Pitco SGH50 Gas Fryer
Performance Tests

Application of ASTM Standard
Test Method F 1361-99

FSTC Report 5011.02.08

Food Service Technology Center
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Specific appreciation is extended Pitco, for supplying the Food Service Technology Center with a gas fryer for controlled testing in the appliance laboratory.

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Executive Summary

Pitco's new SGH50 gas fryer is powered by four optimized atmospheric burners, each with an input rating of 20,000 Btu/h. A programmable cooking computer controls the input to the fryer and provides for a more consistent product. Figure ES-1 illustrates the SGH50 fryer, as tested at the Food Service Technology Center (FSTC).

FSTC engineers tested the fryer under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) standard test method.[1] Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, cooking energy efficiency, and production capacity.

Cooking performance was determined by cooking frozen French fries under three different loading scenarios (heavy—3 pounds per load, medium—1½ pounds per load, and light—¾ pound per load). The SGH50's heavy-load cook time was 2.42 minutes. Production capacity includes the cooking time and the time required for the frying medium to recover to 340°F (recovery time).

Cooking energy efficiency is a measure of how much of the energy that an appliance consumes is actually delivered to the food product during the cooking process. Cooking energy efficiency is therefore defined by the following relationship:

$$\text{Cooking Energy Efficiency} = \frac{\text{Energy to Food}}{\text{Energy to Appliance}}$$

[1] American Society for Testing and Materials. 2000. *Standard Test Method for the Performance of Open, Deep Fat Fryers.* ASTM Designation F 1361-99, in *Annual Book of ASTM Standards,* Philadelphia.

Executive Summary

A summary of the test results is presented in Table ES-1.

Figure ES-1.
Pitco SGH50 Fryer.

Table ES-1. Summary of Fryer Performance.

Rated Energy Input Rate (Btu/h)	80,000
Measured Energy Input Rate (Btu/h)	78,117
Preheat Time to 350°F (min)	8.25
Preheat Energy to 350°F (Btu)	10,275
Idle Energy Rate @ 350°F (Btu/h)	8,510
Cooking Energy Efficiency	
Heavy-Load (%)	54.0 ± 1.2 [a]
Medium-Load (%)	46.1 ± 2.1 [a]
Light-Load (%)	36.8 ± 2.8 [a]
Production Capacity (lb/h) [b]	67.0 ± 0.8 [a]
Average Frying Medium Recovery Time (sec) [b]	16.2

[a]This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.
[b]Based on the heavy-load cooking test with a minimum 10-second preparation time between loads.

Figure ES-2 illustrates the relationship between cooking energy efficiency and production rate for the fryer. Figure ES-3 illustrates the relationship between the fryer's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the daily energy consumption for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds per hour for the SGH50 fryer are 18,950 Btu/h, 37,350 Btu/h, and 55,750 Btu/h respectively.

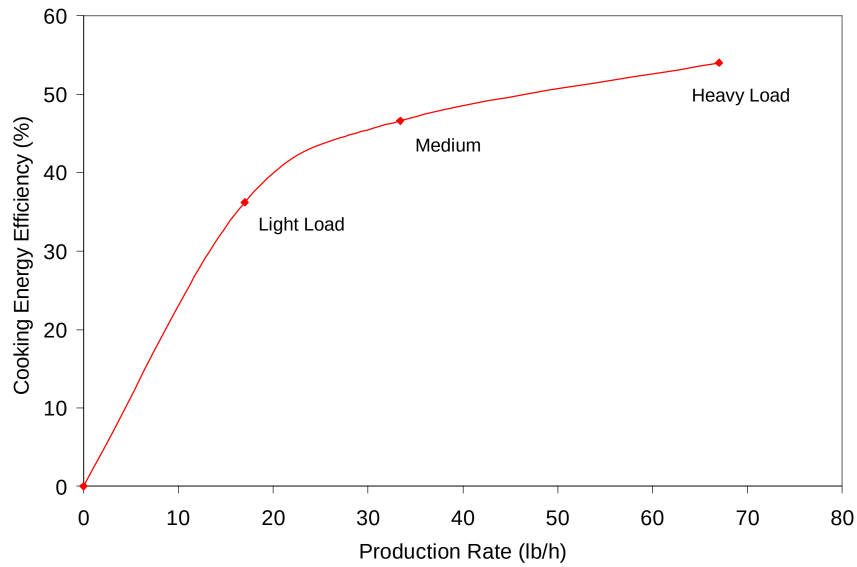

Figure ES-2.

Fryer part-load cooking energy efficiency.

Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

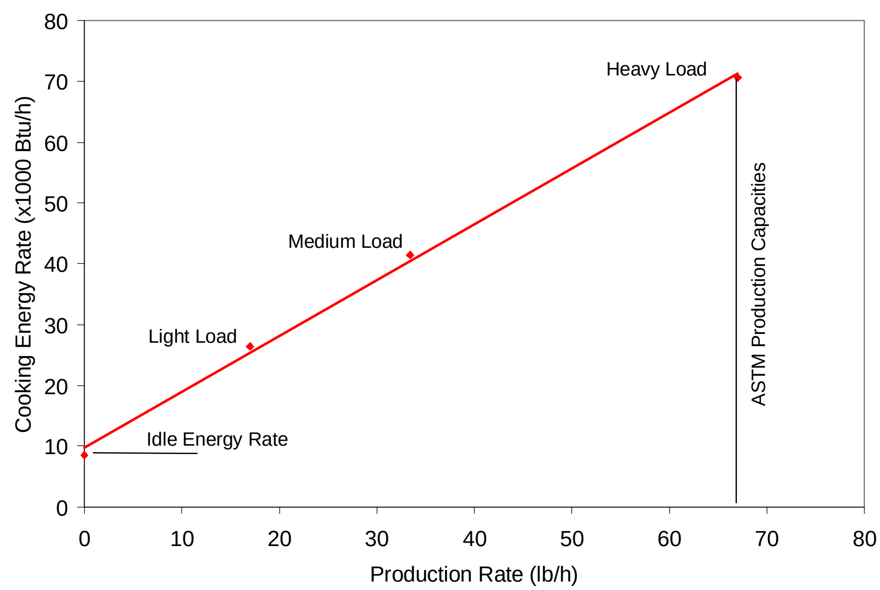

Figure ES-3.

Fryer cooking energy consumption profile.

Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

Executive Summary

Pitco's SGH50 gas fryer exhibited excellent performance for a gas fryer, with a heavy-load cooking energy efficiency of 54% and a production capacity of 67.0 lb/h. In fact, this atmospheric burner SGH50 fryer outperformed other "high-efficiency" gas fryers tested at the FSTC. Its 67 lb/h production capacity was 17% higher than the infrared burner (IR) fryer and its cooking energy efficiency improved on the industry standard IR fryer by 8%.[2] Additionally, the SGH50's idle rate was lower than most gas atmospheric fryers at 8,508 Btu/h, and its preheat time was a very fast 8.25 minutes.

Most food service establishments cook under partial load conditions and medium and light loads are more representative of real world application. The SGH50 fryer posted medium- and light-load cooking energy efficiencies (46.0 % and 36.8 %) and production rates (33.4 lb/h and 17.0) that matched those from the infrared fryer.

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[2] Pacific Gas and Electric Company. 1991. *Development and Application of a Uniform Testing Procedure for Open, Deep Fat Fryers.* Report 008.1-90.22 prepared for Research and Development. San Ramon, California: Pacific Gas and Electric Company.

1 Introduction

Background

Fried foods continue to be popular on the restaurant scene. French fried potatoes are still the most common deep fried food, along with onion rings, chicken and fish. Recent advances in equipment design have produced fryers that operate more efficiently, quickly, safely and conveniently.

Dedicated to the advancement of the food service industry, the 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.

Since the development of the ASTM test method for fryers in 1991, the FSTC has tested a wide range of gas and electric fryers.[2,3,4,5,6,7,8,9,10,11,12]

Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, pilot energy consumption rate, cooking energy efficiency and production capacity.

Introduction

Pitco's SGH50 gas fryer was designed to perform on the same level with advanced fryer designs without requiring the maintenance costs associated with an infrared, powered or forced induction burner designs. The SGH50 gas fryer features four atmospheric burners routed from front to back, a stainless steel frypot and backsplash, and a programmable frying computer. An integrated melt cycle prevents solid frying medium from scorching during preheat.

This report presents the results of applying the ASTM test method to the Pitco SGH50 gas fryer. The glossary in Appendix A is provided so that the reader has a quick reference to the terms used in this report.

Objectives

The objective of this report is to examine the operation and performance of Pitco's SGH50, 14-inch gas fryer at an input rating of 80,000 Btu/h, under the controlled conditions of the ASTM standard test method. The scope of this testing is as follows:

1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the appliance from room temperature to 350°F.
3. Characterize the idle energy use with the thermostat set at a calibrated 350°F.
4. Document the cooking energy consumption and efficiency under three French fry loading scenarios: heavy (3 pounds per load), medium (1 ½ pounds per load), and light (¾ pound per load).
5. Determine the production capacity and frying medium temperature recovery time during the heavy-load test.

Appliance Description

Pitco's SGH50, 14-inch gas fryer has a power rating of 80,000 Btu/h. The fry pot contains four tubes running from front to back each housing an atmospheric burner with the flue gasses routed out the back (see Figure 1-1).

Appliance specifications are listed in Table 1-1, and the manufacturer's literature is in Appendix B.

Figure 1-1.
Pitco SGH50 Frypot.

Table 1-1. Appliance Specifications.

Manufacturer	Pitco
Model	SGH50
Generic Appliance Type	Open Deep Fat Fryer
Rated Input	80,000 Btu/h
Oil Capacity	50 lb
Frying Area	14" x 14"
Controls	Programmable cooking computer
Construction	Stainless Steel

2 Methods

Setup and Instrumentation

FSTC researchers installed the fryers on a tiled floor under a 4-foot-deep canopy hood that was 6 feet, 6 inches above the floor. The hood operated at a nominal exhaust rate of 300 cfm per linear foot of hood. There was at least 6 inches of clearance between the vertical plane of the fryers and the edge of the hood. All test apparatus were installed in accordance with Section 9 of the ASTM test method.[1] See Figure 2-1.

