Metcraft Power Soak Performance Test

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Executive Summary

The objective of this study was to compare the energy performance of Metcraft's new Power Soak PS 200 design with the Maximizer model currently in use at McDonald's. The testing examined the energy input rates, total energy consumption, and the heating element & water temperatures.

Metcraft incorporated improvements such as a 7 kW heating element, 7 high flow nozzles, and an intake grid that was parallel and directly beneath the nozzle jets on the PS 200, compared with that of the Maximizer model that only had a 2.5 kW heating element, 4 high flow nozzles, and an intake opening perpendicular to the nozzle jets

The Power Soak PS 200 exhibited improved temperature response and lower energy consumption rates over the Maximizer during the normal wash cycle at 113°F. The end result was a 14% decrease in calculated daily energy consumption over the previous design (26.4 kWh/d vs. 30.8 kWh/d), based on four wash cycles. The temperature bandwidth of the PS 200 was 0.2 °F vs. 1.0°F for the Maximizer during the four-hour test period, which is a direct result of the redesigned control system. In addition, the PS 200 was able to reach the proper operational temperature in less than half the time required by the Maximizer when the water was initially introduced to the wash tank at 70°F.

The redesigned PS 200 showed marked improvements in energy consumption, temperature controls, and improved wave motion. Metcraft's developments to the Power Soak series delivers enhanced performance with a lower operating cost.

Metcraft Power Soak Evaluation

Background

Dedicated to the advancement of the food service industry, Pacific Gas and Electric Company's Food Service Technology Center (FSTC) has focused on the development of standard test methods for commercial food service equipment since 1987. The primary component of the FSTC is a 10,000 square-foot appliance laboratory equipped with energy monitoring and data acquisition hardware, 60 linear feet of canopy exhaust hoods integrated with utility distribution systems, appliance setup and storage areas, and a state-of-the-art demonstration and training facility.

The test methods, approved and ratified by the American Society for Testing and Materials (ASTM), allow benchmarking of equipment such that users can make meaningful comparisons among available equipment choices. By collaborating with the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) through matching funding agreements, the test methods have remained unbiased to fuel choice. End-use customers and commercial appliance manufacturers consider the FSTC to be the national leader in commercial food service equipment testing and standards, sparking alliances with several major chain customers to date. The work described in this report form the basis for a Standard Test Method for powered pot washing equipment.

The glossary in Appendix A is provided so that the reader has a quick reference to the terms used in this report.

Objectives and Scope

The overall objective of this study was to compare the energy consumption of Power Soak Maximizer to that of Power Soak PS 200. Three different tests were performed, each examining the energy input rates, total energy consumption, heating element temperature and water temperature. All tests were performed with the manufacturer's specified amount of soap added to the water. The wash cycle timers, set by the manufacturer, were set for a four-hour wash cycle. Therefore, the washing tests were performed for 240 minutes.

- The first four-hour test began with the wash tank filled with 70°F water. Energy consumption and temperature were measured over the four-hour test.

- The second four-hour test began after the first wash test, when the water has stabilized at an operating temperature of approximately 113°F. Energy and water temperature were also measured over the four-hour test.

- The last test was an overnight test measuring the heating element energy consumption. As a four-hour wash cycle is completed, the heating element will remain "on" until the unit is drained, thus maintaining the unit's completed wash cycle water temperature. This scenario occurs typically at the end of the evening as the employees leave for the night while a four-hour wash cycle is still in progress.

Appliance Description

The Maximizer and the PS200 each have a 2 hp pump. The Maximizer has a 2.5 kW heating element with four water jets and the PS 200 features a 7 kW heating element with seven water jets. See Figure 1 & 2 for wave motion diagram. Both Power Soak models utilize programmable logic controls capable of trouble-shooting the Power Soak system.

Specifications for the two Power Soak models as tested are listed in Table 1.

Table 1. Power Soak Specifications.

Power Soak Generation 1	
Model	Maximizer
Rated Pump hp	2 hp
Rated Heating Element	2.5 kW
Number of Water Nozzles	4
Diameter of Water Nozzles	1.625 in.
Tank Water Capacity	80 gallons
Power Soak Generation 2	
Model	PS 200
Rated Pump hp	2 hp
Rated Heating Element	7 kW
Number of Water Nozzles	7
Diameter of Water Nozzles	1.125 in.
Tank Water Capacity	83 gallons

