



WASHER DISINFECTOR MACHINE FOR THE DENTAL INSTRUMENTS

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Abstract: This project is centered on the design, development, and implementation of a specialized WD machine for dental applications. Its primary objective is to deliver efficient and reliable disinfection, cleaning, and sterilization of dental instruments. The machine aims to eradicate pollutants, bio-films, and pathogens through mechanical, chemical, and thermal processes, ensuring a high level of infection control within dental settings. To meet stringent regulatory requirements and industry standards, the project will undergo thorough testing, validation, and optimization. The overarching aim of this initiative is to enhance the overall safety, efficiency, and hygiene of dental treatments, thereby contributing to improved patient care and infection control.

I. INTRODUCTION

One essential element of infection control in clinics is the decontamination of reusable medical equipment. Considerable research has been undertaken across a range of studies for equipment types used in clinical practice to document the importance of thoroughly cleaning such devices in order to prevent cross-infection. It is generally accepted that minimizing the possible risks pertaining to the spread of pathogens requires thorough instrument cleaning. Moreover, thorough cleaning is essential to guaranteeing microbial inactivation because the presence of organic or inorganic debris could jeopardize the efficacy of later sterilization or disinfection processes. Specifically, when it comes to dental care, cleaning reusable dental instruments is very important. This is essential for adhering to medico-legal regulations, eliminating chemical residues, and ensuring the longevity and functionality of the device.

Scalers, hand-pieces, and dental mirrors are just a few of the many tools used in dental procedures. Since these instruments makes direct contact with patients' oral cavities and bodily fluids, it is essential to properly sterilize them in order to stop the spread of infections. Although conventional techniques like autoclaving and hand washing have been used to sterilize instruments, their ability to ensure total disinfection may be restricted. As a result, the development of washer disinfector machines has greatly improved the sterilization process's efficiency and safety.

II. PURPOSE OF WASHER DISINFECTORMACHINE

Instruments that are intended to be reused are cleaned with WDs. They could serve purposes beyond just pharmaceuticals and medical instruments. They could be reprocessed, e.g., within the parameters of their intended use for manufacturing equipment (used in the production of medical devices or cutlery), medical devices, sanitary equipment, laboratory equipment, or cutlery and crockery.

The decontamination process aims to:

a. Make the instruments safe for staff handling.

b. Make the item safe to be used on a patient (having followed any necessary additional processing); this includes ensuring, if relevant, that the item is contaminated, that might lead to an inaccurate diagnosis.

When instruments undergo decontamination via a washer disinfector (WD), they are designated for multiple uses without subsequent treatment, such as terminal sterilization. Therefore, the disinfection process within the WD must ensure that the item is microbiologically safe for its designated application once cleaned.

The Benefits of WD over the ultrasonic cleaners in the Dental:

- Washer disinfectors (WD) minimize manual labor and guarantee consistency by providing automated sanitization and sterilization processes.

- WDs offer deep cleaning and disinfection, reaching places that ultrasonic cleaners might not be able to.
- WDs are capable of handling a greater number and variety of dental instruments at once, in contrast to ultrasonic cleaners.
- WDs often have programmable cycles developed exclusively for dental instruments, which maximize cleaning effectiveness and efficiency.
- WDs have heating components for temperature control, guaranteeing regulatory-compliant disinfection.

III. FEATURES COVERED

- Disinfection of Instruments without Human Involvement to improve the pre-sterilization process and life of Instruments.
- Automatic Cleansing Agent/ Solution Dispenser which enables proper & appropriate usage of cleansing solution.
- Systematic arrangement of Instruments must guarantee that the water comes into contact with every surface/side of the devices..

Instruments that are intended to be reused are cleaned with WDs. They could be utilized for more than only pharmaceuticals and medical instruments. They could be reprocessed, e.g., within the parameters of their intended use for manufacturing equipment (used in the production of medical devices or cutlery), medical devices, sanitary equipment, laboratory equipment, or cutlery and crockery.

