Using Radiative Technology to Create a Better Dishwasher

By: Jhony Flores, Eric Puntiel, Tanzil Ruslan

City College of New York

Summary

Some of the most common issues in dishwashers is their questionable longevity and the prolonged drying time. In this paper we will discuss the possibility of adding optional radiative technology, specifically hydronic flooring and radiant panels, to improve the cycle time of the product. By implementing thermal radiative technology, the solar heat will be used to speed up the drying process and it will ensure that the dishes are completely dried. However, this feature does come with a single drawback. Using this feature will consume additional energy, which is why this will be an optional feature. We want to improve the convenience of the dishwasher and make it better tool for the consume. The total cost for this project is estimated to be between $241,800 and $424,040.

Author's Note

This paper is for our Writing for Engineers class taught by Professor Susan Delamare at City College. Any questions or concerns about this paper should be addressed to sdelamare@ccny.cuny.edu.

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Introduction

New dishwasher models have become very energy efficient but at the cost of longer run times for the same results that older dishwashers yield. The average dishwasher cycle can be from anywhere from 2-4 hours, with increasing cycle times for newer models (“Appliance IQ”, 2020). Not everyone has the time to wait for an entire cycle, especially if there are more dishes waiting to be washed. A common problem that occurs with dishwashers, is that people often find that their dishes are not completely dry after the cycle is complete. This is because there is nothing that directly helps the drying process. In modern dishwashers, the drying process utilizes the heat created from the washing process to dry the dishes, conserving a lot of energy. The process of drying is also known as condensation (Slavin, 2018). The heater uses the same water that was used to clean, and it heats it up to create hot air that circulates throughout the system. The hot air is circulated with a big fan that is usually located at the top, to prevent any water from damaging it. This is how modern dishwashers work.

According to a research done on the drying performance of a brand-new dryer, the dishes were, on average, dried to a numerical value of 1.8, which is equivalent to saying that the dishes were 90% dry (Jeong & Lee, 2014). In the same paper another problem was found with the drying process (See Appendix A). As previously mentioned, the drying process was entirely dependent on how much energy was consumed by the washing process. For instance, if the dishes were not very dirty then the sensors would tell the machine to end the wash cycle early, since the dishes were cleaned faster. As a result, there is not a lot of energy that can be recycled to dry the dishes and the dishes are not completely dried.

The final concern that we have about the dishwasher is the longevity of it. The typical dishwasher is supposed to last at least seven years but most of them malfunction before that time period. The most common problem with the dishwasher, according to Sears, is that the dishes do not dry (“Top 5 Dishwasher Problems”, n.d.). To fix the problem they suggest adding a liquid rinse aid to help the drying process. However, we believe that this defeats the purpose of having a good dishwasher. A good dishwasher should be able to do all the work it claims it does without the need for other external products. The only external product that is needed is the detergent but that’s about it. We want to make sure that the dishwasher works in peak condition for at least an average of seven years.

To solve the problems at hand, we want to incorporate thermal radiative technology with the dishwasher to create a better and faster drying process. Thermal radiative technology will involve the use of a direct source of heat that will drastically speed up the drying process. The technology will ensure that the dishes are completely dry every time and it is safe for every dish material. Since this additional feature is bound to consume more energy, we want to make this feature optional for those who are not in need of speeding up the process. This innovation is most appealing to consumers with large families or for anyone who needs the dishwasher to be used frequently and quickly.

Objectives

The primary objective of this team is to research how well these technologies work together and how much energy is consumed while the proposed feature is being used. We want to compare the power consumed during normal usage and the power consumed with the feature. At the same time, we will be testing the effectiveness of the technology and measuring the “dryness” of the dishes. Different types of dishes will be used in terms of materials, shape, and size. Our secondary objective will be researching the best ways to incorporate the technology in terms of design. We want to see where the technology will best work. Will it be better if it is next to the fan up top or will it be better if it is next to the spray or somewhere else perhaps? These are some of the questions we will be answering. The last objective we will focus on is how long the technology will last. We want to see if the intense heat or the water and moisture in the dishwasher interferes with the technology's longevity. If it does, then we can fix the problems so that we can release a dishwasher with good lasting quality.

