when they're done using them.

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Figure 12. Safety of the Dual-Sided Mechanical Tool Storage

Storage Capacity

Storage capacity refers to the specific amount of data storage that a device can accommodate tools and accessories in mechanical. This critical measurement is common place in consumer-facing Industrial Technology and also in designing enterprise storage cabinet or other larger device to function properly.

Figure 13. Storage capacity of the Dual-Sided Mechanical Tool Storage

The capacity of the machine will depend on the number and the total weight of the tools that can be stored. The projected total weight of the combined tools ranges from 30-40 kg. The tools that can be stored are the following but not limited to: ballpeen hammer (≈1.8 kg), adjustable wrench (≈1.6 kg), hand hacksaw (≈0.6 kg), tinner snip (≈1 kg), 1-inch chisel (1 kg), box wrench (≈0.6 kg), open wrench (≈0.8 kg), hand file (≈0.6 kg), riveter (≈0.8 kg), tap handle (≈0.8 kg), micrometer (≈0.6 kg), Vernier caliper (≈1.2 kg), and pipe wrench (≈1.8 kg). With these list, the machinist will be guided on the total number of tools to be stored according to its type.

The Acceptability of the Developed Mechanical Tool Storage

The developed mechanical tool storage is designed to students in the laboratory where the projects fabricated, installed and repairs. The acceptability of the device was based on the performance of the storage.

Usefulness

The usefulness and user satisfaction of the design shown in table 2 indicated the importance and overall function of the fabricated design. It served as the basis for the advantages of using the mechanical tool storage in the machine shop.

TABLE 2. The usefulness of the Dual-Sided Mechanical Tool Storage

Attributes of Usefulness	WM	VD
The mechanical tool cabinet is efficient in tool storing.	3.38	Very Highly Functional
The mechanical tool cabinet can reduce the time in storing tools.	3.21	Highly Functional
The mechanical tool cabinet is convenient to use.	3.34	Very Highly Functional
The mechanical tool cabinet overall features are fine.	3.05	Highly Functional
The mechanical tool cabinet can prevent damage to tools.	3.22	Highly Functional
The mechanical tool cabinet size is acceptable	2.92	Highly Functional
The mechanical tool cabinet ensures the safety of tools in the workplace.	2.99	Highly Functional

Legend:

Weight	Range	Verbal Rating	Verbal Description
4	3.27 – 4.00	VHF	Very Highly Functional
3	2.52 – 3.26	HF	Highly Functional
2	1.76 – 2.51	LF	Less Functional
1	1.00 – 1.75	NF	Not Functional

Table 2 showed the respondents' reaction towards the mechanical tool storage performance and its level of importance. Based on the tabulated data, most of the respondents agreed that the mechanical tool storage is more feasible than the traditional storing of tools, using the ordinary tool box. In addition, the majority of the respondents agreed that the design is efficient in serving its purpose in storing tools having an accumulated weighted mean of 3.38. Moreover, the mechanical tool storage promoted time efficiency in accessing tools and sorting them giving direct effect on work productivity having a weighted mean of 3.21. The data also implied that the respondents though that the overall features of the cabinet were feasible, in terms of design specifications, having a weighted mean of 3.05 and 2.92. An average of 2.99 implied that the mechanical tool storage ensured the safety of tools in the workplace.

Ease of Use

The design can be used even in congested places. It is specified as having the ability to store different kinds of hand

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tools in the machine shop. Since it was designed with several compartments, sorting and accessing the tools would be easier.

Though it is operated manually, it offers safety due to the stability on the rotating structure. The sprockets and chains used provided smooth rotation while the swivel plate gave additional support for steady operation.

Table 3. Ease of Use of the Dual-Sided Mechanical Tool Storage

Attributes of Ease of Use	WM	VD
The mechanical tool storage gave easy access and storage of mechanical tools	3.65	Very Highly Functional
The mechanical tool storage have enough space for keeping the mechanical tools	3.08	Highly Functional
The mechanical tool storage provided steady mobility	3.34	Very Highly Functional
The mechanical tool storage have smooth rotation in accessing the different compartments	3.05	Highly Functional

Legend:

Weight	Range	Verbal Rating	Verbal Description
4	3.27 – 4.00	VHF	Very Highly Functional
3	2.52 – 3.26	HF	Highly Functional
2	1.76 – 2.51	LF	Less Functional
1	1.00 – 1.75	NF	Not Functional

Table 3 showed the respondents' reaction towards the mechanical tool storage usability attributes. Based on the tabulated data, majority of the respondents agreed that the mechanical tool storage can easily be operated. Moreover, with an accumulated weighted mean of 3.65, the mechanical tool storage ensured easy access and storage of different tools in terms of its dimensions. It also delivered enough space in storing the different hand tools, thus the weighted mean of 3.08. Lastly, it ensured sturdiness when moved from one place to another, and gave smooth rotation upon accessing the tools being stored in the different compartments, having a weighted mean of 3.34 and 3.05, respectively.