Researchers instrumented the fryer with thermocouples to measure temperatures in the cold and the cooking zones and at the thermostat bulb. Two thermocouples were placed in the cook zone, one in the geometric center of the frypot, approximately 1 inch above the fry basket support, and the other at the tip of the thermostat bulb. The cold zone thermocouple was supported from above, independent of the frypot surface, so that the temperature of the cold zone reflected the frying medium temperature, not the frypot's surface

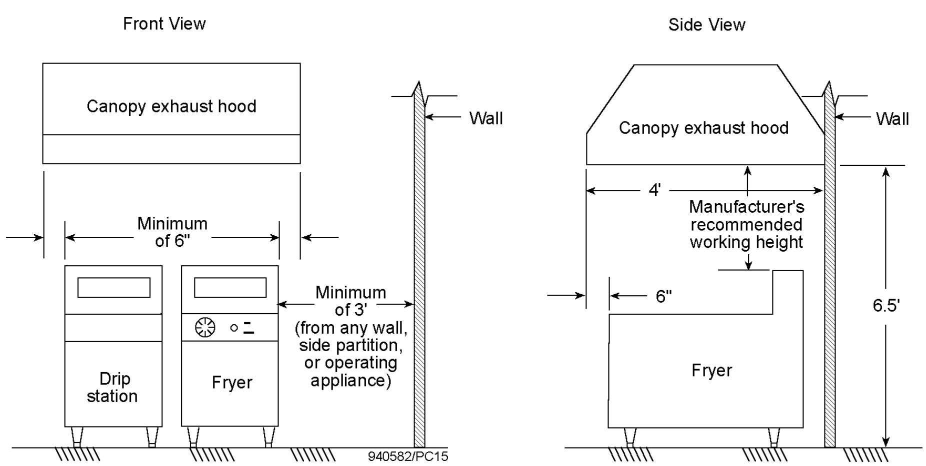

Figure 2-1.
Equipment configuration.

temperature. The cold zone temperature was measured toward the rear of the frypot, 1/8-inch from the bottom of the pot. See Figure 2-2.

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft^3. The gas meter and the thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds. A chemical laboratory used a gas chromatograph to determine the gas heating value on each day of testing. All gas measurements were corrected to standard conditions.

The fryer was filled with Melfry Brand, partially hydrogenated, 100% pure vegetable oil for all tests except the energy input rate determination test. This test required the fryer to be filled with water to inhibit burner cycling during the test.

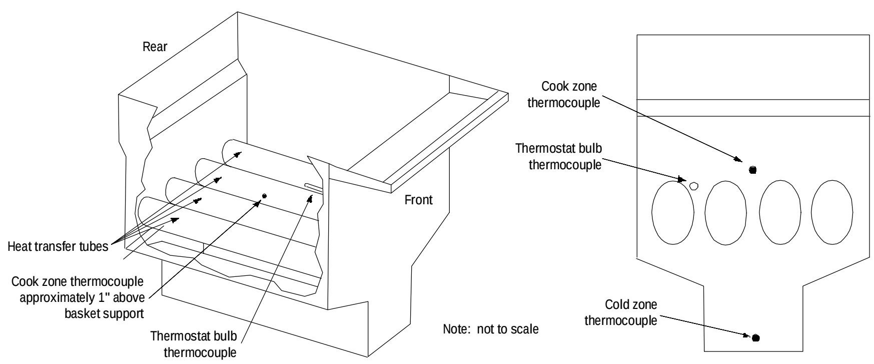

Figure 2-2. Thermocouple placement for testing.

Measured Energy Input Rate

Rated energy input rate is the maximum or peak rate at which the fryer consumes energy—as specified on the fryer's nameplate. Measured energy input rate is the maximum or peak rate of energy consumption, which is recorded during a period when the burners are operating (such as preheat). For the purpose of this test, the fryer was filled with water to the frypot's indicated fill-line. The controls were set to attain maximum output and the energy consumption was monitored for a period of 15 minutes after a full rolling boil had been established. Researchers compared the measured energy input rate with the nameplate energy input rate to ensure that the fryer was operating properly.

Cooking Tests

Researchers specified Simplot® brand ¼-inch blue ribbon product, par-cooked, frozen shoestring potatoes for all cooking tests. Each load of French fries was cooked to a 30% weight loss. The cooking tests involved "barreling" six loads of frozen French fries, using fry medium temperature as a basis for recovery. Each test was followed by a 10-minute wait period and was then repeated two more times. Researchers tested the fryer using 3-pound (heavy), 1 ½-pound (medium), and ¾-pound (light) French fry loads.

Due to the logistics involved in removing one load of cooked French fries and placing another load into the fryer, a minimum preparation time of 10 seconds was incorporated into the cooking procedure. This ensures that the cooking tests are uniformly applied from laboratory to laboratory. Fryer recovery was then based on the frying medium reaching a threshold temperature of 340°F (measured at the center of the cook zone). Reloading within 10°F of the 350°F thermostat set point does not significantly lower the average oil temperature over the cooking cycle, nor does it extend the cook time. The fryer was re-loaded either after the cook zone thermocouple reached the threshold temperature or 10 seconds after removing the previous load from the fryer, whichever was longer.