We want to accomplish all of our objectives swiftly so that we can give enough time for marketing and manufacturing of the product. Our research must be quick but also accurate and so we propose to have a one-year long plan (See Appendix B) for our research.

Preliminary Literature Review

Radiative technology is technology that reproduces the conditions of various climate conditions. There is radiative cooling and radiative heating. We want to use the heating aspect of this technology to help dry the dishes. It's been proven that radiative technology is safe for many buildings' purposes (Vall, Castell, Medrano, 2018). Radiative technology is currently used in many buildings to help with heating (p.2). Common places that have this form of heat are hotels. Hotels typically use this in the entrance to immediately provide warmth to consumers when it is cold. The reason that this is used instead of the common heating is because this heat can be used on a large and small scale. Also, this form of heating has the ability to be drawn from solar energy but the implementation of this is another topic for the future (Vall, et.al, 2018). Of course, we want to use this technology on a small scale since we are dealing with only dishes. This paper serves to prove that this technology is safe for commercial use and so we can incorporate it into our project without having to worry about harmful repercussions.

In our project we plan to use hydronic radiant floors since it is the most common and energy efficient type of radiative energy out in the market ("Radiant Heating", n.d.). This is also convenient to us since this type of system relies on using heated water to create the heat. Dishwashers use a lot of water in the washing process and so we can reuse the water for many different purposes. On top of this we can reuse the heating valve that are already in the dishwasher for maximum energy efficiency. The main parts of the system are the heat emitters, the circulation pumps, the energy source, and the pipes (Fig 1). Since two of these parts are already in the dishwasher, we would just need to add a circulator pump and the piping. We are also considering the use of radiant panels (Fig 2) which is another form of radiative technology. In this form, the heat is created using electricity or tubing with hot water ("Radiant Heating", n.d.). There is a setback with this technology and that is that it requires more energy. This is a type of electric heat and so it is more expensive than the former. The price can be justified since it is the fastest responding

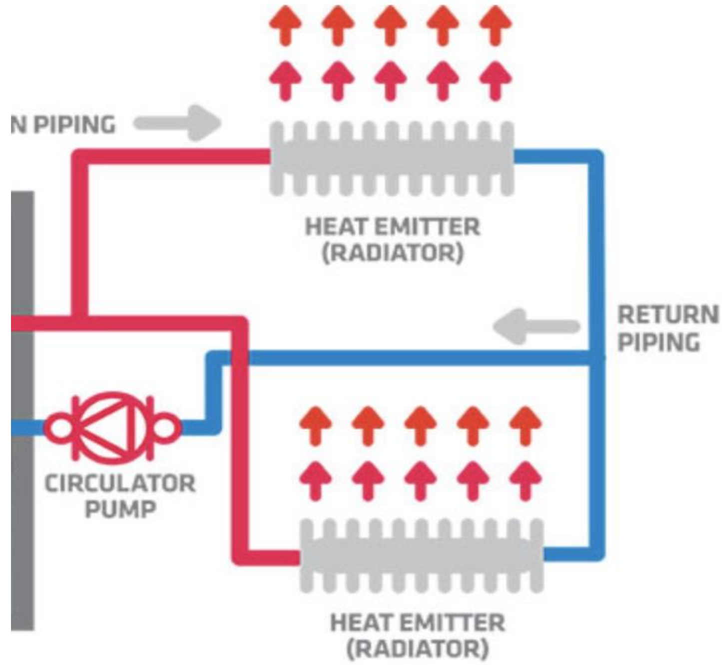


Figure 1: Hydronic Radiant Floor Layout, Reprinted from "How Hydronic Heat Works", n.d.

Figure 2: Radiant Panels, Reprinted from "Radiant Panel Linear", Copyright 2020 Price Industries

heating technology in the market. It is also the best in terms of temperature accuracy ("Radiant Heating", n.d.). We will research how effective this type is and decide whether it is necessary for the dishwasher.

