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ORIGINAL ARTICLE

Design of mechanically operated floor cleaning machine

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Abstract

Although there have been multiple precedents demonstrating the benefits of deploying floor cleaning robots to maintain constructed structures, standard platforms have performance issues. Their fixed morphological design, which severely limits their navigation and access, is a primary contributor to their performance shortfall. The designed robot can change its morphology to seven one-sided tetrominoes in reaction to its sensed environment to maximize its coverage area. This research examines the coverage area performance of the robot and compares it to two widely available fixed morphology robot platforms. The traditional mechanically operated floor cleaning machine is most used in road, school, house, bus stand, mall, airport and other commercial place. This machine does not require any type of external source of energy for its operating. The aim of present work is to design and develop process for cleaning the dry as well as wet floor manually. This mechanically operated floor cleaning machine is designed by keeping the basic consideration for reduction in cost and efforts while being environment friendly and easy to handle. ©2022 ijrei.com. All rights reserved

1. Introduction

Cleaning is the essential need of current time. Cleaning machines are very useful in cleaning floors, outside ground in hospitals, houses, auditoriums, bus stands and public places etc. Many researchers have done so many works in evaluation of design of cleaning machine to give better outcomes, but many researchers were operating their machine with the help of any external source like electrical energy, but this machine has been designed in such a way that it can be operated by manual power and there is no need of electric energy or any other energy. For the above said purpose the manual power is transferred from the chain socket to the gear through chain mechanism then its power transfer to bevel gear and it result to rotate the wheels and floor cleaning work is performed, which makes this machine completely manually operated without any external source of energy and its manufacture, and design is also cheaper in cost and reliable for everyone [1]. It is capable for the cleaning purpose of both dry and wet floor and easily transfer from one place to other due to its light weight and simple design. Also, a benefit is that it is environmentally friendly. The components have been used in designing this mechanically operated floor cleaning machine are steel bar, bevel gear, wheel, wooden clips, bearing, rod, wiper, chain socket, gear. Building maintenance is often characterized by an infinite series of drab, unclean, time-consuming, and unpleasant duties such as floor washing.

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2. Literature review

Various researchers have worked on floor cleaning machines and related properties, and a light has been thrown on some of the recent works done by different scholars. A cleaning machine for the floor was designed and prepared a 3D model of their project or, say, a machine in the modeling software and then analyzed by applying boundary conditions as their project conclusion and found that the level of stress on a handheld machine is within the safe range [2]. A Street Cleaning Machine operated by Tricycle was manufactured. This research article depicts that it has been made for most use in rural areas and concluded that cleansing is working less when the road seems too heavy again damaged [3]. A multi-use floor cleaning machine using A.C. induction Motor and speed reduction method was designed and manufactured. The machine produced was highly efficient and showed flexibility. The operational capacity of the given mechanical project is also fulfilled by using the machine; the process of cleaning the floor can be done quickly and easily in an effective manner [4]. An automatic floor cleaner using a Direct Current Motor and configured a wiper mechanism was designed and fabricated. The proposed machine produced shows flexibility and laboriousness. Successful utilization of Solar Energy saves electricity. The main aim for this project is achieved, and using the device, floor cleaning can be done quickly [5]. In 1868, the first W. McGuffey in Chicago. In the late 1990s & early 2000s, many different companies came into the market to develop robotic vacuum cleaners. But again, the only problem with these cleaning devices is the consumption of electricity for operating them [6]. A floor cleaning machine that was manually operated, which is simply a bicycle working on the same concept up to some extent. But this project lacks efficiency with a high margin of error. Besides the fact that it was not so efficient, it deals with the problem that women could not operate it as efficiently as men. Effective cleaning and sanitizing play an essential role in human beings' health [7]. Several studies on human-robot interaction with floor cleaning robots have been published. Fink et al. [8] describe ethnographic research of floor cleaning robots conducted in various residences over six months. User perception, usage analysis, and social activities involving cleaning robots are all thoroughly researched in their research. Sakamoto et al. [9] offer a computer screen interface for engaging with a floor cleaning robot based on stroke gestures. Their experiments show that the proposed interface can manage a cleaning robot and obtain various views from ceiling cameras. Based on a bio-inspired neural network technique, Luo and Yang suggest multi-robot cooperative sweeping [10]. The authors investigate the total coverage and path planning challenges associated with unstructured workspaces using many cleaning robots. Another critical study [11] describes a cellular decomposition method for dividing a cleaning space into cells and providing a good coverage plan for two indoor floor cleaning robots over the cells. With the market for floor cleaning robotic goods increasingly crowded, interest in benchmarking various automatic systems has developed. Rhim et al. [12] present performance indicators for autonomous cleaning robots. Most cleaning robots identify independent mobility, dust collection, and operating noise as essential performance indices. Wong et al. propose and validate two criteria to capture robotic cleaning performance and coverage efficiency [13]. Cleaning is a physically demanding and labor-intensive job. Cleaners frequently use heavy powered tools (e.g., buffing machines/floor polishing machines, wet and dry vacuums) in addition to a variety of physically demanding tasks such as mopping, wiping surfaces, polishing, and heavy manual handling (e.g., carrying and emptying rubbish, moving furniture, filling, taking, and emptying buckets of water), often under time constraints [14]. According to several studies, cleaning activity is physiologically stressful for both the cardiorespiratory and musculoskeletal systems [15, 16]. Cleaning chores have a high degree of physical demand, including high aerobic strain [17], static muscle loads and repeated motions (ibid), a high frequency of undesirable postures such as stooping and crouching [18], and a subjective sensation that the labor is stressful [19]. Furthermore, various studies have identified psychosocial risk factors associated with cleaning labor, such as a lack of control over work and breaks, a heavy workload, and time constraints [15, 16, 20]. Several studies have found that cleaners are at a high risk of developing health issues, notably musculoskeletal issues that impact the back, neck, shoulders, elbows, and hands. Among the many occupations studied, female domestic servants had the worst health [21]. A high frequency of neck and shoulder issues in a study of Swedish cleaners' musculoskeletal disorders was discovered [22]. Other research [23] has shown similar difficulties that have resulted in high absenteeism [24]. A survey of Danish female cleaners revealed a considerably greater 1-year frequency of musculoskeletal complaints than an age-matched control group [19].

