ME-322

**MACHINE DESIGN**

MINI PROJECT

DESIGN OF A BULK DISHWASHER FOR WATER CONSERVATION IN MEGA KITCHENS​

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**Design of a bulk dishwasher for water conservation in Mega Kitchens**

**Aim :-**

To minimise the water consumption while in turn improving the washing efficiency in a Bulk dishwasher.

**Need Analysis :-**

Water shortage can be tackled by conserving water to the maximum extend. Efficient usage of water is therefore important in all applications. Dishwashing in mega kitchens results in water wastage as well as time-consuming.

Water consumption for dishwashing in mega kitchens like buffets and parties is huge owing to the fact that most of them are hand-washed dishes. Hand washing involves more of an individual’s time while the conventional dishwasher takes more time as a whole to wash dishes.

Thus, it is important to come up with a design which not only improves the efficiency of the dishwasher, but also saves water or reuse it.

**Principle of Operation :-**

Bulk dishwasher incorporates conveyer system rather than box type to decrease the lead time of operation. Bulk dishwasher consists of two washing chambers instead of one chamber partitioned into two compartments as in conventional chambers. The input hot water for dishwashing is preferred to be solar water heated so as to have minimum environmental impact.

The unclean dishes enter into Chamber 1 and pass on to Chamber 2. Chamber 1 has a set of nozzles which sprinkle pressurized detergent water onto the dishes. This detergent water is supplied via a pump at the base of Chamber 2 which contains semi-used water which is obtained via post-washing of dishes. The used water from Chamber 1 flows down from the conveyer to the fully used water tank which is rinsed periodically.

Chamber 2 is for removal of all sorts of debris and detergent from the plates. Chamber 2 contains a set of nozzles which is fed by hot water from solar water heater or heat exchanger (as available). This water is fresh and is used for final cleaning and sterilization of the dishes. This water after cleaning flows into Chamber 1 tank and is called as semi-used water as it can be used for further cleaning.

Water in Chamber 2 is mixed with detergent available at the base. This is accomplished by using a semi-permeable membrane or a sieve to optimize the usage of detergent in the dishwasher. This semi-used water is fed into Chamber 1 for applying detergent. As the water collected in Chamber 2 is still hot than the normal water. This increases the total thermal efficiency of the dishwasher. As water is being reused till maximum saturation, this decreases the water consumption and hence has lesser impact on environment. Dish movement is continuous; hence, the dishes can be washed in minimum lead time without compromising cleaning quality.



**Modelling of Bulk Dishwasher :-**

There are two pumps and four nozzles and hose pipes provided for flexible motion of the nozzles. The reused water pump pumps the water from Chamber 2 base which contains semi-used water (filled with detergent). This water is pumped to Chamber 1 where it is used for applying detergent and for pre-cleaning of dishes. The freshwater pump is used for pumping water from solar water heater source for final cleaning of the dishes via pumping the water to nozzles present in Chamber 2.

Initially, the dishes are placed on the moving conveyer belt marked with specific dish holders and major soiled plates are sponged off. Conveyer along with the dishes enters into the first chamber where water mixed with the detergent is sprayed on the plates with the help of two nozzles (one nozzle and one shower).

The pressurized detergent-mixed water serves the dual purpose of removing the lightly soiled stains and emulsifying the strongly soiled parts. The nozzles are kept adjustable so as to facilitate its orientation as per the need. Two-nozzle arrangement is preferred over one nozzle because the shower arrangement shall cover more area of the plate and emulsifying majority of stains. The nozzle part shall deliver the water with high kinetic energy, thereby removing light stains and some freshly emulsified stains in the initial stage itself, thereby reducing the load in second stage. After passing through the first chamber, the plates are moved to the second chamber. Here, the preheated water (through a solar heater arrangement) is drawn through a pump and sprayed on the plates with the help of two-nozzle arrangement (one nozzle and one shower), thereby removing the leftover stains. Using heated water (70–80 °C) in the process also sterilizes the plates, thereby eliminating the need for any post-processing operation other than drying. The chief highlight of this method is water reusability as the water used in Chamber 2 (freshwater) for rinsing the plates is collected in the tank below and is concentrated with the detergent by using the immersed detergent containers equipped with semipermeable membranes allowing the slow but steady mixing of detergent with water. The concentrated water is then pumped to nozzles in first chamber with the help of a submersible pump of the required rating, thereby reusing the water and reducing the water consumption by a factor of 2. Pumping the water from second chamber also ensures higher water temperature (>50 °C), thereby increasing the emulsifying capacity of concentrated detergent mixed water and also increasing de-soiling capacity of water at the given kinetic energy.