Technical Description

The model we propose is based on radiative technology to create an efficient dishwasher (Fig 3). The primary use of dishwashers is water to wash properly and to have more efficiency in heat. To accomplish the whole process first loading a tray of detergent in the dispenser unit initially and also through the use of sorting from smaller dishes to larger dishes in the tray unit will help the flow of water to rinse and wash properly. Using the controls to set the temperature and then by locking the tray will set the cycle motion. The turbidity sensor is the primary sensor that helps measure the level of soil and water or how clean the water is when the rinse cycle starts. The thermistor helps the temperature of water when certain cycles are being set. In the control mechanism of dishwasher the intake valve drives the water into the machine in the pump section the water is being pressurized to have reversible or direct flow of motor this helps in wash system for spray arms to put force of water to remove the food dirt on the dishes then by using detergent helps to remove color stains. As the water ran clear from the detecting particle by turbidity sensor the drying process starts

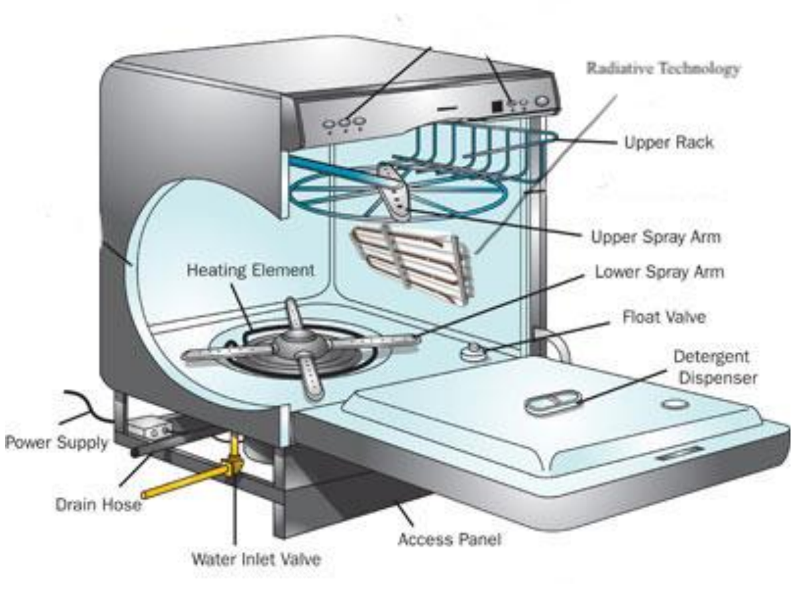


Figure 3: Dishwasher Parts, Reprinted from "How Dishwashers Work", n.d.

after. In the drying process, the thermistor is used for the water temperature up to 130-140 degrees Fahrenheit which may eliminate any water and bacterial particles. The rest of the toxic water may go through the pipe underneath. If the option is enabled, then the radiative heating technology will turn on and the dishes will be dried much quicker.

1. **Power Supply -** The power supply is attached with a cord that allows the dishwasher to take electricity.
2. **Drain Hose** – The drain hose drains dirty water from the dishwasher through the tube.
3. **Water Inlet Valve** – It allows fresh water to enter while the cleaning cycle is running, and it controls how much water is used during the process.
4. **Access Panel** – It is a small removable portion of the exterior part of the dishwasher. To open and remove the access panel will have all items that can be interacted with.
5. **Detergent Dispenser** – It dispenses the detergent at the right time of the wash cycle.
6. **Float Valve –** The float valve has a ball that fits in the cup shape opening. When the water level rises the ball floats which opens the drain hose allowing water to remove to reach a good level.
7. **Lower Spray Arm** – It is a freely moving component that sprays and cleans the lower component of the dishes.
8. **Upper Spray Arm** – It is a freely moving component that sprays and cleans the upper level of dishes.
9. **Lower Rack** – This is where all the dishes and other utensils are placed and is closer to heating element thus improving more heat than the upper rack
10. **Upper Rack** – This is where all the dishes are placed and is farther away from the heating element as they are not much exposed to heat like the lower rack.

