"Eco-Friendly Floor Cleaning Machine"

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ABSTRACT:

While many modern floor cleaning robots offer convenience and efficiency, they often struggle with limited accessibility due to their rigid structural design. These fixed-morphology platforms can have difficulty navigating complex environments, which affects their cleaning performance. Recent advancements have introduced shape-shifting robots that can adapt their form—like rearranging into various tetromino-like shapes—to better suit their surroundings and improve floor coverage. Studies comparing these flexible robots to traditional fixed models have shown improvements in their ability to clean larger, more irregular areas.

Despite these technological developments, manually operated floor cleaning machines remain widely used—especially in places like roads, schools, homes, bus stands, malls, and airports. Their popularity stems from their simplicity, low cost, and independence from electricity or any external power source.

The goal of this project is to design and build a mechanical floor cleaner that can effectively clean both dry and wet surfaces using only human effort. The design focuses on being budget-friendly, energy-free, and easy to operate, while also offering a sustainable and eco-friendly solution for everyday cleaning tasks.

1.INTRODUCTION:

Cleaning is a part of our everyday life, whether it is in homes, hospitals, schools, or public places like bus stands and auditoriums. While there are many machines available to make cleaning easier, most of them run on electricity or fuel. That makes them expensive to use and difficult to operate in places where power is not always available.

To solve this problem, we designed a simple, manually operated floor cleaning machine that does not need any electricity or external power. It works by using the force generated when someone pushes it forward. That motion is transferred through a chain and gear mechanism, which then rotates a cleaning brush underneath. The best part is—it can clean both dry and wet floors effectively, and it is easy to move around.

We used affordable and common materials like steel rods, wheels, wooden clips, gears, and bearings to build the machine. Because it is lightweight and not complicated to use, anyone can operate it without needing special skills.

What really makes this machine stand out is that it is eco-friendly, low-cost, and easy to maintain. It does not use electricity, so it is great for the environment and saves money. Plus, it is perfect for daily cleaning tasks in places where traditional cleaning machines are not practical or affordable.

2.LITERATURE REVIEW:

Over the years, many researchers have focused on improving floor cleaning machines, exploring various methods and technologies to make them more efficient, flexible, and user-friendly. Some studies have concentrated on the mechanical and structural safety of handheld devices, with 3D modelling and stress analysis confirming their safe operation under common working conditions.

In one approach, a tricycle-operated street cleaner was developed, mainly targeted at rural areas. While the machine functioned adequately, its performance declined significantly when faced with damaged or uneven roads. Another design introduced a multi-functional floor cleaner powered by an A.C. induction motor with a speed reduction system. It proved highly effective and versatile in cleaning, meeting its intended mechanical and operational goals.

A separate innovation utilized a DC motor with a wiper mechanism, even integrating solar energy for power supply. This design demonstrated good cleaning efficiency while promoting energy conservation.

Historically, mechanical floor cleaning tools date back to 1868 when W. McGuffey in Chicago created one of the earliest cleaning devices. By the late 1990s and early 2000s, the market began to shift toward robotic vacuum cleaners, although their reliance on electricity remains a limitation.

Some manual floor cleaning systems inspired by bicycle mechanics have also been created. However, these often suffered from poor efficiency and were not inclusive, as they required significant physical strength, making them difficult for everyone—especially women—to operate effectively.

In more advanced studies, human-robot interaction in floor cleaning has become a key research area. Fink et al. conducted long-term observational studies of cleaning robots in homes, analysing how people interacted with them socially and practically. Meanwhile, Sakamoto et al. introduced a gesture-based interface using ceiling-mounted cameras to enhance robot control.

Several researchers have worked on cooperative robotic cleaning, like Luo and Yang's bio-inspired neural network approach for multi-robot coordination in complex environments. Another significant study proposed cellular decomposition to divide large cleaning areas, allowing two robots to cover the space efficiently.

As the market for autonomous cleaning devices grows, researchers like Rhim et al. have started developing benchmarking tools to evaluate robotic performance based on criteria like mobility, cleaning efficiency, noise levels, and dust collection. Wong et al. further expanded on these indicators to assess cleaning coverage and performance effectively.

Despite the rise of robotic systems, manual cleaning remains physically demanding and labour-intensive. Workers often use heavy equipment like buffing machines, wet/dry vacuums, and engage in tasks that involve mopping, lifting heavy objects, and handling water buckets. These activities are frequently performed under time pressure.

Scientific studies have shown that cleaning work places significant stress on the musculoskeletal and cardiorespiratory systems. Cleaners often experience static muscle loads, repetitive motions, and are required to work in uncomfortable postures such as crouching and bending. The labour is not only physically intense but also comes with psychosocial stressors, including limited control over schedules, excessive workload, and insufficient rest breaks.

