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Development and Fabrication of Glove Donning System

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ABSTRACT: Disease poses a threat to all living things. There are several ways for diseases to spread. Diseases spread by contact or communication are extremely dangerous and difficult to control. As a result, it is critical to prevent the spread of these deadly diseases. Gloves are the primary piece of medical equipment used to prevent infection spread through contact, and they have become an integral part of our daily lives during COVID-19. However, touching the outer part of the gloves has the potential to spread the disease. When removing and inserting gloves, the majority of contact occurs. The glove donning system is a machine that automatically inserts gloves without any contact with body. In this system, there are mainly two mechanisms used, and the whole setup is arranged in an airtight box. For the separation of gloves from the packet, a vertically moving suction box that is always vacuuming is used, which can separate each glove. When the gloves reach the centre of the box, an iris mechanism is used to enlarge the gloves and take them from the suction box to a duct where the hand is inserted. When the gloves are inserted into the duct, the whole chamber becomes sealed, and if we vacuumize it, the gloves enlarge and we can insert our hand.

KEY WORDS – Glove Donning, Vacuum Chamber, Iris Mechanism, Automation

I. INTRODUCTION

The possibility of disease exists for all living beings. Diseases can spread in a variety of ways. It is extremely harmful and challenging to control diseases that are transmitted by contact or communication. Therefore, it is essential to stop the spread of these fatal diseases. The most beneficial piece of equipment for limiting the spread of infections through contact is a pair of gloves. The applications of gloves are very large; they are mainly used in medical fields, chemical factories, food industries, and so on. Gloves were widely used after COVID-19 because they reduced the chances of the coronavirus spreading through contact. However, there is a high risk of disease transmission through the gloves while wearing and removing them because there may be contaminants in the gloves and in our hands. Also, to wear gloves manually, it takes about 20 seconds. This is also the negative side of manually wearing gloves. Gloves are an absolute necessity in the medical industry and many other industries. It improves hygiene and reduces health issues. There is a possibility of tearing the gloves off if we wear them improperly. Also, it is important to avoid touching the outer part of the gloves before use. The modern world uses automated and contactless machines for all purposes because they increase the efficiency of work and its hygiene. So here we are, automating the process of glove donning with a machine. The machine's primary goals are to reduce body contact and improve work productivity. The gloves must first be separated from their packaging and enlarged to the appropriate size before being inserted into the hand. We use a vacuum chamber that is completely sealed with a hole that holds gloves so that gloves can be expanded to a specific size. Each glove is separated using a vacuum suction box, and it is then taken to an open duct using an iris mechanism. In summary, automatic glove donning systems provide a helpful solution to the issues presented on by manual glove donning. These systems represent a promising technological improvement in the area of personal protective equipment since they increase efficiency, lower the danger of contamination, and improve worker comfort. Future adoption of these systems is highly likely as continued research and development work

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to improve and innovate them, resulting in safer and more effective workplaces.

II. DESIGN AND FABRICATION

1. **Design:** SolidWorks 2018 was used to complete the entire design. Fig. 1 (a) shows the preliminary design done during the first phase.

After further research, we developed a new design with more compact and suitable mechanisms and components, as shown in Fig. 1 (b). All components in the modified design are mentioned in the fig 1 (c) and in Table 1

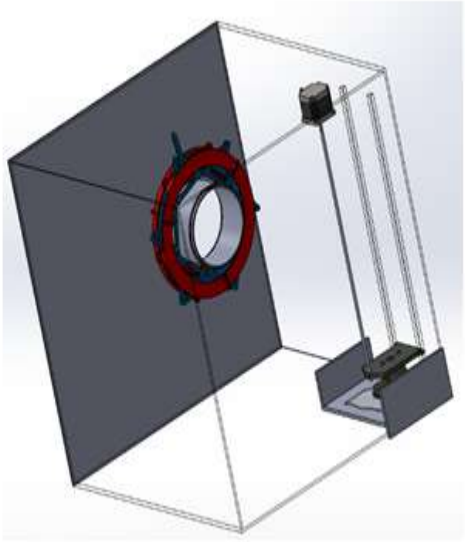

Fig 1 (a)