**Specifications :-**

* Parameter Specifications​
* Conveyer speed =5 inch/s​
* Time to transverse (1 dish) = 10 s​
* Time in freshwater chamber 10/2 = 5 s​
* Nozzle output (for 1 unit) =0.15 L/s​
* Total output (2 nozzles) =0.3 L/s​
* Total freshwater used (per dish) = 0.305 l/s \* 5 s = 1.5 L​
* Power used by one pump 18 W​
* Total power used by 2 pumps 36 W​
* Weight of conveyer =0.3 \* 25 = 7.5 kg​
* Weight of standard SS plates 0.25 \* 10 = 2.5 kg​
* Total load on conveyer motor= 10 kg​
* Conveyer motor type BLDC​
* Conveyer motor power =1 KW​
* Continuous motor torque= 3 Nm​
* Motor peak torque =14 Nm​
* Motor operating voltage =48 V​

**Components in spray system :-**

PUMPS –

Choosing the correct pump for the system is the first step. The efficiency of the pump will affect pipe and valve size and the downstream equipment required. ​Remember, pumps provide flow, not pressure. Pressure is the result of restriction of flow.​

For high pressure operation:​

 Positive displacement style pumps are typically used. Every rotation provides a fixed flow rate​ regardless of downstream constriction. ​Pressure increases when flow is restricted Over-pressurized conditions can occur when nozzles or strainers are clogged or​valves are closed. ​A safety valve that lowers pressure is required when using positive displacement pumps.

For low pressure operation:

Centrifugal pumps are typically used.​ Vanes spin the fluid and velocity is increased as the pump casing restricts flow.​

System pressure is adjusted by restricting flow .​

**Life Cycle Assessment :-**

The goal of this study is to determine whether or not a bulk dishwashing machine is more efficient than hand washing for both energy and water consumption. The analysis aims to see which method has a larger environmental impact as measured by carbon dioxide (CO2). The scope of this life cycle assessment (LCA) is limited to the phase when the dishwasher is being used.

Different stages of dishwashing



Hand washing inputs(per dish)

Phase1 Water Water used (L) 1.18 (L)

Phase2 Energy (J) to distribute water 8520

Natural gas (J) to heat water 99,161

Bulk dishwasher inputs (per dish)

Phase 1 Water used Litres used 1.5 (L)

Phase 2 Energy to heat water 220,000 (J)

Energy for distribution 1,137,240 (J)

**SAFETY :-**

PIPING AND VALVES​

Improperly sized piping and valves are common causes of spray nozzle performance problems.​ Here are key factors to consider when setting up or troubleshooting your system:​

**Is the system flow at the nozzle adequate?**​

Typically, system flow should be two to three times the desired nozzle flow rate.​

**Is pressure at the nozzle adequate?**​

Friction, pipe length, valves, elbows and the distance between the pump and nozzle can all result in pressure loss. Refer to page 30 for more information about pressure drop.​

**Is fluid velocity in the pipe greater than (3.7 m/sec.)?**​

If so, turbulence, noise, vibration and losses could interfere with nozzle performance.​

* More pressure will be required for solutions heavier than water to achieve comparable flow rates.
* The lack of proper filtration is a very common problem and can wreak havoc with any spray system. Fluid should be filtered prior to pump inlets.
* It is important to remember that the nozzle orifice will be the smallest restriction in your system so you need to use a strainer sized to prevent nozzle clogging.
* Filters and strainers, of course, need to be cleaned on a regular basis.

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**CONCLUSION :-**

The idea for development of bulk dishwasher was due to the issue of overuse of water and time wastage in dishwashing during large religious feasts. The problem was solved by designing a belt-conveyer-based dishwasher which uses water twice, firstly for rinsing and secondly by collecting and concentrating the semi-used water with detergent and then using it again for initial rinsing of other plate and then finally discarding it, thereby reducing the water usage by a factor of 2. The energy required for transporting the water has been reduced by approximately 15%. The water heating element in the dishwasher had been eliminated as it uses completely solar heated water, thereby considerably reducing the electrical energy usage.