Unfortunately, this has led to a high rate of health issues, especially musculoskeletal disorders affecting the back, neck, shoulders, and arms. Several studies have identified female domestic workers as particularly vulnerable, reporting higher rates of neck and shoulder pain. These conditions often result in absenteeism, reduced productivity, and long-term health problems. Surveys have even shown that female cleaners are significantly more likely to suffer from these issues compared to their peers in other professions.

3.METHODOLOGY:

The development of the manually operated floor cleaning machine follows a simple yet effective mechanical approach. The design focuses on utilizing manual power to achieve both dry and wet cleaning without the use of electricity or fuel. The methodology can be explained in the following steps:

3.1 Power Transmission Mechanism

The machine is equipped with two rear wheels that are firmly connected to a central rotating shaft. As the user pushes the machine forward, the wheels rotate, transferring mechanical power to the shaft.

3.2 Chain Drive System

This shaft is connected to a sprocket, which drives a chain mechanism. The chain is used to transmit rotational motion from the wheels to the cleaning brush through a series of gears.

3.3 Bevel Gear Assembly

At the end of the chain drive, bevel gears are installed at a 90-degree angle. These gears convert the horizontal rotation from the shaft into vertical rotation, enabling the cleaning brush to spin effectively.

3.4 Brush Operation

The rotating brush at the bottom of the machine interacts directly with the floor surface. As the user moves the machine manually, the brush spins and cleans the surface—removing dust, debris, and moisture.

3.5 Wet Cleaning Mechanism

A gravity-fed water tank is mounted on the machine with an outlet controlled by a manual valve. During wet cleaning, the user can open the valve to allow water to flow onto the floor. A rear-mounted rubber wiper then helps collect the water and dry the cleaned surface.

3.6 Portability and Ease of Use

The machine's lightweight construction, ergonomic handle, and freely moving caster wheel at the front make it easy to steer and operate. This allows users to clean both large and tight areas without strain.

4.COMPONENTS:

The design and construction of the manually operated floor cleaning machine involve several key components, each selected for functionality, durability, and ease of maintenance. The main components are as follows:

Frame: The supporting structure is fabricated using zinc-coated steel to ensure strength, stability, and resistance to corrosion. It provides the foundation for mounting all other elements securely.

Wheels:

Two rear wheels (65 mm diameter) are attached to a rotating shaft to generate manual power, while a front caster wheel (50 mm diameter) allows for smooth steering and directional control.

Shaft: (Cylindrical Rod)

Figure 1 CYLINDRICAL ROD

A central shaft links the rear wheels and transmits rotational motion to the cleaning mechanism. It serves as the axis of power transfer within the system.

Chain Drive System:

Figure 2 CHAIN DRIVE SYSTEM

A roller chain (1319 mm in length, 80 links) connects the shaft to the bevel gears, enabling efficient transmission of mechanical power from the wheels to the brush unit.

Bevel Gears:

Figure 3 BEVEL GEAR

Positioned at right angles, the bevel gears (35 mm diameter, 2:1 gear ratio) redirect the horizontal rotational input into vertical motion needed to spin the cleaning brush.

Cleaning Brush:

Figure 4 CLEANING BRUSH

A circular microfiber brush (10-inch diameter) is mounted at the base. It rotates to clean dust and debris from both dry and wet surfaces as the machine moves.

Water Tank:

Figure 5 WATER TANK

A plastic tank with a capacity of approximately 2.5–3 litres are mounted for wet cleaning applications. It is connected via UPVC piping and includes a manually operated valve to control water flow.

Wiper:

Figure 6 WIPER

A rubber wiper is placed at the rear to collect residual water after wet cleaning, ensuring a cleaner and drier floor surface.

Other Elements: Additional parts such as bearings, rods, chain sockets, and wooden clips are used to ensure proper assembly, motion smoothness, and structural integrity.

Each component is chosen not only for its functionality but also for affordability.

5. BUDGET ALLOCATION:

Table 1 PROJECT COST

S. No.	Item Description	Adjusted Cost (₹)
1	Welding Material	1350
2	Welding Charge	1000
3	2 Big Wheels	635
4	1 Small Wheel	75
5	Square Mop	270
6	Wiper	130
7	2 Bevel Gears	390
8	Water Tub	65
9	Back Axle Threading Charge	75
10	Bearing	70
11	Spray Painting	250
12	M-Seal	50
13	2 L-Bends	65
14	Ball Valve	115
15	End Cap & R. Pipe (1/2 inch)	150
16	Glue	50
17	13mm Washers	50
18	Tank Handle	60
	TOTAL	**4840**

We built the Eco-Friendly Floor Cleaning Machine with a simple goal in mind — to make effective cleaning accessible and affordable, especially where electricity or expensive equipment isn't an option. Amazingly, the entire machine was developed on a budget of just **₹5000**. By choosing locally available, recyclable materials and cutting out any need for electricity or batteries, we created a device that's not only eco-friendly but also budget-friendly.