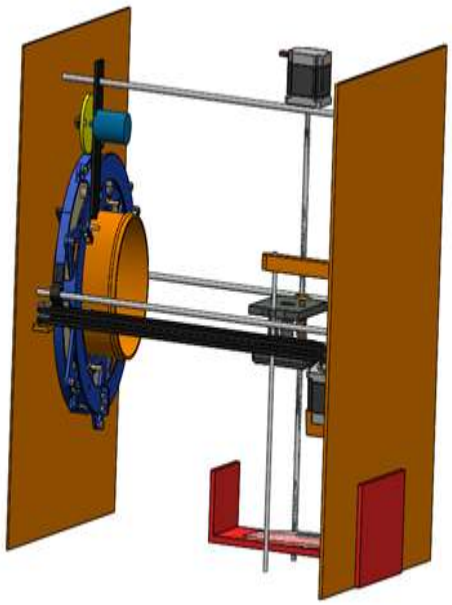

Fig 1 (b)

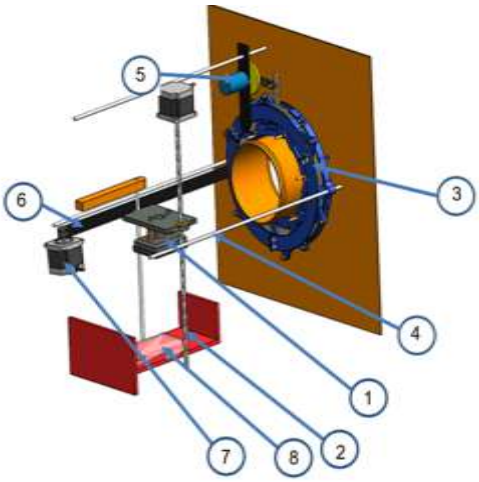

Fig 1 (c)

SL.NO	PARTS	DESCRIPTION
1	Glove separation box	It is a 50-80 mm box with small holes at the bottom and a duct for the connection of the vacuum pipe used to separate each glove from its packet.
2	Lead screw	It is 500mm in length and 8mm in diameter; its pitch is 2 mm. It is used for the vertical movement of the separation box.

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3	Iris mechanism	It is for the enlarging and horizontal movement of gloves; its inner diameter is 155 mm, its outer diameter is 253 mm, and its thickness is 35 mm.
4	Steel rod	It is a 400-mm steel rod through which the iris mechanism moves.
5	DC Motor	It is a 12V motor for enlarging the iris mechanism.
6	Timing belt	For the horizontal movement of the iris mechanism, a 5mm thick, 800mm long belt is used.
7	Stepper motor	For the motion of the timing belt and lead screw, a 12V DC stepper motor is used.
8	Glove	Latex surgical gloves with extended cuff

Table 1 – Main components

1. **Fabrication**: A 500 x 400 x 400 mm frame was built by using a steel square pipe, as shown in Fig. 1 (d), and the iris mechanism in Fig. 1 (e) was 3D printed with PLA material. The lead screw set used for the vertical movement of the suction box is shown in Fig. 1(f). The frame was covered by an ACP sheet of 3mm thickness. The steel rod and lead screw for the suction box were first aligned vertically, and the lead screw was connected to the stepper motor in Fig. 1(g). Then the steel rods and the belt drive for the iris mechanism were arranged. For vacuumizing the suction box and the chamber, a solenoid valve is used, as shown in Fig. (h)

Fig 1 (d)

Fig 1 (e)

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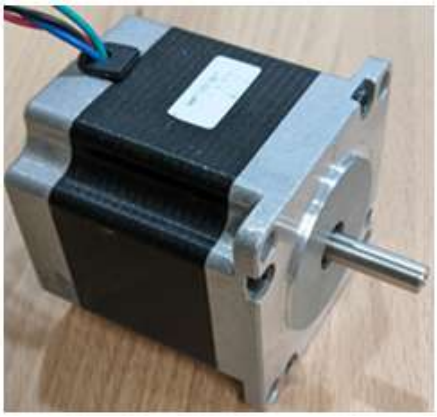
Fig (f)



Fig(g)

Fig(h)