The first load of each six-load cooking test was designated a stabilization load and was not counted when calculating the elapsed time and energy used. Energy monitoring and elapsed time of the test were determined after the second load contacted the frying medium. After removing the last load and allowing the fryer to recover, researchers terminated the test. Total elapsed time, energy consumption, weight of fries cooked, and average weight loss of the French fries were recorded for the last five loads of the six-load test.

Cooking tests were run in the following sequence: three replicates of the heavy-load test, followed by three replicates of the medium-load test, followed by three replicates of the light-load test. This procedure ensured that the reported cooking energy efficiency and production capacity results had an uncertainty of less than ±10%. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results.

The ASTM results reporting sheets appear in Appendix C.

3 Results

Energy Input Rate

Prior to testing, the energy input rate was measured and compared with the manufacturer's nameplate value. This procedure ensured that the fryer was operating within its specified parameters. The energy input rate was 78,120 Btu/h (a difference of 2.4% from the nameplate rating).

Preheat and Idle Tests

These tests show how the fryer uses energy when it is not cooking food. The preheat time allows an operator to know precisely how long it takes for the fryer to be ready to cook. The idle energy rate represents the energy required to maintain the set temperature, or the appliance's stand-by losses.

Preheat Energy and Time

Researchers filled the fryer with new oil, which was then heated to 350°F at least once prior to any testing. The preheat tests were conducted at the beginning of a test day, after the oil had stabilized at room temperature overnight. Pitco's cooking computer has an integrated melt cycle to prevent scorching of solid shortening, but was turned off due to the use of liquid shortening used in the ASTM test procedure. Pitco's SGH50 fryer was ready to cook in 8.25 minutes. Figure 3-1 shows the preheat characteristics.

Idle Energy Rate

Once the frying medium reached 350°F, the fryer was allowed to stabilize for half an hour. Time and energy consumption was monitored for an additional two-hour period as each fryer maintained the oil at 350°F. The idle energy rate during this period was 8,510 Btu/h.

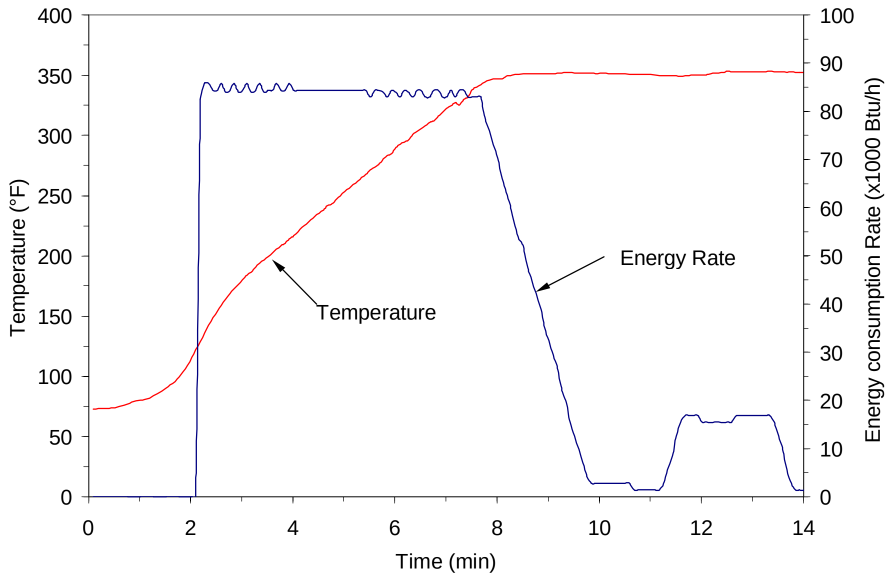

Figure 3-1.
Pitco SGH50 preheat characteristics.

Test Results

Input, preheat, and idle test results are summarized in Table 3-1.

Table 3-1. Input, Preheat, and Idle Test Results.

Rated Energy Input Rate (Btu/h)	80,000
Measured Energy Input Rate (Btu/h)	78,120
Preheat	
Time to 350°F (min)[a]	8.25
Energy (Btu)	10,275
Electric Energy Rate (Wh)	2.86
Rate to 350°F (°F/min)	33.7
Idle Energy Rate @ 350°F (Btu/h)	8,510
Idle Electric Energy Rate (W)	15.1

Cooking Tests

The fryers were tested under three loading scenarios: heavy (3 pounds of fries per load), medium (1 ½ pounds of fries per load) and light (¾ pound of fries per load). The fries used for the cooking tests consisted of approximately 6% fat and 66% moisture, as specified by the ASTM procedure. Researchers monitored French fry cook time and weight loss, frying medium recovery time, and fryer energy consumption during these tests.

Heavy-Load Tests

The heavy-load cooking tests were designed to reflect a fryer's maximum performance. The fryers were used to cook six 3-pound loads of frozen French fries—one load after the other in rapid succession, similar to a batch-cooking procedure. Figures 3-2 shows the average temperature of the frying medium and cold zone during the heavy-load tests.