11. **Heating Element** – This regulates the heat of the water for the cleaning process. It also regulates the heating of air for the drying process.
12. **Radiant Technology**- To finish the design the panels will use radiative heat to ensure that every dish is dry. Research is needed to check where the technology will be most effective and so the position is subject to change

Budget

Table 1. Budget Details/Expenses

Item	Cost	Time	Annual Costs
Equipment			
(5) Dishwashers	$2,000 - $3,500	one time	$2,000 - $3,500
(5) Radiative Technology	$1000 - $1400	one time	$1000 - $1400
Additional Equipment Fees	$1,500	annually	$1500
Equipment Totals-	$2,600 - $4,640		
Personnel			
Full-Time Researcher (Mechanical Engineer)	$58,000 - $114,000	annually	$58,000 - $114,000
Full-Time Researcher (Electrical Engineer)	$63,000 - $134,000	annually	$63,000 - $134,000
Graduate Student (Mechanical Engineer)	$43,000 - $81,000	annually	$25,000 - $39,000
Graduate Student (Statistician)	$21,000 - $39,000	annually	$21,000 - $39,000
Consultant Fees	$160/hr	40 hrs.	$6,400
Personnel Totals-	$191,400 - $374,400		
Lab Space			
Research Lab	$3,900	monthly	$46,800
Annual Total	$241,800 - $424,040		

Note. Retrieved from "Estimating an economic-efficient frontier for dishwasher consumer choice," 2018.

Our first-year budget (Table 1) covers the costs associated with our initial objectives, mainly determining how much energy is used while the radiative heating option is turned on. We expect to have completed our research in a year. The budget is subject to change if any unexpected events occur. An example for this is if we accidentally damage one of the radiative technologies, which can be damaged by the water. All budget estimates are based on inferences as well as from figures and cost projections available online. We primarily used information from Okwelum and Blum's (2018) research on energy costs.

We plan to have a staff of two full time researchers, and two graduate students, with backgrounds in mechanical engineering, data analysis, and electrical engineering. Experimentation will be done in a laboratory, in order to minimize any unexpected variables. Minor expenses such as the detergent and test dishes are included in the "Additional Expenses" section and we will pay rent for our laboratory on a monthly basis. A backup budget will also be available to cover any unforeseen expenses that we may encounter.

References

Appliance IQ. (2020). Retrieved from https://www.whirlpool.com/content/whirlpoolv2/en_us/blog.html

Blum, H., & Okwelum, E. (2018). Estimating an economic-efficient frontier for dishwasher consumer choice. Energy Efficiency, 11 [Table 1]. Retrieved from https://link.springer.com/article/10.1007/s12053-018-9627-7

Grabianowski, E. (n.d.). [Figure 3] How Dishwashers Work. Retrieved from https://home.howstuffworks.com/dishwasher.htm

How does Hydronic Heating work? Hydronic Heating Equipment Suppliers. (n.d.). [Figure 1] Retrieved from https://www.hydroheat.com.au/homeowners/hydronic-heating-works/

Jeong, S. W., & Lee, D. H. (2014). Drying performance of a dishwasher with internal air circulation. Korean Journal of Chemical Engineering, 31. Retrieved from https://link.springer.com/article/10.1007/s11814-014-0194-0

Jeong, S. W., & Lee, D. H. (2014) [Figure 4]. Drying performance of a dishwasher with internal air circulation. Korean Journal of Chemical Engineering, 31. Retrieved from https://link.springer.com/article/10.1007/s11814-014-0194-0

Jeong, S. W., & Lee, D. H. (2014) [Figure 5]. Drying performance of a dishwasher with internal air circulation. Korean Journal of Chemical Engineering, 31. Retrieved from https://link.springer.com/article/10.1007/s11814-014-0194-0

Radiant Heating. (n.d.). Retrieved from https://www.energy.gov/energysaver/home-heating-systems/radiant-heating

Radiant Panel Linear - Radiant. (n.d.). [Figure 2] Retrieved from https://www.priceindustries.com/radiant/products/rpl-radiant-panel-linear?SwitchMarket=International