III. WORKING

The entire system and its components are kept in an airtight box with just one opening at the hand-inserted duct. As soon as the glove is inserted into that entrance, the opening will close. A solenoid valve is used to change the direction of the flow of air for vacuumizing the separation box and the chamber simultaneously. It is automated by using an Arduino microcontroller; the first signal is given by an ultrasonic sensor placed outside of the hand-inserted duct. When the sensor detects the hand, it gives a signal to the Arduino, which rotates the lead screw and also turns on the solenoid valve. Thus, the separation box moves vertically and separates each glove from the pack. Now the iris mechanism moves towards the separation box and enlarges the gloves after picking it up, and then the vacuum on the separation box stops by changing the flow direction of the solenoid valve. As shown in Fig. 1(i). for the contraction and enlarging of iris mechanism DC motor is used. When the gloves are placed on the duct, the system as entirety seals, allowing us to vacuum it. The expanded iris moves towards the duct. Since the solenoid valve to the chamber is now open, vacuuming the chamber causes the gloves to expand to a specified size, allowing us to place our hand inside of it before drawing the glove into our hand. After that while removing hand, the sensor detects and the entire process starts again

Fig 1 (i)

We manually tested each component's operation after placing it in the proper alignment. The system is automated using an Arduino Uno after testing, and the circuit for the system is shown in Figs. 1 (j)and (k)

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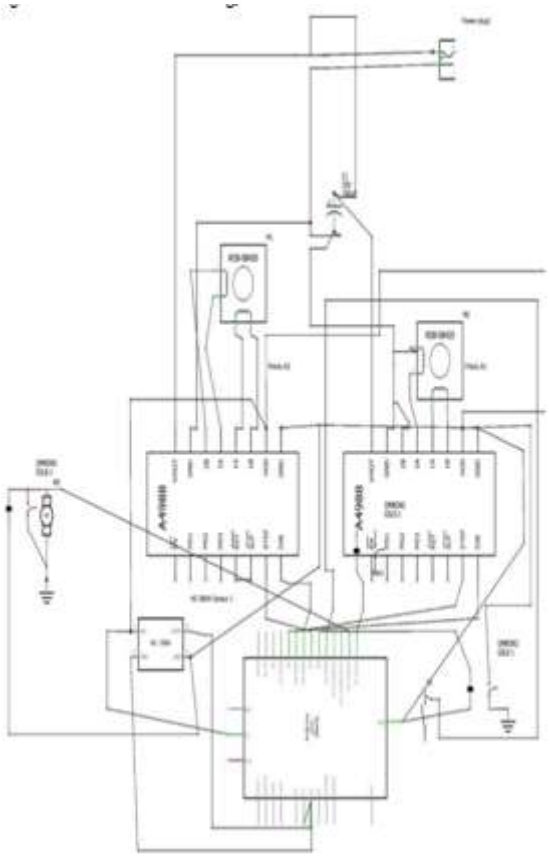

Fig 1 (j)

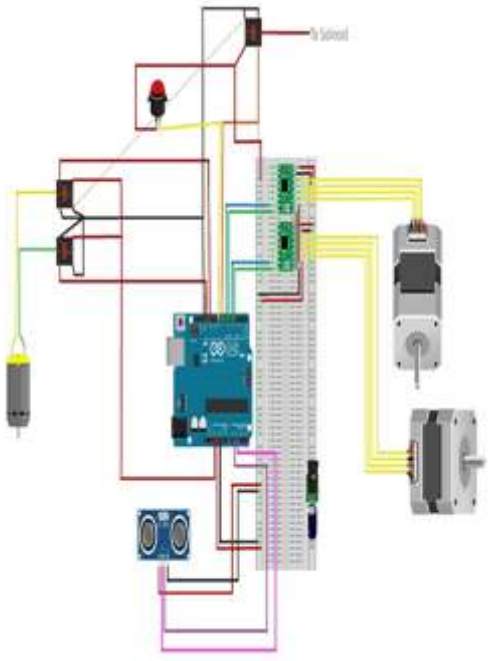

Fig 1 (k)

The stepper motor is controlled by two A4988 stepper drivers, and the entire circuit is set up on a breadboard. The Arduino Uno receives a signal when the sensor recognizes the hand. All processes in an order are assigned a time delay. Following a signal to the solenoid valve, the vacuum on the suction box begins after the stepper motor for the lead screw begins to operate. Two relays are used to control the clockwise and anticlockwise turning of the DC motor in the iris mechanism. The electronic components used are mentioned in the table 2. The whole assembly is assembled in an airtight chamber, as shown in Fig.1 (l)