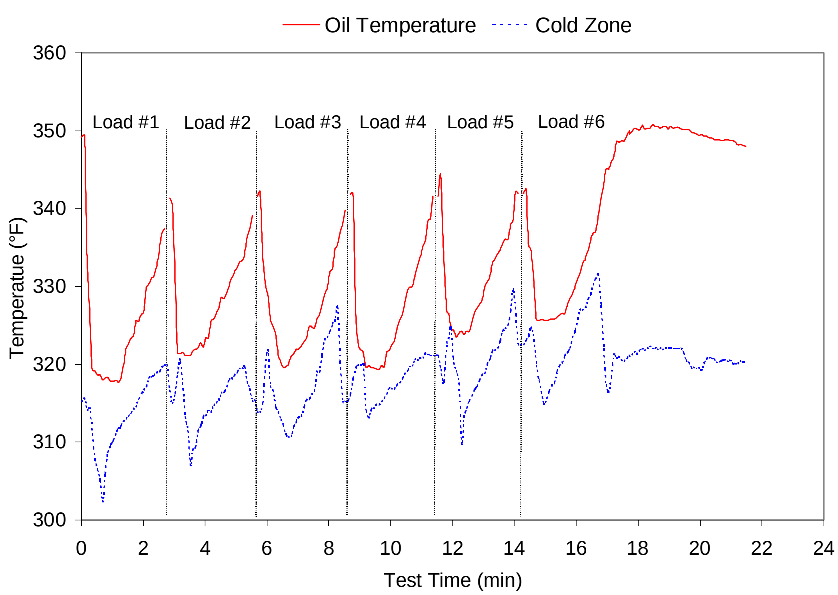

Figure 3-2. Frying medium temperarture during a heavy load test for the SGH50 fryer

The first load was used to stabilize the fryer, and the remaining five loads were used to calculate cooking energy efficiency and production capacity. The average frying medium and cold zone temperatures during the heavy-load test were 329°F and 317°F, respectively. The heavy load cook time for the fryer was 2.42 minutes with a recovery time of 16 seconds. Figure 3-3 illustrates the temperature response of the SGH50 fryer while cooking a 3-pound load of frozen French fries. Production capacity includes the time required to remove the cooked fries and reload the fryer with a new batch of frozen fries (approximately 10 seconds per load).

Figure 3-3.
Fryer cooking cycle temperature signature.

Medium and Light-Load Tests

Medium- and light-load tests represent a more typical usage pattern for a fryer in cook-to-order applications. Since a fryer is often used to cook single basket loads in many food service establishments, these part-load efficiencies can be used to estimate the fryer's performance in an actual operation.

Both the medium- and light-load tests were conducted using a single fry basket. The medium-load tests used 1½ pounds of fries per load and the light load tests used ¾ pounds of fries per load. Cooking energy efficiencies at 33.4 (medium) and 17.0 (light) pounds per hour were 46.0% and 36.8%, respectively.

Test Results

Energy imparted to the French fries was calculated by separating the various components of the fries (water, fat, and solids) and determining the amount of heat gained by each component (Appendix D). The fryer's cooking energy efficiency for a given loading scenario is the amount of energy imparted to the fries, expressed as a percentage of the amount of energy consumed by the fryer during the cooking process.

Heavy-load cooking energy efficiency results were 53.8%, 53.8%, 54.6%, yielding a maximum uncertainty of 2.1%. Table 3-2 summarizes the results of the ASTM cooking energy efficiency and production capacity tests.

Table 3-2. Cooking Energy Efficiency and Production Capacity.

	Light Load	*Medium Load*	*Heavy Load*
Load Size (lb)	¾	1 ½	3.0
French Fry Cook Time (min)	2.40	2.41	2.42
Average Recovery Time (sec)	14.4	17.4	16.2
Production Rate (lb/h)	17.0 ± 0.3	33.4 ± 1.1	67.0 ± 0.8
Energy Consumption (Btu/lb)	1,553	1,243	1,056
Cooking Energy Rate (Btu/h)	26,410	41,428	70,653
Electric Energy Rate (W)	17	18	20
Cooking Energy Efficiency (%)	36.8 ± 2.8	46.6 ± 2.1	54.0 ± 1.2

Figure 3-4 illustrates the relationship between cooking energy efficiency and production rate for this fryer. Fryer production rate is a function of both the French fry cook time and the frying medium recovery time. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