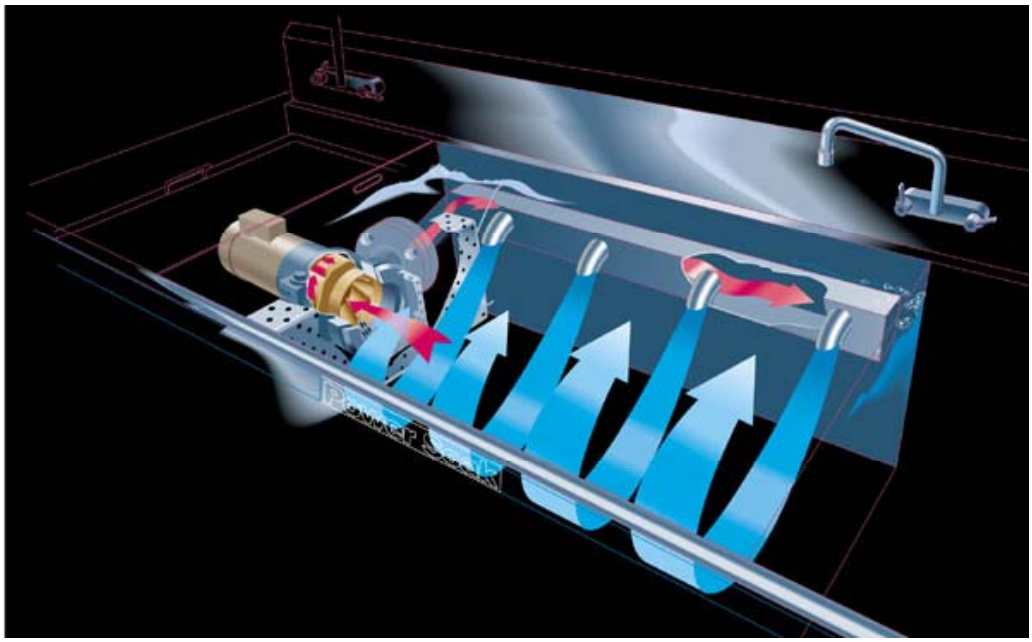

Figure 1: Maximizer Wave Motion Diagram (Courtesy of Metcraft, Inc.).

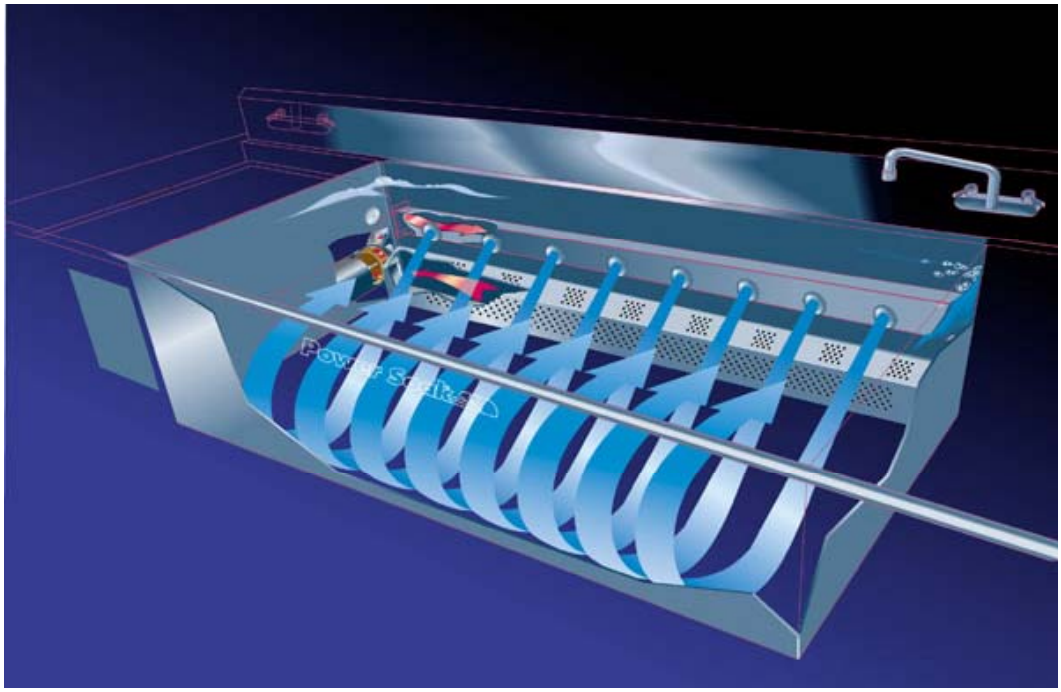

Figure 2: PS 200 Wave Motion Diagram (Courtesy of Metcraft, Inc.).

Test Setup

FSTC researchers installed the Power Soak on a tiled floor where the models were balanced and the appropriate water and sewer hook-ups were installed. See Figure 3.

Figure 3. Power Soak with Computer and Voltage Regulator.