Table 2-Electronic components used

ITEM	SPECIFICATION	QTY
Arduino uno	Operating Voltage:5V Input Voltage:7-12	1
Ultrasonic sensor	3.3V-5V,8mA,40Hz, Range:3 cm	1
Stepper driver	A4988 stepper driver, 5V	2
Relay	5V, 70mA, 5pin	2
Stepper motor	12V DC, Torque: 400N.m,	2
Solenoid valve	12v, 4.3W	1
Vacuum pump	Flow rate: 60L/min, Power: ¼,	1
DC gear motor	100RPM, 12V, 2.9 kg-cm	1
LED driver	12V,2A	2
Capacitor	100 µF,16V	1
Switch	On/off	1

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Fig 1(l)

IV. FIELD OF APPLICATION

1. Medical field

Infection Control: Glove donning system can help improve infection control procedures in hospital settings. By doing away with manual glove donning, these systems decrease the possibility of cross-contamination and the spread of diseases. Healthcare personnel can maintain a greater degree of hygiene by limiting contact with potentially infectious surfaces.

Time Efficiency: Putting on gloves manually might take some time, especially if healthcare professionals need to do it frequently between patient interactions. Automatic glove donning devices speed up the procedure by quickly and effectively wearing gloves, saving healthcare professionals a lot of time. This enables them to focus more on providing patient care and reduces wait times in crowded healthcare facilities.

Ergonomics and Comfort: Due to their frequent manual glove donning, medical professionals frequently face hand fatigue and discomfort. Systems that automatically don gloves provide ergonomic advantages by eliminating repetitive motions and reducing hand strain. This may increase healthcare professionals' comfort and possibly lower their chance of suffering musculoskeletal injuries.

Training and Education: Systems that automatically put on gloves can be very useful training and educational tools. They can aid in strengthening infection control procedures and helping medical professionals and students practise safe glove-donning methods. These systems can also offer real-time evaluation and feedback, encouraging regular compliance to best practises.

2. Chemical field

Chemical Handling Safety: Systems that automatically don gloves can increase safety by reducing the possibility of chemical exposure. These procedures ensure that gloves are put on correctly, removing any chance of gaps or poor fit that can result in unexpected contact with dangerous substances. These devices assist in safeguarding workers from chemical burns, absorption, or other negative effects by reducing the possibility of skin exposure.

Chemical Containment: Contamination and spills must be avoided when working with chemicals. Specialised chemical-resistant gloves and protective clothing can be integrated with automatic glove donning systems. By ensuring a proper seal between the gloves and clothing, this integration improves containment and lowers the possibility of unaware release or leakage of dangerous substances.

Worker Comfort and Productivity: Long-term chemical handling can be demanding on the body and uncomfortable. Systems for automatically putting on gloves minimise the strain on employees' hands and do away with the need for repetitive action. These devices have the potential to increase productivity and lower the risk of musculoskeletal injuries by enhancing comfort and minimising hand fatigue.

Compliance with Regulations: The chemical operations must adhere to strict safety and legal requirements. Companies can help achieve these criteria by utilising automatic glove donning systems that guarantee appropriate glove usage and attention to safety procedures.

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3. Food industry

Food Safety and Hygiene: In the food industry, ensuring strict standards of food safety and hygiene is important. Systems for automatically putting on gloves make ensuring they are put on properly, reducing the chance of contamination from bare hands. By preventing cross-contamination between various food products, allergies, or pathogens, these systems enhance food safety and lower the risk of contracting foodborne illnesses.

Worker Safety and Comfort: Long-term glove use is common among workers in the food firm, which can be uncomfortable and tyre the hands. Systems that automatically don gloves provide ergonomic advantages by eliminating repetitive motions and relieving hand strain.

Efficiency and Productivity: It might be time-consuming for workers to regularly change gloves when preparing and processing food. Systems for automatically wearing gloves minimise the procedure and let employees do it fast and effectively. In circumstances where food production moves quickly, this boosts general productivity, lowers downtime, and makes operations run more smoothly.

V. RESULT AND DISCUSSIONS

The development and fabrication of automatic glove donning system was successfully completed;
Time taken for all the processes;

- Glove separation: 10 sec.
- Forward movement of the iris mechanism: 5 sec.
- Cuffing of the iris mechanism: 4 sec.
- Backward movement of the iris mechanism: 5 sec.
- Time taken for vacuuming the donning box: 90 sec.