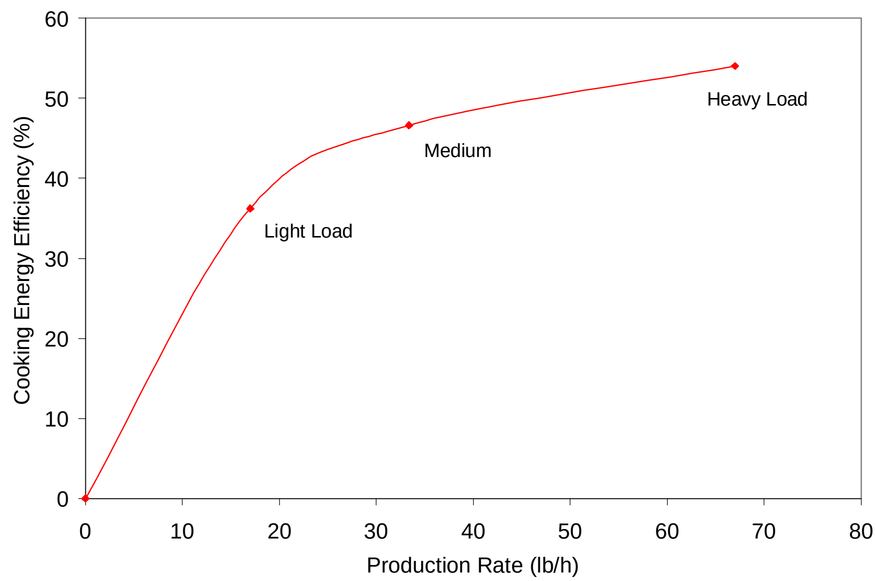

Figure 3-4.
Fryer part-load cooking energy efficiency.

Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

Figure 3-5 illustrates the relationship between the fryer's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the daily energy consumption for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds per hour for the stock model were 18,950 Btu/h, 37,350 Btu/h, and 55,750 Btu/h, respectively. For an operation cooking an average of 15 pounds of food per hour over the course of the day (e.g., 150 lb of food over a ten hour day), the average daily energy consumption for the SGH50 fryer would be 23,550 Btu/h.

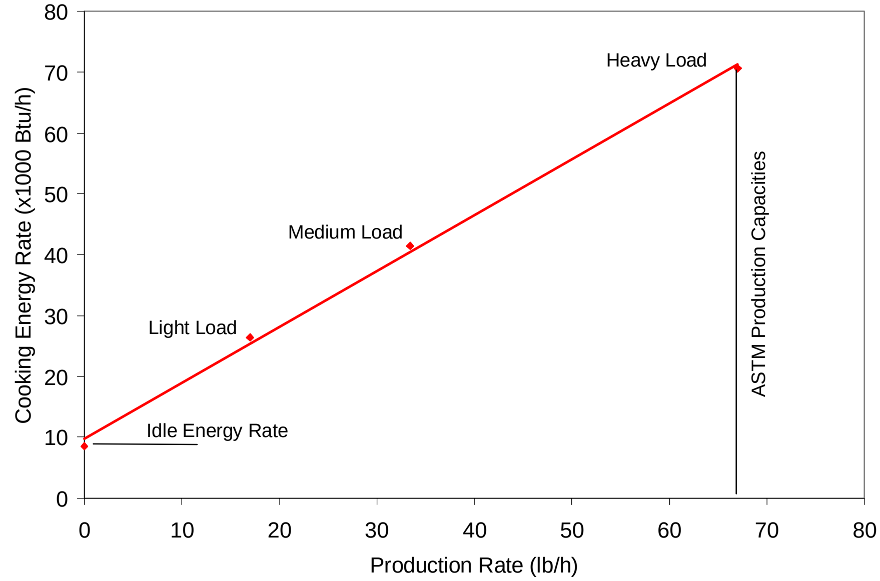

Figure 3-5.
Fryer cooking energy consumption profile.

Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

4 Conclusions

Pitco's newly designed SGH50 gas fryer redefines the performance limits for an atmospheric burner fryer. The fryer demonstrated cooking energy efficiencies and production capacities that were previously seen only in high-end infrared burner fryers. With improved heat transfer between the burners and the frying medium, the SGH50 was able to cook a heavy load (3 pounds) of French fries in a very quick 2.42 minutes and was ready to cook another load within 16 seconds.

Its 67 lb/h production capacity was 17% higher than previously-tested infrared burner (IR) fryers and its cooking energy efficiency improved on the industry standard IR fryer by 8%.[2,6] These figures rank the SGH50 fryer among the top fryers tested to date at the Food Service Technology Center.

The SGH50's engineered burner and heat exchanger package was very effective in transferring heat to the frying medium. The fryer's 8¼-minute preheat was the quickest among 14-inch fryers and it exhibited substantially lower standby (idle) losses than typical for a normally aspirated burner system. While the fryer's idle rate was somewhat higher than other high–end fryers, it was about half that of other atmospheric burner fryers (8,508 Btu/h vs. 15,000 Btu/h).[2, 6,8,9,10,11]

This competitive idle rate translated to good part-load performance. Under medium and light-load conditions, the SGH50 fryer posted comparable efficiencies to other top performing fryers (46.6% vs. 46.0% medium-load efficiency, and 36.8 % vs. 37.0% light-load efficiency). Since most food service establishments operate at an average of 15 pounds per hour over a typical day, these performance figures are more representative of real world application.

The SGH50 fryer's remarkable performance and more simple design than the AG14 [12] offer operators the best of both worlds: a high performance fryer without the higher maintenance cost typically associated with advanced fryer designs. With its high productivity and energy efficient design, this fryer would be a good match for any operation.

5 References

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A Glossary

Cooking Energy (kWh or kBtu)

The total energy consumed by an appliance as it is used to cook a specified food product.

Cooking Energy Consumption Rate (kW or kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking Energy Efficiency (%)

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy-, medium-, and light-load tests.