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IV. DENTAL STERILIZATION

Sterilization is a meticulous procedure designed to eradicate all living organisms, whether pathogenic or not, in both their vegetative and spore forms found on the exterior of the material undergoing sterilization. The hallmark of sterilization is the attainment of sterility, indicating the complete absence of living microorganisms. Healthcare facilities employ various methods, either physical or chemical, to achieve sterilization. These methods encompass steam under pressure, dry heat, ethylene oxide (ETO) gas, hydrogen peroxide gas, vaporized hydrogen peroxide, and liquid chemical agents.

It's crucial to note that sterilization aims for absolute Elimination or removal of all types of microbial life, distinguishing it from disinfection. Unfortunately, there's occasional confusion in terminology, with some healthcare professionals and literature erroneously referring to disinfection as sterilization and describing items as "partially sterile." Chemicals utilized to destroy microorganisms in various forms, including fungal and bacterial spores, are referred to as chemical sterilants. Remarkably, these same germicides, when exposed for shorter durations, can also function effectively for high-level disinfection purposes.

V. MANUAL INSTRUMENT CLEANING CONS

In healthcare settings, cleaning manual instruments has several drawbacks and difficulties such as:

- Inconsistency: The efficiency of manual cleaning greatly depends on the skill and diligence of the individual, resulting in differences in cleanliness between staff members and situations.
- Restricted Scope: Some instrument sections, especially those with intricate designs or small openings, may be difficult to manually access, which raises the possibility of residual contamination.

- **Time-Consuming:** Workflow efficiency may be hampered by the time-consuming and laborious nature of manual cleaning procedures, which call for a substantial amount of work to achieve thorough decontamination.
- **Error Prone and Fatigue:** Long cleaning sessions by hand may cause operator fatigue, potentially resulting in distractions and increased error risk.
- **Compliance and Training:** Ensuring personnel receives sufficient training and consistently follows established cleaning protocols can be

VI. WASHER DISINFECTOR MACHINE DESCRIPTION

Ensuring the prevention of contamination and the outbreak of infections are imperative in any dental practice, with the safety of all individuals—both staff and patients—holding paramount significance. Throughout the years, the predominant methods of physical heat sterilization in dental settings have included saturated steam, chemical steam, and dry heat. However, the latter two techniques are commonly regarded as unreliable and possessing limited utility.

At the initiation of the sterilization cycle's preliminary phase, a pump is engaged to extract the air present within the sterilization chamber. This phase is fundamental, as the existence of air in the chamber serves as an insulating barrier, impeding the uniform penetration and diffusion of steam throughout the instruments. Following the expulsion of air from the chamber, steam is introduced, with the process of air-steam substitution occurring across multiple stages.

Upon the culmination of the phase involving air evacuation and substitution with steam, the pressure within the chamber exceeds atmospheric pressure, resulting in a rise in the boiling point of water and consequentially, a generation of hotter vapor. Upon reaching the boiling temperature, the materials housed within the autoclave remain in a contact with the steam for the predetermined duration necessary to eliminate all vegetative forms and living spores. Subsequently, the steam is evacuated, and the material undergoes vacuum drying. The final phase of the cycle entails restoring the pressure within the sterilization chamber to match atmospheric pressure.

VII. PURPOSE OF WD IN HEALTH INDUSTRY

To prevent infectious organisms from spreading among patients, medical and surgical instruments must be disinfected and sterilized using disinfectants and sterilization techniques. Healthcare rules must state whether cleaning, disinfection, or sterilization is required based on the item's intended usage, as not all patient care devices must be sterilized.

Medical equipment, supplies, and other items used in healthcare settings can be cleaned of organic and inorganic contaminants with the aid of washer disinfection systems. The main goal is to disinfect objects in order to get rid of or lessen the microbial load, which includes bacteria, viruses, and fungi, and to stop infections linked to healthcare (HAIs). In order to ensure consistency and efficacy in sterilization practices, washer disinfection processes aid in standardizing cleaning and disinfection procedures. By guaranteeing that medical equipment and equipment are thoroughly cleaned and disinfected before reuse, it improves the safety of healthcare professionals and patients.