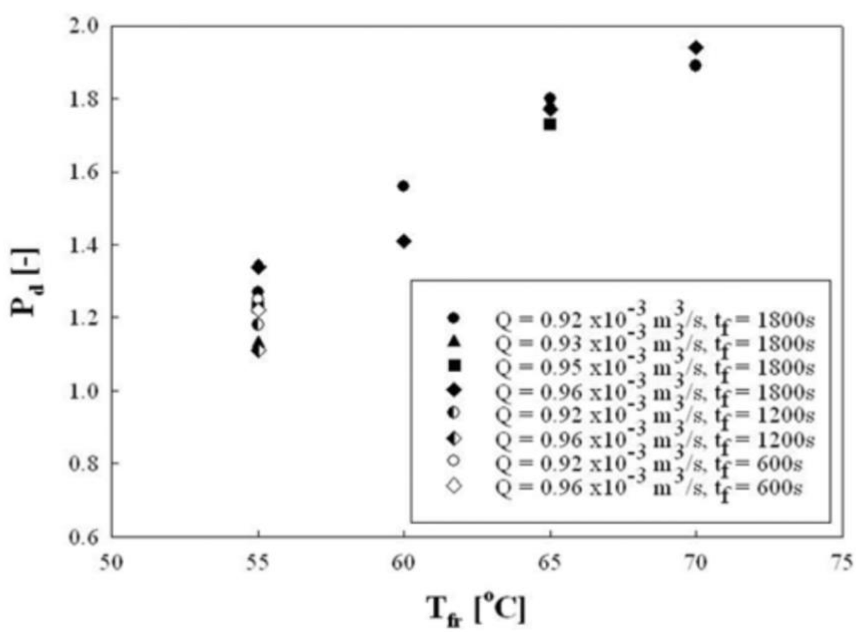
Slavin, T. M. (2018, April 20). How Does a Dishwasher Dry? Retrieved from https://www.hunker.com/12145906/how-does-a-dishwasher-dry

Top 5 Dishwasher Problems and Solutions. (n.d.). Retrieved from https://www.searshomeservices.com/blog/top-5-dishwasher-problems-and-solutions

Vall, S., Castell, A., & Medrano, M. (2018). Energy Savings Potential of a Novel Radiative Cooling and Solar Thermal Collection Concept in Buildings for Various World Climates. Energy Technol., 6. Retrieved from https://onlinelibrary-wiley-com.ccny-proxy1.libr.ccny.cuny.edu/action/showCitFormats?doi=10.1002/ente.201800164

Appendix A –Drying Performance of the Dishwasher

In the paper by Seong Woo Jeong and Dong Hyun Lee (2014), the two explore how effective the recent energy efficient dishwashers are in drying. The process involves condensation, where water and heat from the previous wash cycle is used to reuse energy that can be used for the drying process. The authors state "As shown in the energy balance results, the energy required to evaporate water from the dish surfaces during the drying step corresponded to the energy accumulated on the dishes from the heat energy supplied in the final rinse step" (Jeong & Lee, 2014). In Fig 4, the graph illustrates how more energy is needed when the temperature is lower, due to a short wash cycle, as well as how poorly dry it is.



Variation of drying performance with final rinse temperature (T_{fr}).

Figure 4: Chart of Temperature vs Dryness, Reprinted from "Drying performance of a dishwasher with internal air circulation" (2014)

The authors used a multitude of tools to ensure that his results were accurate. He used computers that measured humidity, power meters to measure energy consumption, and many other tools that measured temperature. The amount of moisture on the dishes was measured according to how much water was on the surface area. The drying performance was quantified with a scale that was created by the authors which ranges from 0 to 2. A 0 indicated that the dishes were completely wet and a 2 is completely dry. The drying process is largely dependent on a large fan that is located at the bottom of the dishwasher (Fig 5). This fan circulates the hot air which dries the dishes.