Duty Cycle (%)
Load Factor

The average energy consumption rate (based on a specified operating period for the appliance) expressed as a percentage of the measured energy input rate.

$$\text{Duty Cycle} = \frac{\text{Average Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

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.

Heating Value (Btu/ft^3)
Heating Content

The quantity of heat (energy) generated by the combustion of fuel. For natural gas, this quantity varies depending on the constituents of the gas.

Idle Energy Rate (kW or Btu/h)
Idle Energy Input Rate
Idle Rate

The rate of appliance energy consumption while it is "idling" or "holding" at a stabilized operating condition or temperature.

Idle Temperature (°F, Setting)

The temperature of the cooking cavity/surface (selected by the appliance operator or specified for a controlled test) that is maintained by the appliance under an idle condition.

Idle Duty Cycle (%)
Idle Energy Factor

The idle energy consumption rate expressed as a percentage of the measured energy input rate.

$$\text{Idle Duty Cycle} = \frac{\text{Idle Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

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 all burners or elements are "on").

Pilot Energy Rate (kBtu/h)
Pilot Energy Consumption Rate

The rate of energy consumption by the standing or constant pilot while the appliance is not being operated (i.e., when the thermostats or control knobs have been turned off by the food service operator).

Preheat Energy (kWh or Btu)
Preheat Energy Consumption

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

Preheat Rate (°F/min)

The rate at which the cook zone heats during a preheat.

Preheat Time (minute)
Preheat Period

The time required for an appliance to "preheat" from the ambient room temperature (75 ± 5°F) to a specified (and calibrated) operating temperature or thermostat set point.

Production Capacity (lb/h)

The maximum production rate of an appliance while cooking a specified food product in accordance with the heavy-load cooking test.

Production Rate (lb/h)
Productivity

The average rate at which an appliance brings a specified food product to a specified "cooked" condition.

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.

Recovery Time (minute, second)

The average time from the removal of the fry baskets from the fryer until the frying medium is within 10°F of the thermostat set point and the fryer is ready to be reloaded.

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.

B Appliance Specifications

Appendix B includes the product literature for the Pitco SGH50 fryer.

C Results Reporting Sheets

Manufacturer:	Pitco
Models:	SGH50
Date:	April 2002

Test Fryers and Burners

Description of operational characteristics: Pitco's SGH50 gas fryer is rated at 80,000 Btu/h and features a programmable cooking computer that controls four atmospheric burners, running from front to back. The frypot and backsplash are made of stainless steel.

Apparatus

__√__ Check if testing apparatus conformed to specifications in section 6.

Deviations: None.

Energy Input Rate

Gas Heating Value (Btu/scf)	1017
Name Plate (Btu/h)	80,000
Measured (Btu/h)	78,117
Percentage Difference (%)	2.35

Thermostat Calibration

Thermostat Setting (°F)	350
Oil Temperature (°F)	350

Results Reporting Sheets

Preheat Energy and Time

Gas Heating Value (Btu/scf)	1018
Starting Temperature (°F)	72
Energy Consumption (Btu)	10,275
Electric Energy Rate (Wh)	2.86
Duration (min)	8.25
Preheat Rate (°F/min)	33.7

Idle Energy Rate

Gas Heating Value (Btu/scf)	1018
Idle Energy Rate @ 350 °F (Btu/h)	8,508
Electric Energy Rate (W)	15.1

Heavy Load Cooking Energy Efficiency and Cooking Energy Rate

Gas Heating Value (Btu/scf)	1018
Load Size (lb)	3.00
French Fry Cook Time (min)	2.42
Average Recovery Time (sec)	16.2
Production Rate (lb/h)	67.0 ± 0.8
Energy to Food (Btu/lb)	570
Cooking Energy Rate (Btu/h)	70,653
Electric Energy Rate (W)	20
Energy per Pound of Food Cooked (Btu/lb)	1,056
Cooking Energy Efficiency (%)	54.0 ± 1.2

Results Reporting Sheets

Medium Load Cooking Energy Efficiency and Cooking Energy Rate

Gas Heating Value (Btu/scf)	1016
Load Size (pounds)	1.5
French Fry Cook Time (min)	2.41
Average Recovery Time (sec)	17.4
Production Rate (lb/h)	33.4 ± 1.1
Energy to Food (Btu/lb)	572
Cooking Energy Rate (Btu/h)	41,428
Electric Energy Rate (W)	18
Energy per Pound of Food Cooked (Btu/lb)	1,243
Cooking Energy Efficiency (%)	46.6 ± 2.1

Light Load Cooking Energy Efficiency and Cooking Energy Rate

Gas Heating Value (Btu/scf)	1016
Load Size (pounds)	¾
French Fry Cook Time (min)	2.40
Average Recovery Time (sec)	14.4
Production Rate (lb/h)	17.0 ± 0.3
Energy to Food (Btu/lb)	570
Cooking Energy Rate (Btu/h)	26,410
Electric Energy Rate (W)	17
Energy per Pound of Food Cooked (Btu/lb)	1,553
Cooking Energy Efficiency (%)	36.2 ± 2.8

D Cooking Energy Efficiency Data

Table D-1. Specific Heat and Latent Heat.