VIII. IMPACT OF WASHER DISINFECTANT ON DENTAL STERILIZATION

No studies have examined what the impact that these machines had on their owners, users as well as the impact on the daily delivery of care. These collective socio-technical experiences (interactions between people and technology in the workplace) may help shape future strategies that aim to encourage the transition towards using washer disinfectant and best practice in infection control. There was little impact reported on the daily routine among the dentists from the usage of washer disinfectant. It was acknowledged that sufficient instruments were needed to ensure the decontamination cycle time did not impact on the accessibility of instruments.

The most notable impact on the daily routine of the dental nurses was the time it took for the device to run a cycle. One dentist acknowledged the increased cycle time but the nurses at this practice (Practice 1) found the process to be quicker relative to the time they spent scrubbing instruments (Q2). This was not the perception regarding other nurses at the other practices, where the cycle time was reported as a negative factor.

IX. WORKING STAGES OF WD MACHINE

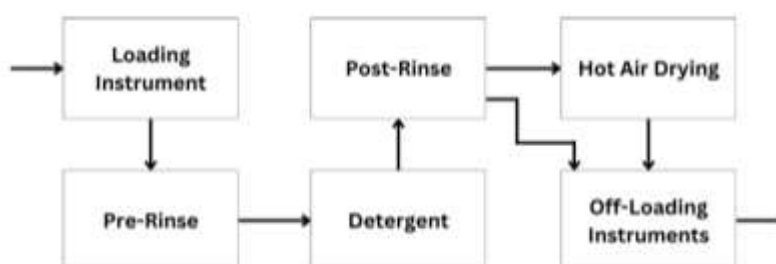


Figure 1 - Cycle Flow Diagram

1. **Loading Instruments** - The super-critical and semi-critical instruments will be placed systematically in the machine.
 2. **Pre-Rinse Cycle** - Water from the mini water reservoir will be circulated through the piping system at a high pressure. The water will strike the surface of the instrument which will result in the removal of organic and inorganic Bio-burden from the surface of the instrument.
 3. **Detergent Cycle** - As the pre-rinse cycle will end, the detergent cabinet will dispense a proper dose of disinfectant solution; and it will reduce the over-dosage & wastage of solution.
 4. **Hot air drying Cycle** - The hot air from the system will strike wet instruments & the cycle will ensure the instruments will be dry which can increase the efficacy of the sterilization cycle.
- Working Mechanism of WD machine.

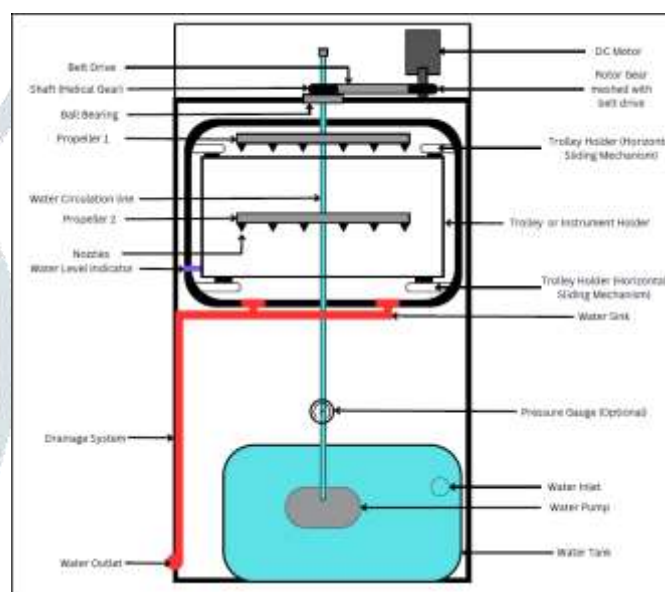


Figure 2 – Mechanism of WD Machine

Above diagram illustrates the Mechanism of the machine and placement of components. Here is the detailed explanation:

Initially, the dentist or dental assistant, herein referred to as the End User, will be responsible for filling the water tank facilitated by the machine and arranging the instruments in the instrument tray located inside the working cabinet. The water level indication system integrated into the water tank ensures that there is no overflow and prevents water wastage.