3. Methodology

The system is assembled with a pair of existing wheels that rotates with the help of a shaft. The shaft and wheels are joined together. The wheels provide power to the gear through the chain mechanism, and the bevel gears are connected perpendicularly. The help of bevel gear rotates the brush. The revolutions start to move when we exert forces on this machine manually. As the wheel starts spinning, it becomes straightforward to move it forward or backward, and as the lower end of the machine is installed with a brush, the brush starts operating, cleaning the surface where it is interacting.

3.1 Chain mechanism

The total length of the chain used is 1319 mm with 80 links. A chain mechanism is a way of transmitting mechanical power from one shaft to another shaft. The socket used in the chain mechanism is shown in the fig. 1, it is used to give power to the wheels. The emphasis is conveyed by a roller chain, known as the drive chain or transmission chain [25].

Figure 1: Chain socket

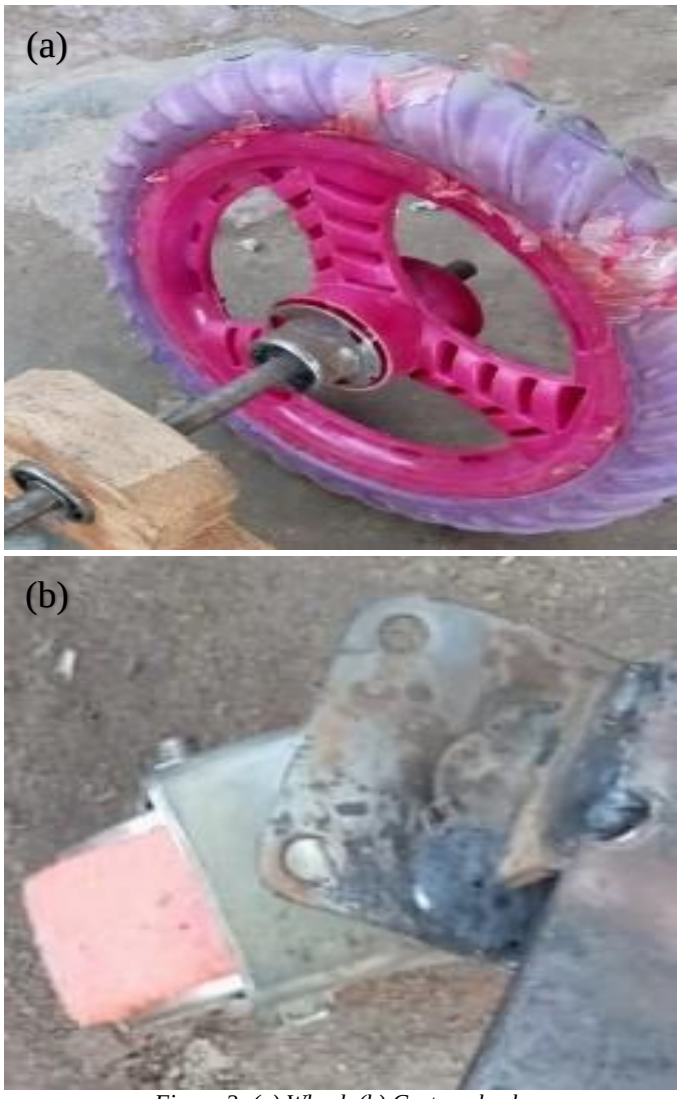

Figure 2: (a) Wheel, (b) Caster wheel

Two wheels made of plastic material with dimensions of 65mm in diameter and 30mm, in thickness were fitted on the backside, as shown in fig. 2. One caster wheel of diameter 50mm was fitted on the front side for 360-degree rotation, as shown in fig. 2. A bevel gear has its axis perpendicular to each other, and the standard value of the gear ratio is 1:2, 2:1 and 3:1 [26] This gear is used for speed reduction; in this machine, the bevel gear's diameter is 35mm (see fig.3.).

Figure 3: Bevel gear

There are two essential functions to which bearings are supposed to perform, and the bearing used in the machine is shown in fig.4 (a). These are:

- Motion transfer takes place, i.e., they guide and support components that move/turn relative to one another.
- Transmission of forces [27].

A cleaning brush (portable disc brush) with inner and outer diameters of 5 inches and 10 inches, respectively, was used, as shown in fig. 4(b). The cleaning brush is installed at the extreme lower portion of the machine and mounted with the bevel gears, which rotates it with the help of a chain and sprocket unit. The main work of the brush is to clean the floor surfaces.

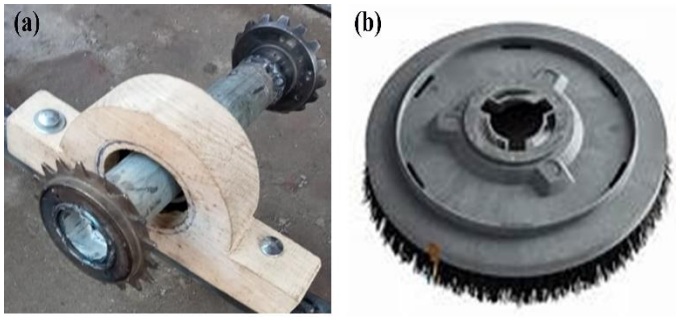

Figure 4: (a) Rolling bearing, (b) Prolite disc brush

4. Results and discussion

Normal speed of humans = 1.4m/s
D = diameter of wheel = 165mm = 0.165m
V = Velocity of humans = 1.4m/s = $\frac{\pi DN}{60}$
Therefore, N = 162 rpm (wheel)

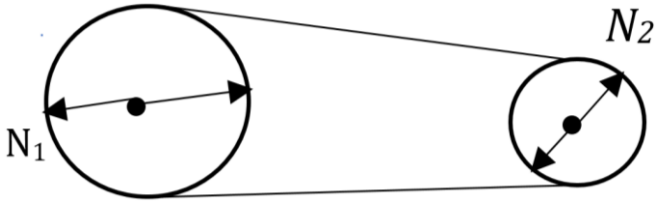

Figure 5: Chain sprocket mechanism

N_1 = rpm of large Sprocket
N_2 = rpm of small sprocket
T_1 = no. of teeth in large sprocket = 32
T_2 = no. of teeth in small sprocket = 18

VR (Velocity Ratio of Chain Drives) = $\frac{N_1}{N_2} = \frac{T_2}{T_1}$

So, N_2 = 288 rpm

Assume gear module = 2mm
T_l = number of teeth in gear = 20
T_s = number of teeth in pinion = 12
Diameter of gear (D_l) = m×T_l = 40mm
Diameter of pinion (D_s) = m×T_s = 24mm

Gear Ratio, $\frac{T_s}{T_l} = \frac{N_l}{N_s}$
$N_s = \frac{N_l \times T_l}{Ts}$
N_s = 480 rpm

So, N_s is the speed of the brush which clean the surface.

5. Application

- It is used for Floor Cleaning Purpose.
- It is used for hospital Cleaning.
- To clean bus stand areas.
- To clean railway station floor areas.
- It is used to clean for all suitable areas.