Compared to typical floor cleaners that can cost anywhere from ₹8000 to ₹25000, our model does the job at a fraction of the cost. It's lightweight, easy to use, and designed to last — making it perfect for schools, hospitals, and homes, especially in rural or low-resource areas. This project proves that with smart design and careful planning, clean doesn't have to be costly.

6.GALLERY:

Figure 7 SIDE VIEW

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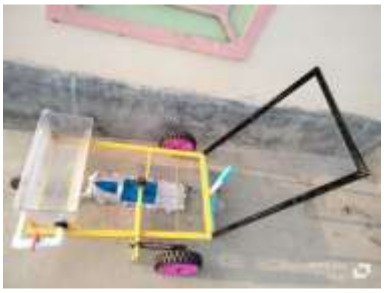

Figure 8 TOP VIEW

Figure 9 FRONT VIEW

7.CHARTS:

7.1 Component Material Breakdown (Pie Chart)

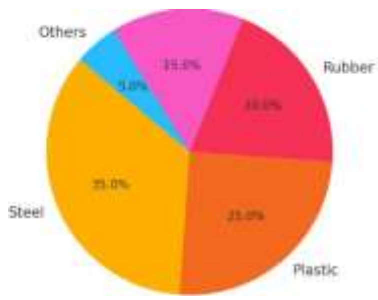

Figure 10 COMPONENT MATERIAL BREAKDOWN

This chart gives a clear picture of what the machine is made of. Steel makes up the largest share, primarily used for strength in the frame. Plastics and rubber are used in the body, wheels, and cleaning mop due to their flexibility and water resistance. The use of recyclable and locally available materials reflects the project's focus on sustainability and cost-effectiveness.

7.2 Force vs Cleaning Efficiency (Line Chart)

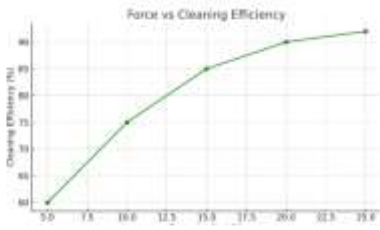

Figure 11 Force vs Cleaning Efficiency

This graph shows how efficiently the machine cleans as more manual force is applied. Interestingly, even with a modest push, the cleaning performance is already quite good, and it improves steadily with more effort. This confirms that the machine is not only effective but also easy to operate, even for users who may not have much physical strength.

7.3 Cost vs Durability of Materials (Bar Chart)

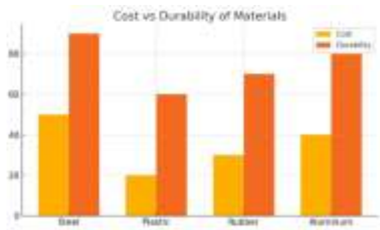

Figure 12 Cost vs Durability of Materials

Here, we compare how much each material costs versus how long it lasts. While materials like steel and aluminum are a bit more expensive, they're very durable, making them a smart investment in the long run. On the other hand, plastics and rubber are more budget-friendly but slightly less durable. This balance was carefully considered to keep the machine both affordable and long-lasting.

7.4 Water Usage Efficiency (Line Chart)

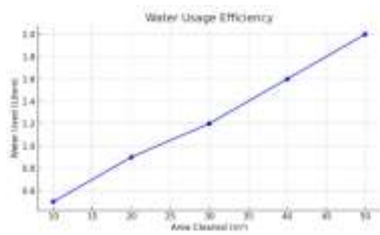

Figure 13 Water Usage Efficiency

This chart highlights how little water the machine needs to clean effectively. Even large areas can be cleaned using just a small amount of water, which makes it perfect for places where water conservation is important. It also supports the project's eco-friendly goals by reducing water waste.

8.CONCLUSION:

In an age where sustainability, simplicity, and cost-effectiveness are more important than ever, the mechanically operated floor cleaning machine stands out as a meaningful response to everyday challenges. This project wasn't just about building a cleaning tool—it was about rethinking how we approach basic tasks like cleanliness without relying on electricity, batteries, or complex systems.

Through the thoughtful integration of gears, chains, bearings, and water control mechanisms, the machine harnesses human motion and translates it into efficient, practical cleaning. It performs with impressive consistency on both dry and wet surfaces and does so without causing strain, excessive noise, or environmental harm. From material selection to testing and refinement, every decision made in this design was guided by the goal of creating something that is reliable, user-friendly, and accessible to all.