By implementing more advanced technologies, we can improve its efficiency and performance, and we can also reduce the time taken for glove donning. Making a provision for inserting two hands at the same time can reduce the time taken by half. Looking ahead, the future of automatic glove donning systems holds promise for further advancements. Integration with emerging technologies like artificial intelligence, machine learning, and robotics can enhance adaptability, precision, and the user experience. The main parts of the system we can improve are:

- Pneumatic systems should be used for the motions.
- Design the chamber and its parts with ergonomics in consideration.
- Optimise the iris mechanism's design.
- Use modern technology to more accurately arrange all components and pieces.
- Increase the use of lightweight, durable materials.

Thus, the future scope of automatic glove donning systems is vast and promising. Advancements in adaptability, integration, sensing technologies, robotics, and user experience will drive the evolution of these systems, enhancing efficiency, safety, and hygiene across a wide range of industries

VI. CONCLUSION

In conclusion, the establishment of automatic glove-donning devices is a significant development for both industrial automation and workplace safety. Numerous advantages are provided by these systems, such as higher effectiveness, enhanced hygiene, and fewer contamination concerns. Automatic glove donning systems have been studied and put into use in a variety of fields, including industrial, healthcare, and lab settings. These systems' design and construction involve factors including the creation of mechanical mechanisms, sensor integration, and control algorithms. According to further research, there are a variety of strategies to improve the automatic glove-donning system,including machine learning algorithms, computer vision systems, haptic feedback methods, and use a pneumatic system instead of mechanical parts.

We can focus on improving the design, maximising the functionality, and expanding the applicability of automatic glove donning systems by undertaking further study in this field. Even more advanced and efficient systems may result from integration with other automation technologies, like as robotics and artificial intelligence. Overall, automatic glove donning systems have the potential to transform a number of industries by enhancing worker safety, boosting output, and upholding strict hygienic requirements. These systems will continue to play a significant part in establishing safer and more effective working conditions as a result of continued innovation and advancement.

SCOPE FOR FUTURE WORK

The future scope of automatic glove donning systems holds immense potential for further advancements and applications. Here are some key areas of future development:

- Enhanced Adaptability and Customization: Future systems can be designed to accommodate a wider range of glove types,

sizes, and materials. Customization options can allow for specific industry requirements, ensuring compatibility with different tasks and environments.

- Integration with Robotics and Automation: Automatic glove donning systems can be integrated with robotic platforms or automated workstations, allowing for seamless integration into existing automation workflows. This integration will enable synchronised operations, reduce human intervention, and increase overall process efficiency. Robots can assist in the supply and removal of gloves, further streamlining the donning process.
- Continuous Improvement in User Experience: The user experience of automatic glove donning systems can be further improved by focusing on user interface design, intuitive controls, and user feedback mechanisms. Enhancements can be made to optimise user comfort, reduce cognitive load, and provide clear instructions for operation.

REFERENCES

[1]. Alhmidi, H., Gonzalez-Orta, M., Cadnum, J.L., Mana, T.S., Jencson, A.L., Wilson, B.M. and Donskey, C.J., 2019. Contamination of health care personnel during removal of contaminated gloves. American journal of infection control, 47(7), pp.850-852.

[2]. Priyadharsini, K., Kumar, J.D., Deepakkumar, A., Chandran, S. and Babu, C.G., 2021, February. A Novel System for Surgical Gloves Removing and Reusing-IoT Approach. In IOP Conference Series: Materials Science and Engineering (Vol. 1059, No. 1, p. 012071). IOP Publishing

[3]. Sobenko, L.R., de Camargo, A.P., Botrel, T.A., dos Santos, J.D., Frizzone, J.A., de Oliveira, M.F. and da Silva, J.V., 2018. An iris mechanism for variable rate sprinkler irrigation. biosystems engineering, 175, pp.115-123.

[4]. Preece, D., Lewis, R. and Carré, M., 2020. Efficiency of donning and doffing medical examination gloves. International Journal of Ergonomics, 10(1), pp.1-17.

[5]. Tümer, E.H. and Erbil, H.Y., 2021. Extrusion-based 3d printing applications of pla composites: A review. Coatings, 11(4), p.390.

[6]. Preece, D., Hong Ng, T., Tong, H.K., Lewis, R. and Carré, M.J., 2021. The effects of chlorination, thickness, and moisture on glove donning efficiency. Ergonomics, 64(9), pp.1205-1216