User Satisfaction

The user satisfaction of the design shown in table 4 indicated the approval of the users on the importance and overall function of the fabricated design.

Table 4. Users' satisfaction with the Dual-Sided Mechanical Tool Storage

Attributes of User's Satisfaction	WM	VD
The mechanical tool storage was made from sturdy materials	3.78	Very Highly Functional
The mechanical tool storage is reliable in storing hand tools	3.21	Highly Functional
The mechanical tool storage is cost-effective	2.85	Highly Functional
The mechanical tool storage overall mechanism is adequate	3.15	Highly Functional

Legend:

Weight	Range	Verbal Rating	Verbal
4	3.27 – 4.00	VHF	Description
3	2.52 – 3.26	HF	Very Highly Functional
2	1.76 – 2.51	LF	Highly Functional
1	1.00 – 1.75	NF	Less Functional

Table 4 showed the respondents' response on how satisfied they were in using the mechanical tool storage. Based on the tabulated data, majority of them agreed that the mechanical tool storage served its purpose on storing and accessing several types of hand tools, as well as smooth and steady movement of the storage when transferred. The accumulated weighted mean of 3.78 implied that the storage was fabricated from quality materials. Moreover, it was made with intricacy in connecting and assembling the different parts. The respondents also agreed that the mechanical tool storage is reliable in keeping the tools, achieving a weighted mean of 3.21. This also inferred that the design was successful in keeping the tools from dirt, grime, and moisture that can cause oxidation and rust. The data also implied that the design is cost-effective and can easily be manufactured and fabricated, having a weighted mean of 2.85. An average of 3.15 indicated that the respondents were satisfied on the overall functionality of the mechanical tool storage.

Summary of the Performance of the device as Acceptability

The dual-sided mechanical tool storage showed satisfactory performance in the different factors and attributes of the design. It gave adequate results in fulfilling its purpose in storing different types of hand tools, accessibility upon usage, and achieving competency upon user's intervention.

Table 5. Summary of the Performance of the device as Acceptability

Performance of the Device as to Acceptability	Identified Respondent Groups					
	Students (50)		Chairpersons (5)		Instructors (10)	
	WM	VD	WM	VD	WM	VD
Perceived Usefulness	2.96	HF	3.2	HF	3.3	VHF
Perceived Ease of Use	3.34	VHF	3.4	VHF	3.1	HF
User's Satisfaction	3.14	HF	3.4	VHF	3.2	HF
Average:	3.15		3.33		3.2	
Interpretation:	HF		VHF		HF	

Legend:

Weight	Range	Verbal Rating	Verbal Description
4	3.27 – 4.00	VHF	Very Highly Functional
3	2.52 – 3.26	HF	Highly Functional
2	1.76 – 2.51	LF	Less Functional
1	1.00 – 1.75	NF	Not Functional

The data presented above showed the summary of the respondents' feedback with regards to the mechanical tool storage performance as perceived in its usefulness, ease of use, and user's satisfaction. It is apparent that the different respondent groups agreed that the mechanical tool storage mechanism displayed competence with the traditional way of storing hand tools. An overall average on the students group, chairpersons' group, and instructors' group of 3.15, 3.33, and 3.2, respectively, implied that the mechanical tool storage can be an innovative way in safe keeping the hand tools. Furthermore, it was successful in preserving the integrity of hand tools against dirt, grime, and moisture that will affect the tools performance. It can also be inferred from the data that in terms of its usefulness, the design was reliable in organizing tools thus reducing hazards in the machine shop.

The Test Efficiency of the Craftsman in Selecting and Packing Tools

Project Simulation and Strain Testing

Through several tests and simulations done using Autodesk Inventor's Finite Element Analysis Simulation tool, the researcher was able to gather data on the strain experienced by the mechanical tool storage design and its members.

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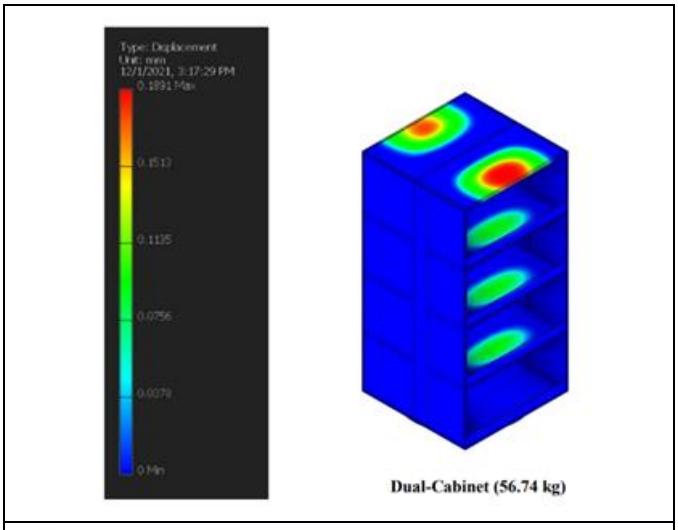