Specific Heat (Btu/lb, °F)	
Ice	0.500
Fat	0.400
Solids	0.200
Frozen French Fries	0.695
Latent Heat (Btu/lb)	
Fusion, Water	144
Fusion, Fat	44
Vaporization, Water	970

Cooking Energy Efficiency Data

Table D-2. Heavy-Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electric Energy Consumption (Wh)	4.56	4.61	4.59
Gas Energy (Btu)	16,032	15,823	15,600
Cook Time (min)	2.42	2.42	2.42
Total Test Time (min)	13.4	13.5	13.4
Weight Loss (%)	29.83	29.09	29.69
Initial Weight (lb)	15.000	15.000	15.000
Final Weight (lb)	10.570	10.637	10.546
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	65.2	65.2	65.2
Final Moisture Content (%)	43.8	44.5	44.4
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	9.780	9.780	9.780
Final Weight of Water (lb)	4.630	4.733	4.682
Sensible (Btu)	2,210	2,210	2,210
Latent - Heat of Fusion (Btu)	1,407	1,407	1,407
Latent - Heat of Vaporization (Btu)	5,011	4,897	4,904
Total Energy to Food (Btu)	8,629	8,514	8,521
Energy to Food (Btu/lb)	575	568	568
Total Energy to Fryer	16,063	15,854	15,631
Energy to Fryer (Btu/lb)	1,070	1,056	1,041
Cooking Energy Efficiency (%)	53.8	53.8	54.6
Cooking Energy Rate (Btu/h)	71,891	70,271	69,757
Electric Energy Rate (W)	20.5	20.5	20.5
Production Rate (lb/h)	67.3	66.6	67.1
Average Recovery Time (sec)	15.6	16.8	15.6

Cooking Energy Efficiency Data

Table D-3. Medium-Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electric Energy Consumption (Wh)	4.03	4.08	4.18
Total Energy (Btu)	9,256	9,196	9,485
Cook Time (min)	2.39	2.42	2.42
Total Test Time (min)	13.3	13.5	13.7
Weight Loss (%)	29.82	29.69	29.75
Initial Weight (lb)	7.500	7.500	7.500
Final Weight (lb)	5.264	5.274	5.269
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	65.2	65.2	65.2
Final Moisture Content (%)	42.2	43.8	43.2
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	4.890	4.890	4.890
Final Weight of Water (lb)	2.221	2.310	2.276
Sensible (Btu)	1,105	1,105	1,105
Latent - Heat of Fusion (Btu)	704	704	704
Latent - Heat of Vaporization (Btu)	2,586	2,501	2,533
Total Energy to Food (Btu)	4,394	4,310	4,342
Energy to Food (Btu/lb)	586	575	579
Total Energy to Fryer	9,283	9,224	9,513
Energy to Fryer (Btu/lb)	1,236	1,228	1,267
Cooking Energy Efficiency (%)	47.4	46.8	45.7
Cooking Energy Rate (Btu/h)	41,693	41,022	41,569
Electric Energy Rate (W)	18.2	18.2	18.3
Production Rate (lb/h)	33.8	33.5	32.9
Average Recovery Time (sec)	16.8	16.2	19.2

Cooking Energy Efficiency Data

Table D-4. Light Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electric Energy Consumption (Wh)	3.80	3.74	3.77
Total Energy (Btu)	5,683	5,779	5,971
Cook Time (min)	2.37	2.42	2.42
Total Test Time (min)	13.3	13.2	13.1
Weight Loss (%)	29.68	29.71	29.97
Initial Weight (lb)	3.750	3.750	3.750
Final Weight (lb)	2.637	2.636	2.626
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	65.2	65.2	65.2
Final Moisture Content (%)	45.4	46.0	45.6
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	2.445	2.445	2.445
Final Weight of Water (lb)	1.197	1.213	1.198
Sensible (Btu)	564	559	564
Latent - Heat of Fusion (Btu)	352	352	352
Latent - Heat of Vaporization (Btu)	1,210	1,193	1,209
Total Energy to Food (Btu)	2,114	2,097	2,113
Energy to Food (Btu/lb)	564	559	564
Total Energy to Fryer	5,708	5,804	5,997
Energy to Fryer (Btu/lb)	1,519	1,544	1,596
Cooking Energy Efficiency (%)	37.1	36.2	35.3
Cooking Energy Rate (Btu/h)	25,616	26,347	27,267
Electric Energy Rate (W)	17.1	17.0	17.2
Production Rate (lb/h)	16.9	17.1	17.1
Average Recovery Time (sec)	17.4	12.6	12.6

Cooking Energy Efficiency Data

Table D-8. Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency			Production Capacity
	Heavy Load	Medium Load	Light Load	
Replicate #1	53.8	47.4	37.1	67.3
Replicate #2	53.8	46.8	36.2	66.6
Replicate #3	54.6	45.7	35.3	67.1
Average	54.0	46.6	36.2	67.0
Standard Deviation	0.5	0.9	0.9	0.3
Absolute Uncertainty	1.2	2.1	2.2	0.8
Percent Uncertainty	2.1	4.6	6.2	1.3