Researchers instrumented the Power Soak units with thermocouples to measure water and heating element temperatures. Nine thermocouples were placed in the wash tank, eight along the walls and one directly on the heating element surface. Four were positioned 2 inches above the bottom of the tanks, and four were located 2 inches beneath the water surface. The thermocouples were spaced 1/3 of the tank's length from the sides. The crosses (red) in Figure 4 illustrate the placement and location of the thermocouple.

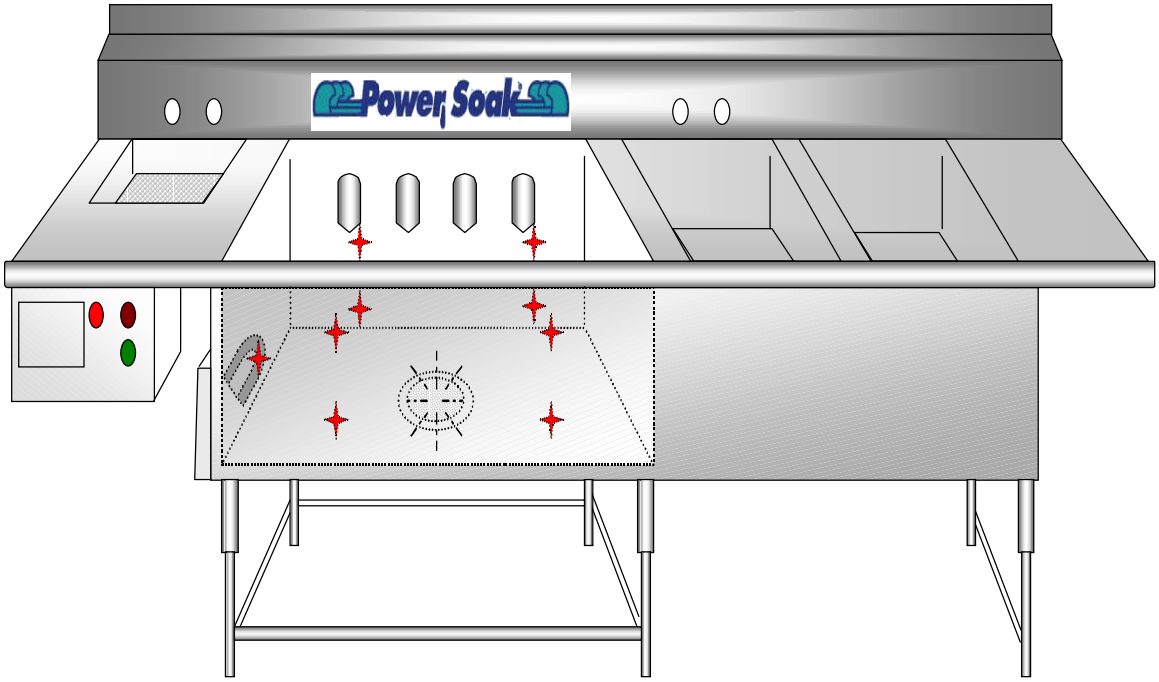

Figure 4: Thermocouple Placement

Power and energy were measured with a calibrated watt/watt-hour transducer that generated an analog signal for instantaneous power and a pulse for every 10 Wh. The transducer and thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds using a Fluke Helios data logger and recorded on a PC. A Staco voltage regulator was used to maintain a constant 208 voltage for all tests.

Figure 5 shows the Maximizer during testing. The picture demonstrates the wave action that occurs in the wash tank during operation.

Figure 5: The Maximizer During Testing

Power Soak Test Results

The Power Soak's test duration of four hours was pre-determined by McDonald's and Metcraft from actual field wash times. All tests were performed to mimic actual washing performance with a pre-determined amount of soap. The following section is a discussion of the results from the three tests performed with supporting tables and charts.

Wash Cycle Test: 70°F Initial Water Temperature

The first four-hour test began with the wash tank filled with 70°F water where energy consumption and temperature were measured.

Figures 6 & 7 show the two Power Soak models with an initial water tank temperature of 70°F. As the test begins, each unit's heating element is cycled "on" as the water begins heating up to an operating temperature of 113°F. The major difference between these two models is that the PS 200 has a 7 kW heating element, while the Maximizer has a 2.5 kW heating element. The PS 200 reached the operating temperature of 113°F in 87 minutes at a rate of 0.48°F per minute. The Maximizer only reached 113°F as the test was completed with a temperature rise of 0.20°F per minute. While the PS 200 operated at 113°F for the majority of the four-hour test, it used only 1.4 kWh more than the Maximizer. The test results are shown in Table 2.