Once the water reaches the designated level, the first cycle, known as the Pre-Rinse Cycle, will commence. During this cycle, water from the water tank will be propelled into the working cabinet using a submersible pump, operating at a specified flow rate of 3.43 gallons per minute (GPM). The pump will be linked to the lower end of a vertical propeller shaft pipe. Water supplied by the pump will be directed onto the surface of the instruments via a horizontal pipe furnished with a nozzle, mounted on the vertical water circulation shaft. The upper extremity of the propeller shaft will be attached to a conveyor belt responsible for driving the vertical pipe. The conveyor belt will be powered by a 24V DC motor. The Pre-Rinse Cycle will last for duration of 90 to 120 seconds.

Upon completion of the Pre-Rinse Cycle, the machine will immediately transition to the second cycle, known as the detergent cycle. During this phase, a predetermined quantity of detergent will be dispensed onto the instrument surfaces. This cycle will occur for duration of 15 to 30 seconds.

The third cycle, termed the Post-Rinse Cycle, closely resembles the Pre-Rinse Cycle, with the only variation being the duration of the cycle, which will last for 120 to 180 seconds. Upon completion of the Post-Rinse Cycle, the machine will initiate the final cycle, the Drying Cycle. During this phase, hot air will be blown onto the instrument surfaces to facilitate drying, preparing them for offloading and subsequent sterilization cycles.

X. FUTURE SCOPE

1. Automation and Robotics:

The integration of automation and robotics represents a significant advancement in sterilization procedures, aiming to reduce human intervention and potential errors. Envision sophisticated robotic arms efficiently handling the loading and unloading of instruments, ensuring consistent positioning for optimal sterilization. Moreover, these robots could autonomously execute routine maintenance tasks such as cleaning and calibration, thereby minimizing downtime and ensuring uninterrupted operation. By optimizing these processes, healthcare facilities stand to enhance efficiency, diminish labor costs, and improve overall sterilization outcomes.

2. Enhanced Disinfection Technologies:

Ongoing research and development endeavors in disinfection technologies hold the promise of transforming the effectiveness of sterilization processes. Advanced chemical formulations with augmented antimicrobial properties have the capability to penetrate challenging-to-reach areas and eradicate a wider spectrum of pathogens. Similarly, ultrasonic cleaning technology employs high-frequency sound waves to dislodge contaminants from instrument surfaces, achieving a more thorough level of cleanliness. Additionally, plasma sterilization techniques utilize ionized gas to eradicate microorganisms, offering expedited cycle times and compatibility with various materials. By leveraging these innovative technologies, healthcare facilities can ensure meticulous and dependable sterilization of medical instruments, thereby mitigating the risk of healthcare-associated infections and enhancing patient outcomes.

3. Integration with Sterilization Tracking Systems:

The integration of washer disinfectant machines with sterilization tracking systems and electronic medical records (EMRs) provides unparalleled traceability and compliance with regulatory standards in the sterilization process. These integrated systems are capable of capturing and storing comprehensive data on each sterilization cycle, including key parameters such as cycle duration, temperature, pressure, and instrument types processed. By linking this information with patient records in EMRs, healthcare providers can easily monitor the sterilization history of each instrument, ensuring adherence to proper sterilization protocols prior to use on patients. Moreover, these systems facilitate proactive maintenance scheduling and documentation, thereby ensuring equipment reliability and compliance with regulatory requirements. Ultimately, the seamless integration of washer disinfectant machines with sterilization tracking systems enhances patient safety, regulatory adherence, and operational efficiency within healthcare settings.

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