

AGA Food Service Equipment, Model Infinity G2842 Gas Fryer Performance Tests

Application of ASTM Standard
Test Method F 1361-99

FSTC Report 5011.04.12

**Food Service Technology Center
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Executive Summary

AGA Food Service Equipment's new model gas fryer, the Infinity G2842 uses a powered pre-mix burner and patented heat exchanger design to heat a 29.5 lb oil capacity fry vat. Figure ES-1 illustrates the Infinity G2842 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 cook times for the three loading scenarios were 2.67 minute for the heavy-load tests, 2.35 minutes for the medium-load tests and 2.17 minutes for the light-load tests. 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.

Table ES-1. Summary of Fryer Performance



Rated Energy Input Rate (Btu/h)	75,000
Measured Energy Input Rate (Btu/h)	73,470
Preheat Time to 350°F (min)	9.2
Preheat Energy to 350°F (Btu)	10,660
Idle Energy Rate @ 350°F (Btu/h)	4,010
Heavy-Load Cooking-Energy Efficiency (%)	57.7 ± 3.3
Medium-Load Cooking-Energy Efficiency (%)	54.1 ± 3.1
Light-Load Cooking-Energy Efficiency (%)	44.4 ± 2.6
Production Capacity (lb/h) ^a	63.6 ± 2.2
Average Frying Medium Recovery Time (sec) ^b	<10

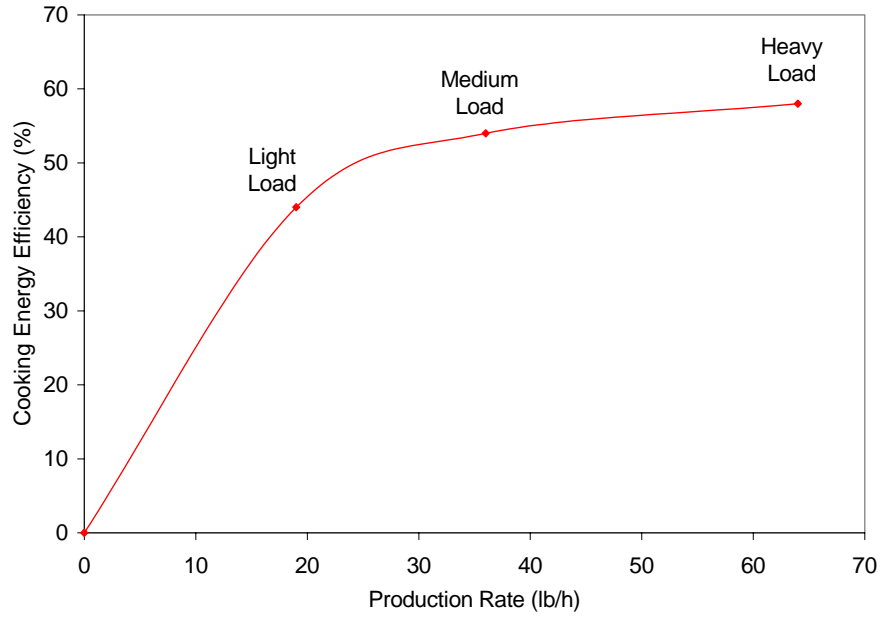
^a This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

^b Based on the heavy-load cooking test with a minimum 10-second preparation time between loads.

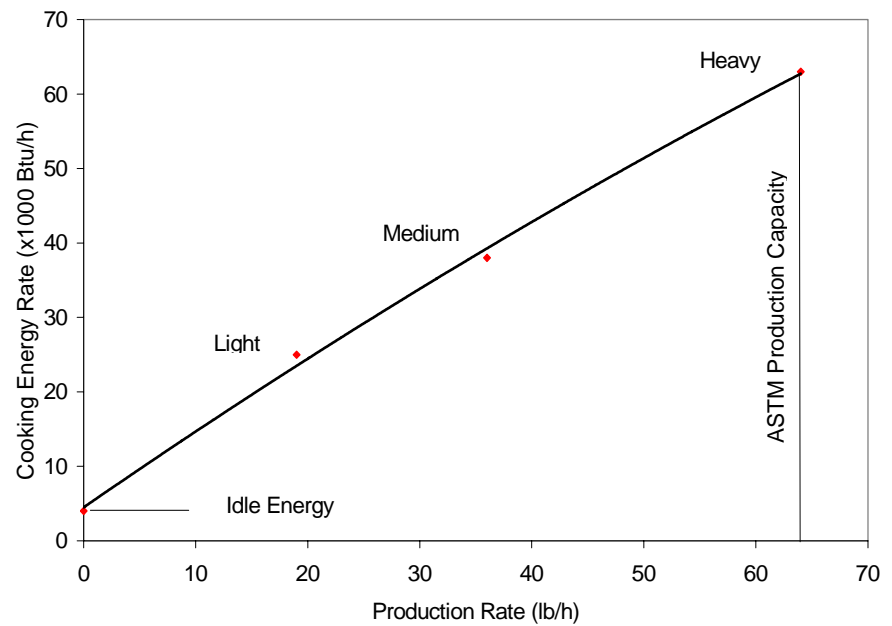
Figure ES-2 illustrates the relationship between cooking-energy efficiency and production rate for the fryer. Figure ES-3 illustrates the relationship between the fryer's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the daily energy consumption for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds per hour for the Infinity G2842 fryer are 14,760 Btu/h, 35,120 Btu/h, and 53,810 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 12 hour day), the average daily energy consumption for the G2840F fryer would be 20,000 Btu/h.