6. Conclusions

The present machine has been designed in such a way that it may work manually which has many advantages like it is environment friendly, low cost, reduces human effort and time. It is a good option in current scenario because as we can see energy crisis or energy shortage is in limelight all over the world. It is capable to operate easily by the help of hands with negligible risk. The mechanically operated floor cleaning machine can be used in the place of room cleaning and reduces human effort. It works very efficiently and the manually operated eco-friendly and economic, road and floor cleaner is successfully capable to cover an area. Maintenance of machine is very cheap, and it is easily controllable with associated benefits of cleaning for the along with reduction in environment pollution.

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] Vardhaman Ladage, Shardool Jawanja, lDnyanesh Kamat, Rutuja Majgaonkar, Bhagyashri Kadam. "Semi-Automatic Floor Cleaning Machine, International Journal of Design and Manufacturing Technology (IJDMT) Volume 8, Issue 1, 01–07, 2016.
[5] Shubham Khade, Student, Department of Mechanical Engineering, Kolhapur Institute of Technology Collage of Engineering, Shivaji University, Kolhapur, Maharashtra, India, "MultiI-Use Floor Cleaning Machine"
[6] 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.
[7] 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.
[8] J. Fink, V. Bauwens, F. Kaplan, P. Dillenbourg, Living with a vacuum cleaning robot, Int. J. Soc. Robot. 5 (3) (2013) 389–408, http://dx.doi.org/10.1007/s12369- 013-0190-2.
[9] D. Sakamoto, K. Honda, M. Inami, T. Igarashi, Sketch and run: a stroke-based 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.
[10] C. Luo, S.X. Yang, A real-time cooperative sweeping strategy for multiple cleaning robots, Proceedings of the IEEE Internatinal Symposium on Intelligent Control, 2002, IEEE, 06 2003, http://dx.doi.org/10.1109/isic.2002.1157841.
[11] A. Janchiv, D. Batsaikhan, G. hwan Kim, S.G. Lee, Complete coverage path planning for multi-robots based on, Control, Automation and Systems (ICCAS), 11th International Conference on, IEEE, 2011, October, pp. 824–827 (ISBN: 9788993215038).
[12] S. Rhim, J.-C. Ryu, K.-H. Park, S.-G. Lee, Performance evaluation criteria for autonomous cleaning robots, 2007 International Symposium on Computational Intelligence in Robotics and Automation, IEEE, 2007, http://dx.doi.org/10.1109/ cira.2007.382916.
[13] 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).
[14] Kru¨ger, D., Louhevaara, V., Nielsen, J., Schneider, T., 1997. Risk Assessment and Preventative Strategies in Cleaning Work. Wirtschaftsverlag NW, Bremerhaven.
[15] 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.

[16] Louhevaara, V., 1997. Professional cleaning in the European Union: ergonomics. In: Das, B., Karwowski, W. (Eds.), Advances in Occupational Ergonomics and Safety 1997. IOS Press, Amsterdam, pp. 565–568.
[17] Hagner, I.M., Hagberg, M., 1989. Evaluation of two floor mopping work methods by measurement of load. Ergonomics 32, 401–408.
[18] 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.
[19] 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.
[20] Woods, V., Buckle, P., Haisman, M., 1999. Musculoskeletal Health of Cleaners. HSE Books, Suffolk.
[21] Tuomi, K., Ilmarinen, J., Eskelinen, L., Jarvinen, E., Toikkanen, J., Klockars, M., 1991. Prevalence and incidence rates of diseases and work ability in different work categories of municipal occupations. Scandinavian Journal of Work Environment and Health 17 (Suppl.), 67–74.
[22] Hagner, I.M., Hagberg, M., 1989. Evaluation of two floor mopping work methods by measurement of load. Ergonomics 32, 401–408.
[23] Johansson, S.E., Ljunggren, G., 1989. Perceived exertion during a self-imposed pace of work for a group of cleaners. Applied Ergonomics 20, 307–312.
[24] Edsberg, E., Haakonsen, H., Myhre, H., Festervoll, I., Winge, T., Bjorset, HH., et al., 1983. Theme ergonomics. Arbeidsmiljo 8, 15–55.
[25] Michael R. Lindeburg, Mechanical Engineering Manual for sprocket and pinion, 2013, Page 6-60.
[26] ANSI-AGMA D03, Design manual for Bevel Gears, American Gear Manufacturers Association, Virginia. 2005.
[27] 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.

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