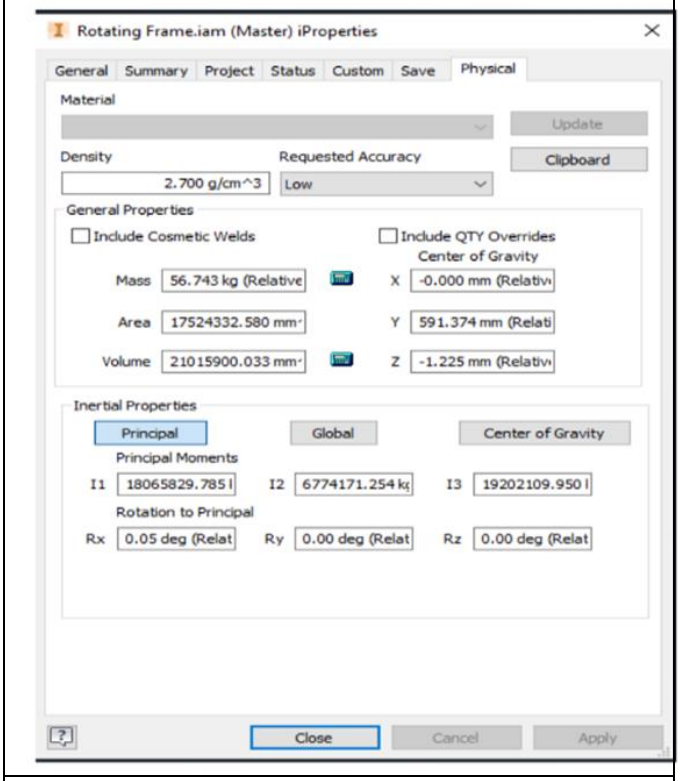

Figure 14. Deformation Due to Loading

The design was simulated in order to specify the amount of strain the material will have based on the load (weight of the tools) being stored. It is apparent that the strain experienced by the mechanical tool storage was concentrated in the section wherein the tools are being placed. The projected total weight of the combined tools that the storage can hold ranges from about 30 kg to 40 kg. However, in the simulation, the researcher used a higher load to see if the projected design will be able to store that amount of weight. The simulated design showed a maximum deformation of 0.1891 mm with a load of 56.74 kg, torque of 100 N-m, and speed of rotation as 3 revolutions per minute. Thus, gave an implication that the mechanical tool storage is more than able to store the proposed total weight of tools.

IV. Summary, Findings, Conclusions, and Recommendations

Summary

The dual-sided mechanical tool storage can replace the traditional storage and shelving of tools. The two-sided rotating storage provide enough space with superior flexibility while storing a variety of hand tools including screwdrivers, wrenches, hacksaws, files, hammers, calipers, steel rule, gage block, and height gages and tester. The total weight to be stored in the mechanical tool storage is about 55-60 kg.

The mechanical tool storage works greatly in a machine shop, even in congested places, especially for storing lightweight tools. It helped in the reduction of time consumed in accessing the tools and sorting out, therefore yielding to significant changes in terms of work efficiency. Although it can store several power and hand tools, it had its limits in storing bulkier equipment.

Findings

According to the results, the dual-sided mechanical too storage had met the technical requirements with its design. It featured the freedom of movement and easy access of the stored hand tools. Moreover, it encompassed the ergonomic factors in terms of design dimensions, mobility, and safety.

The simulated design showed that the deformation was concentrated on the section wherein the tools were placed. It was able to hold a load of 56.74 kg with a maximum deformation of 0.1891 mm, giving an implication that the dual-sided mechanical tool storage can store the projected total weight of stored hand tools with minimal deformation.

Moreover, the dual-sided mechanical tool storage showed satisfactory performance in terms of usefulness, ease of use, and user's satisfaction. An overall average on the students group, chairpersons' group, and instructors' group of 3.15, 3.33, and 3.2, respectively, implied that the mechanical tool storage can be an innovative way in safe keeping the hand tools.

Conclusion

Based on the findings, the researcher concluded that the dual-sided mechanical tool storage yield significant changes in terms of work efficiency. In addition, it aided in sorting and easy access on tools, as well as keeping the tools from damage in terms of corrosion from moisture and metal oxidation.

Recommendations

It is recommended that future researchers will double the size of the mechanical tool storage so that heavy equipment like power tools can be stored. Furthermore, switches can be installed for automatic rotation (wherein the top most switch is the closing of the storage; the middle switch will open the 1st compartment; and the lower switch will open the 2nd compartment). Moreover, a battery can be added to serve as a back-up power supply in case of blackout. The traditional button/switches can also be replaced by button sensor.

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