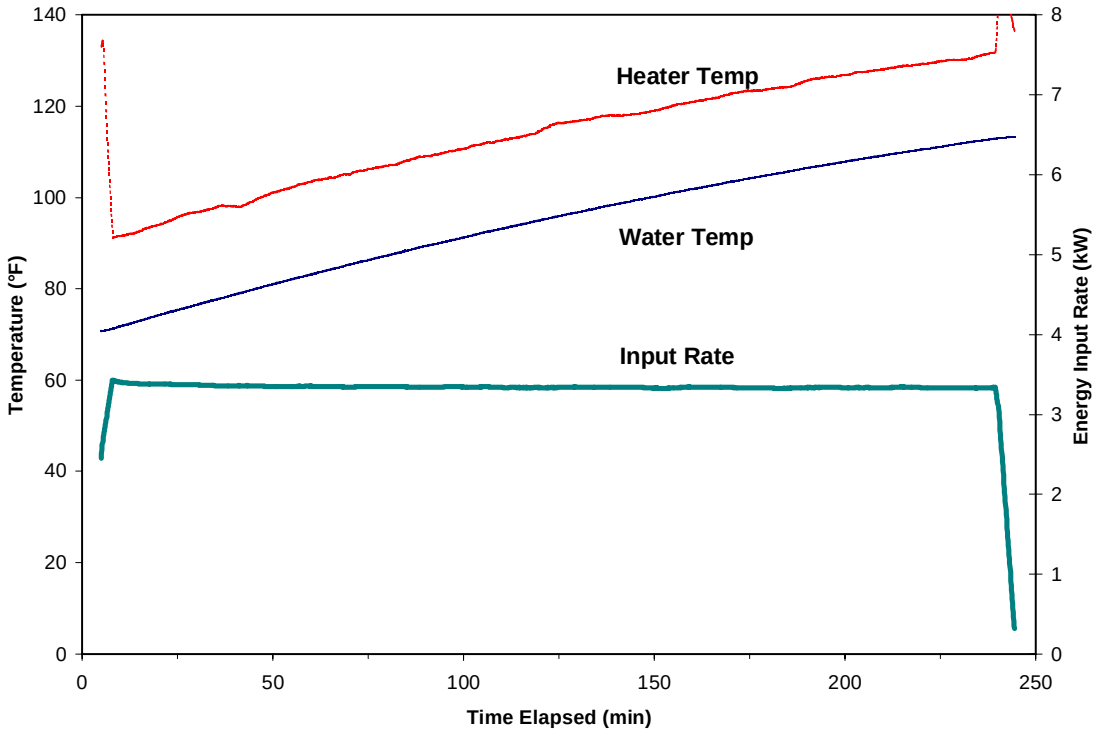

Figure 6. Power Soak Maximizer : 70°F Heat Up Test

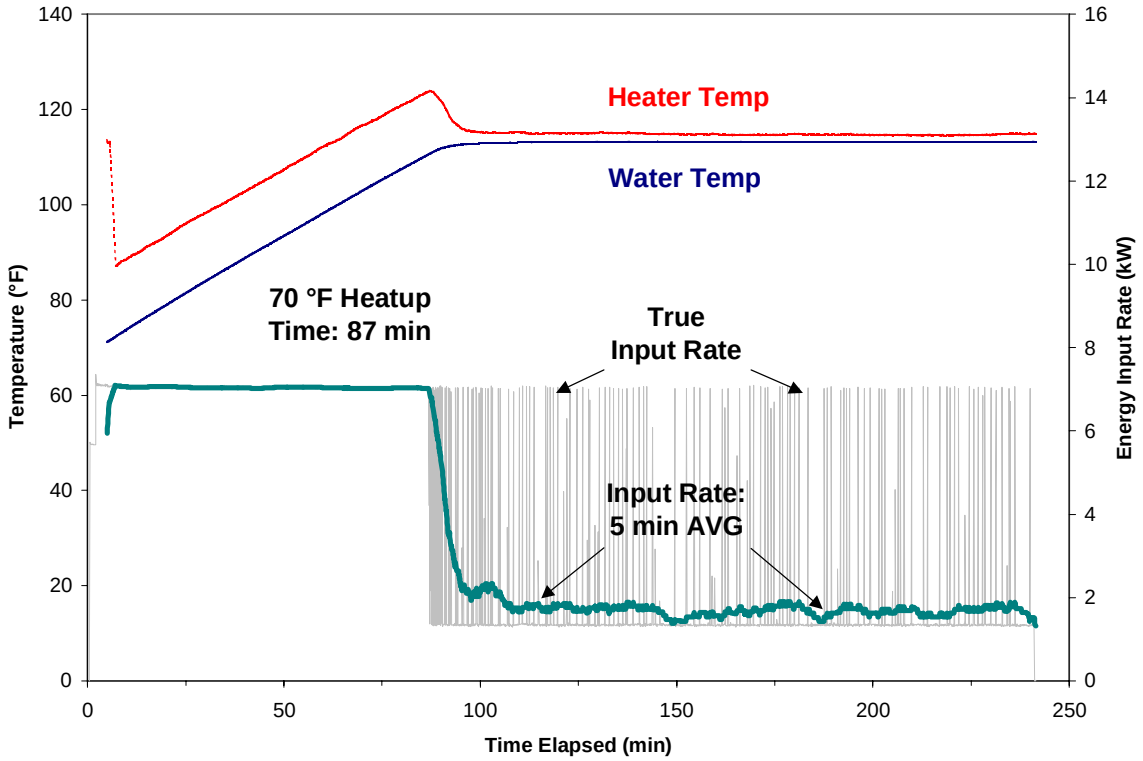

Figure 7. Power Soak PS200: 70°F Heat Up Test

Table 2. Starting Water Temperature at 70°F Test Results.

	Maximizer	PS 200
Initial Water Temperature (°F)	70.6	70.0
Ending Water Temperature (°F)	113.2	112.0
Degrees Per Minute Temperature Rise (°F)	0.20	0.48
Time To Reach Operating Temperature (min.)	236	87
Energy Consumed Reaching Operating Temperature (kWh)	13.3	10.2
Average Energy Heat-Up (kW)	3.35	7.00
Average Energy Holding Idle – 113°F (kW)	3.35	1.80
Total 4 Hour Energy Consumption (kWh)	13.3	14.7
Total Test Time (min.)	236	240

Wash Cycle Test: 113°F Initial Water Temperature

The second four-hour test began after the first wash test when the water had stabilized at an operating temperature of approximately 113°F. Energy and water temperature were measured.

Both models were able to maintain the operating temperature of 113°F, yet the controls of the PS 200, with it's 7 kW element, held a tighter temperature band illustrated in Figures 8 and 9.

In Figure 10 (a half-hour snapshot of Figure 9) the PS 200 demonstrates its tight thermostat tolerance. The controls for the PS 200 allow the heating element to cycle "on/off" with greater frequency and better control, thus having a temperature bandwidth of 0.2°F. The temperature bandwidth of the Maximizer was 1.0°F. In addition to holding the PS 200 temperature set point, the unit consumed only 6.6 kWh, which is 1.1 kWh less than the 7.7 kWh consumed by the Maximizer. The test results are shown in Table 3.