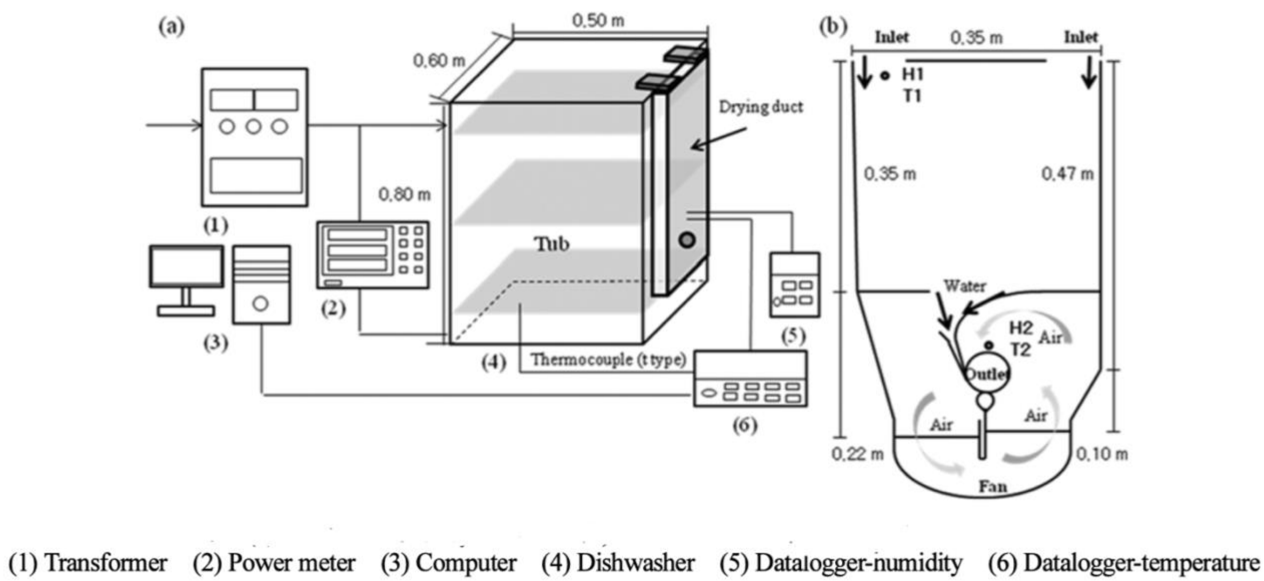
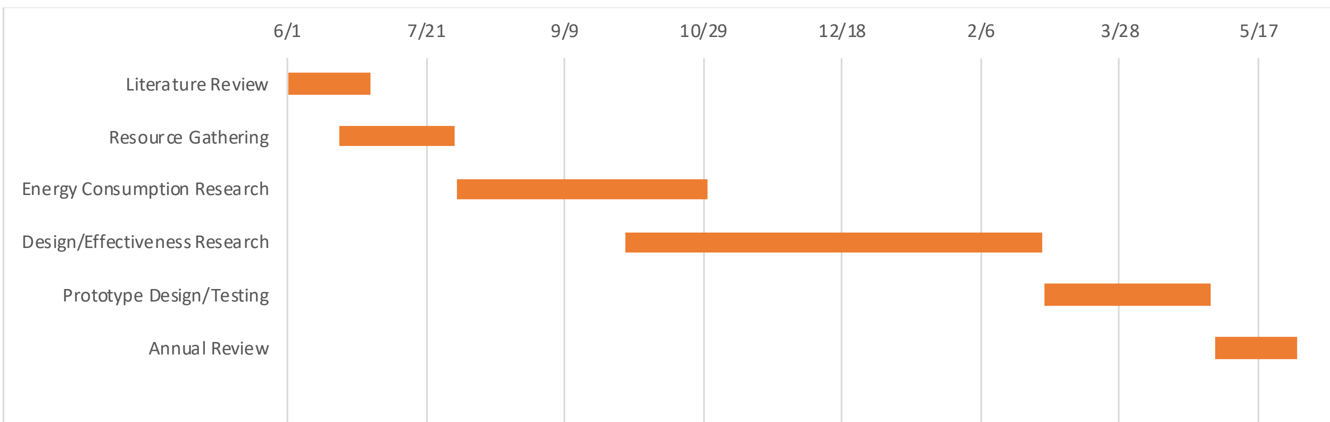


Figure 5: a) The setup used for the research and b) Visual of Air Circulation, Reprinted from “Drying performance of a dishwasher with internal air circulation” (2014)

Appendix B – Project Task Schedule

Table 2. Task Schedule

START DATE	END DATE	DESCRIPTION
6/1/20	7/1/20	Literature Review
6/20/20	8/1/20	Resource Gathering
8/1/20	11/1/20	Energy Consumption Research
10/1/20	3/1/21	Design/Effectiveness Research
3/1/21	5/1/21	Prototype Design/Testing
5/1/21	6/1/21	Annual Review



Note. Table created by Project Group Members