The successful development and testing of the prototype proved that innovation doesn't always require high-tech solutions. Sometimes, the most impactful changes come from going back to the basics—simplifying instead of complicating, and designing with people and the planet in mind.

This work opens doors for further development, especially in under-resourced communities, institutions that prioritize green solutions, and public spaces where maintenance teams often face constraints. With thoughtful improvements and larger-scale adaptation, this machine has the potential to redefine what sustainable cleaning can look like.

REFERENCES:

[1] William D. Callister, Materials Science and Engineering, 7th edition, 2006, Pages 134- 174K. Elissa, "Title of paper if known," unpublished.

[2] M. Ranjith Kumar, N. Kapilan- "Design and Analysis of Manually Operated Floor Cleaning Machine" - International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERT IS040912 [www.ijert.org] Vol. 4 Issue 04, (April-2015).

[3] Sandeep. J. Meshram, Dr. G.D. Mehta – "Design and Development of Tricycle Operated Street Cleaning Machine" - Journal of Information, Knowledge, and Research in Mechanical Engineering ISSN 0975 – 668X| (Nov 15 to Oct 16) | Volume – 04, Issue– 01

[4] International Journal of Mechanical Engineering and Technology (IJMET) Volume 8, Issue (5, May 2017), pp. 656–664 Article ID: IJMET_08_05_072 ISSN Print: 09766340 and ISSN Online: 0976- 6359.

[5] M. Ranjit Kumar, Mechanical Engineer and N. Kapilan, Professor, Mechanical Engineering, Design and Analysis of Manually Operated Floor Cleaning Machine, International Journal of Engineering Research and Technology (IJERT), Vol. 4 Issue 04, April 2015.

[6] J. Fink, V. Bauwens, F. Kaplan, P. Dillenbourg, Living with a vacuum cleaning robot, Int. J. Soc. Robot. 5 (3) (2013) 389–408,

[7] D. Sakamoto, K. Honda, M. Inami, T. Igarashi, Sketch and run: a strokebased interface for home robots, In Proceedings of the 27th International Conference on Human Factors in Computing Systems, CHI 09, ACM Press,2009,http://dx.doi. org/10.1145/1518701.1518733.

[8] S.C. Wong, L. Middleton, B.A. MacDonald, N. Auckland, Performance metrics for robot coverage tasks, Proceedings of Australasian Conference on Robotics and Automation, Vol. 27 2002, November, p. 29 (ISBN: 0-909040-90-7).

[9] Kru¨ger, D., Louhevaara, V., Nielsen, J., Schneider, T., 1997. Risk Assessment and Preventative Strategies in Cleaning Work. Wirtschaftsverlag NW, Bremerhaven.

[10] Aickin, C., 1998. Ergonomic assessment (manual handling) of cleaning work. Productivity ergonomics and safety—the total package. In: Proceedings of the International Workplace Health and Safety Forums and the 33rd Ergonomics Society of Australia Conference 1998. Gold Coast, Australia, 6pp.

[11] Hagner, I.M., Hagberg, M., 1989. Evaluation of two floor mopping work methods by measurement of load. Ergonomics 32, 401–408.

[12] Messing, K., Haentjens, C., Doniol-Shaw, G., 1992. Invisible and essential: the work activity of women who clean toilets in passenger's trains. Travail Humain 5, 353–370.

[13.] Søgaard, K., Fallentin, N., Nielsen, J., 1996. Work load during floor cleaning: the effect of cleaning methods and work technique. European Journal of Applied Physiology and Occupational Physiology 73, 73–81.

[14] Woods, V., Buckle, P., Haisman, M., 1999. Musculoskeletal Health of Cleaners. HSE Books, Suffolk.

[15] Hagner, I.M., Hagberg, M., 1989. Evaluation of two floor mopping work methods by measurement of load. Ergonomics 32, 401–408.

[16] Johansson, S.E., Ljunggren, G., 1989. Perceived exertion during a selfimposed pace of work for a group of cleaners. Applied Ergonomics 20, 307–312.

[17] Edsberg, E., Haakonsen, H., Myhre, H., Festervoll, I., Winge, T., Bjorset, HH., et al., 1983. Theme ergonomics. Arbeidsmiljo 8, 15–55.

[18] Michael R. Lindeburg, Mechanical Engineering Manual for sprocket and pinion, 2013, Page 6-60.

[19] ANSI-AGMA D03, Design manual for Bevel Gears, American Gear Manufacturers Association, Virginia. 2005.

[20] Rubini R, Meneghetti U (2001) Application of the envelope and wavelet transform analyses for the diagnosis of incipient faults in ball bearings. Mech Syst Signal Process 15(2):287–302.