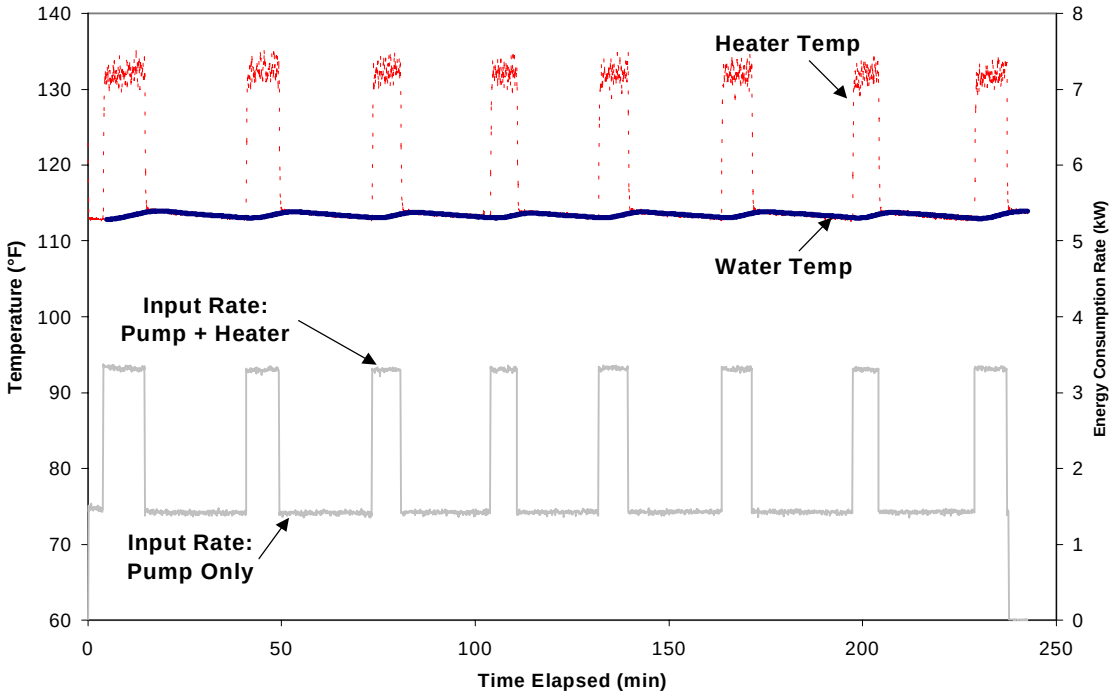

Figure 8. Power Soak Maximizer: 113°F Holding Test

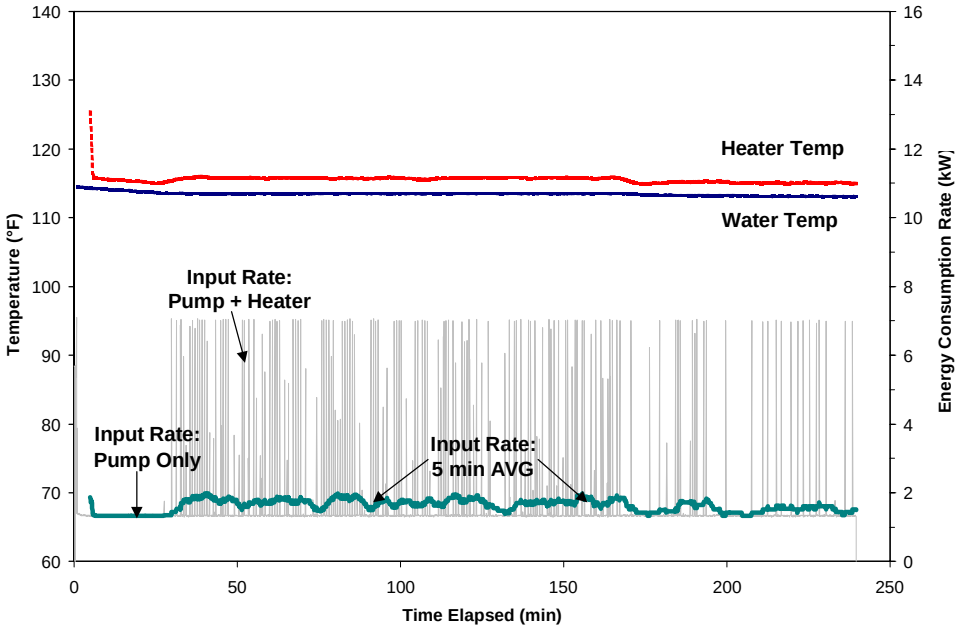

Figure 9. Power Soak PS 200: 113°F Holding Test

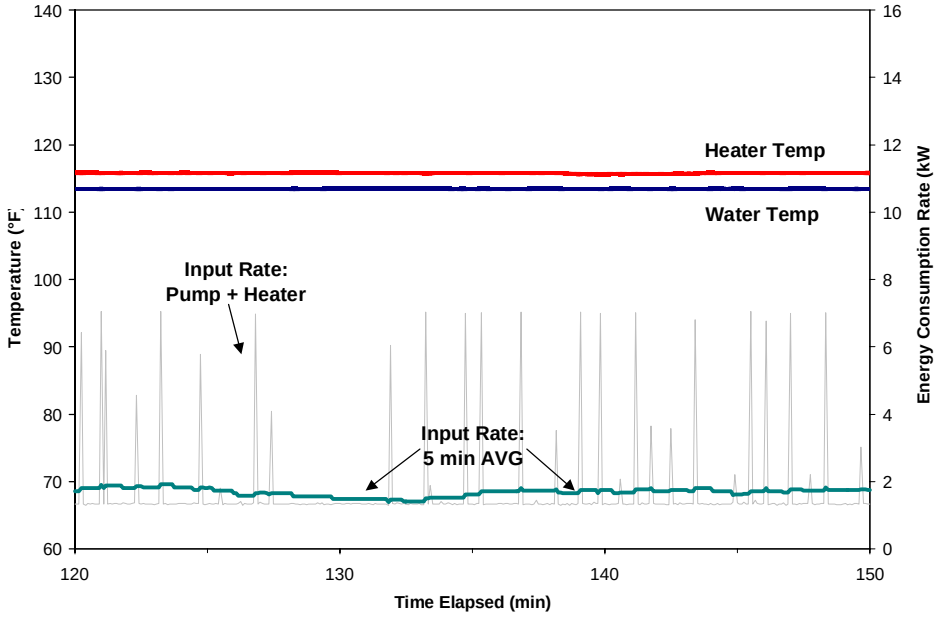

Figure 10. Power Soak PS200: 113°F Holding Test Snapshot

Table 3. Starting Water Temperature of 113°F Test Results.

	Maximizer	PS 200
Initial Water Temperature (°F)	112.8	113.0
Ending Water Temperature (°F)	114.0	114.6
Average Water Temperature (°F)	113.4	113.4
Temperature Bandwidth During Test (°F)	1.0	0.2
Pump Input Rate (kW)	1.4	1.3
Heating Input Rate (kw)	1.9	5.7
Average Input Rate (kW)	1.9	1.6
Total 4 Hour Energy Consumption (kWh)	7.7	6.6
Total Test Time (min.)	230	240

Overnight Heating Element Energy Consumption Test

The last test was an *overnight test* measuring the heating element's energy consumption. As a four-hour wash cycle is completed, the pump shuts off while the heating element remains "on" until the unit is drained, thus maintaining the unit's completed cycle's water temperature. This scenario typically occurs at the end of the night as the employees leave for the evening while a four-hour wash cycle is still in progress.

In these overnight tests, as well as the 113°F wash tests, both models tried to maintain a steady soaking temperature of 113°F. During the 400-minute test, the PS 200 consumed 7.48 kWh and the Maximizer consumed 5.22 kWh as illustrated in Figures 11 and 12. Although the PS 200 consumed more energy than the Maximizer, it successfully maintained and even increased the water temperature approximately 0.8°F throughout the entire night. However, the Maximizer was unable to maintain a constant soaking temperature as the water temperature dropped 2.8 °F.

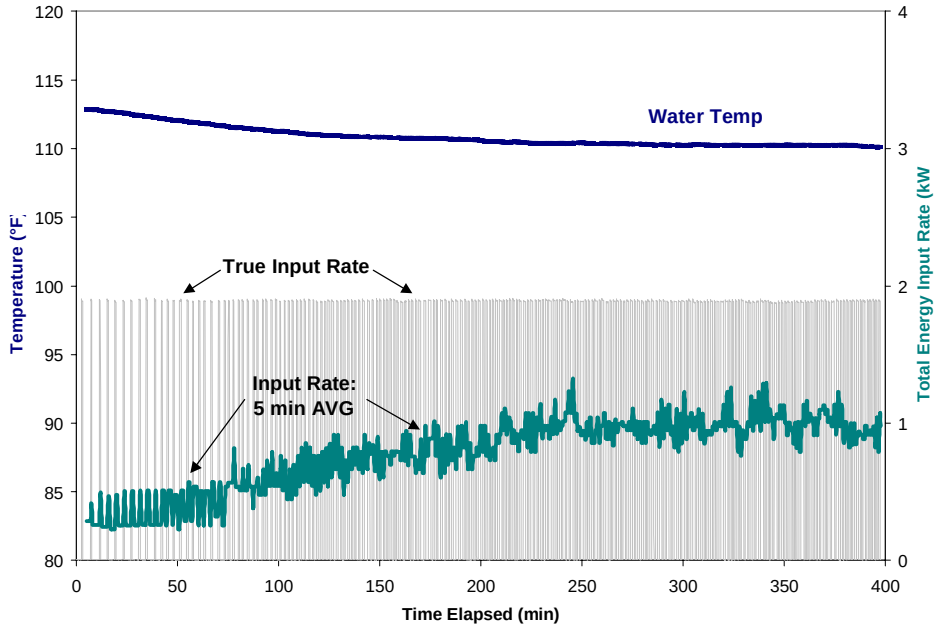

Figure 11. Power Soak Maximizer: Overnight Test

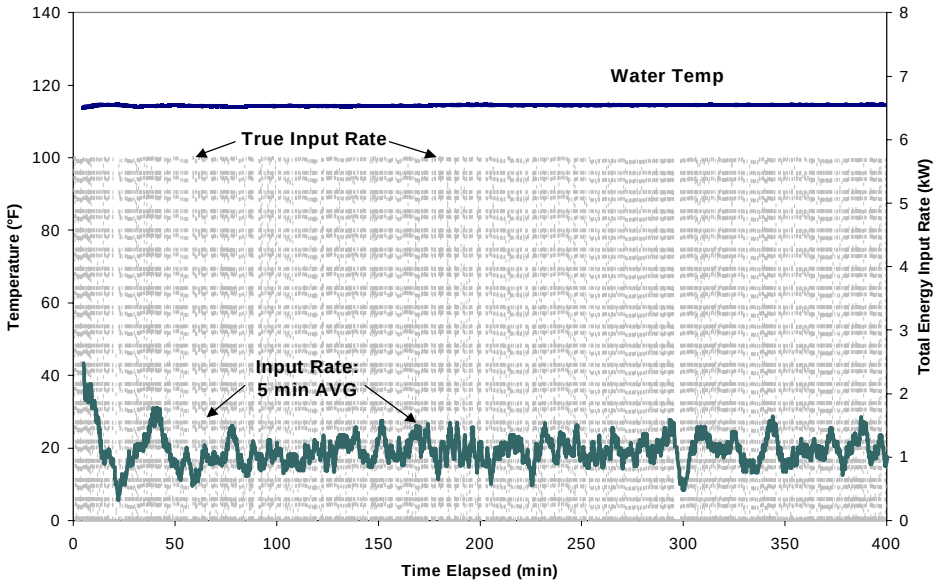

Figure 13. Power Soak PS 200: Overnight Test

Table 4. Overnight Energy Consumption Test Results

	Maximizer	PS 200
Initial Water Temperature (°F)	112.8	113.4
Ending Water Temperature (°F)	110.0	114.6
Average Water Temperature (°F)	110.9	114.4
Water Temperature Change During the Night (±°F)	- 2.8	+ 0.8
Initial Ambient Temperature (°F)	73.5	73.7
Ending Ambient Temperature (°F)	71.2	69.3
Ambient Temperature Drop During the Night (°F)	- 2.3	- 4.4
Heating Input Rate (kW)	0.78	1.15
Total Test Energy Consumption (kWh)	5.22	7.48
Total Test Time (min.)	398	398

Energy Cost Model

The test results can be used to estimate the annual energy consumption for the Power Soak models in a real-world operation. A simple cost model was developed to calculate the relationship between the various operating modes (e.g., start wash at 70°F, 113°F and leaving the machine on overnight) and the annual operating cost. For this energy and cost model, the Power Soak wash cycle was four hours, with 4 wash cycles per day, 365 days per year.

The overnight test time was estimated to be 8 hours/day. Table 5 summarizes the daily energy consumption and associated annual energy cost for the two tested Power Soaks under this scenario.

In should be noted that although the PS 200 consumed slightly more energy during the 70°F initial water temperature scenario, the operational cycle temperature is specified to be approximately 113°F by Metcraft, Inc. and McDonalds.

Table 5. Estimated Power Soak Energy Consumption and Cost.

	Maximizer	PS 200	
Energy Consumption – 4 Cycles: Initial Temp. 70°F (kWh)	53.20	58.80	
Overnight Usage – 1 Cycle (kWh)	5.22	7.48	
Total Electric Energy (kWh/day)[a]	58.42	66.28	
Annual Cost ($/year)[b]	$2,132.00	$2,419.00	
Energy Consumption – 4 Cycles: Initial Temp. 113°F (kWh)		30.80	26.40
Overnight Usage – 1 Cycle (kWh)	5.22	7.48	
Total Electric Energy (kWh/day)[a]	36.02	33.88	
Annual Cost ($/year)[b]	$1,315.00	$1,237.00	

[a] Based on 4 wash cycles per day and 1 overnight cycle.

[b] Power Soak energy costs are based on $0.10/kWh.

Conclusions and Recommendations

The Power Soak PS 200 exhibited improved temperature response and lower energy consumption rates over the Maximizer during the normal wash cycle at 113°F. The end result was a 14% decrease in energy consumption over the previous design (26.4 kWh/d vs. 30.8 kWh/d). The temperature bandwidth of the PS 200 was 0.2°F vs. 1.0°F for the Maximizer during the four-hour test period, which is a direct result of the redesigned control system.

In addition, the PS 200 was able to reach the proper operational temperature in less than half the time required by the Maximizer when the water was initially introduced at 70°F. Although the Maximizer was able to consume less energy than the PS200 during tests where the initial water temperature was 70°F, the more significant cost savings were obtained during wash cycles where the initial water temperature was 113°F. Since this scenario was the manufacturer's recommended and specified wash condition, the cost savings realized with introducing initial 113°F water will be the realistic savings seen in actual operation.

While the PS 200 consumed more energy than the Maximizer, it successfully maintained and even increased the water temperature approximately 0.8°F throughout the entire night. However, the Maximizer was unable to maintain a constant soaking temperature as the water temperature dropped 2.8 °F.

The redesigned PS 200 showed marked improvements in energy consumption, temperature control, and improved wave motion. Metcraft's further developments to the Power Soak series delivers an enhanced machine, while costing the operator less.

A Glossary

Energy Consumption Rate (kW or kBtu/h)

The average rate of energy consumption during the 4 hr. wash cycle.

Energy Input Rate (kW or kBtu/h)
Energy Consumption Rate
Energy Rate

The peak rate at which an appliance will consume energy, typically reflected during preheat.

Heatup Rate (°F/min)

The rate at which the wash tank water heats up operational set point.

Heatup Time (°F/min.)

The amount of time the appliance needs to reach its operational temperature.

Measured Input Rate (kW or Btu/h)
Measured Energy Input Rate
Measured Peak Energy Input Rate

The maximum or peak rate at which an appliance consumes energy, typically reflected during appliance preheat (i.e., the period of operation when the element is "on").

Preheat Energy (kWh or Btu)
Preheat Energy Consumption

The total amount of energy consumed by an appliance during the preheat period.

Rated Energy Input Rate
(kW, W or Btu/h, Btu/h)
Input Rating (ANSI definition)
Nameplate Energy Input Rate
Rated Input

The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

Test Method

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

Typical Day

A sampled day of average appliance usage based on observations and/or operator interviews, used to develop an energy cost model for the appliance.