Executive Summary

*Figure ES-2.
Fryer part-load cooking-
energy efficiency.*



*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

The AGA Food Service Equipment, model Infinity G2842, powered, pre-mix burner efficiently transfers energy to its relatively small 29.5 lb fry vat. The fryer's innovative design achieved high cooking energy efficiency and productivity during each of the loading scenarios. Most notable was the 57.7% energy efficiency and 63.6 lb/h production capacity exhibited during the 3.0 lb, heavy load tests. The G2842 also reached full operating capacity in approximately nine minutes and had a low idle energy rate of 4,010 Btu/h. This preheat and idle performance provides the operator with a short start-up time and assures low energy use between cooking events.

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,-15}

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

AGA Food Service Equipment's, model Infinity G2840 fryer utilizes a powered, pre-mix burner and patented heat exchanger design to heat its 12-inch, 29.5-lb capacity fry vat. A flat bottom fryer, the Infinity G2842 is constructed of stainless steel, and has a programmable solid-state thermostat with an optional melt cycle for solid shorting use.

This report presents the results of applying the ASTM test method to the Infinity, model Infinity G2842 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 AGA Food Service Equipment's, model Infinity G2842, 12-inch gas fryer with an input rating of 75,000 Btu/h, under the controlled conditions of the ASTM standard test method. The scope of this testing is as follows:

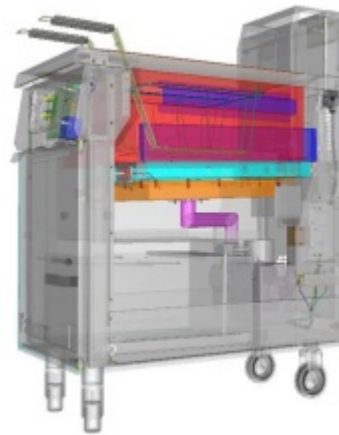
1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the appliance from room temperature to 350°F.
3. Characterize the idle energy use with the thermostat set at a calibrated 350°F.
4. Document the cooking energy consumption 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.

Introduction

Appliance Description

AGA Food Service Equipment's, model Infinity G2842, 12-inch gas fryer is heated by a single powered, pre-mix burner rated at 75,000 Btu/h (see Figure 1-1).

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



*Figure 1-1.
Infinity G2842 fry vat.*

Table 1-1. Appliance Specifications

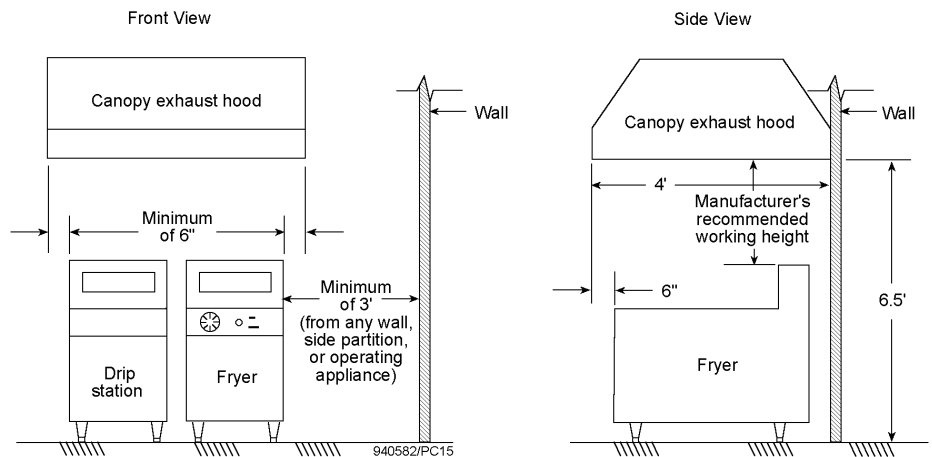
Manufacturer	AGA Food Service Equipment
Model	Infinity G2842
Generic Appliance Type	Open Deep Fat Fryer
Rated Input	75,000 Btu/h
Frying Area	12" x 19"
Oil Capacity	29.5 lb
Controls	Designated settings control dial
Construction	Stainless Steel

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.

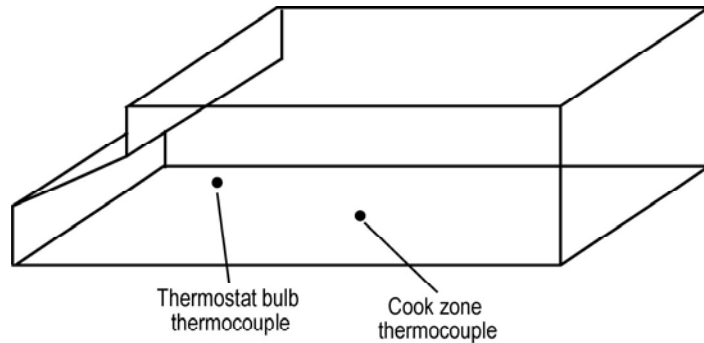
*Figure 2-1.
Equipment configuration.*



Researchers instrumented the fryer with thermocouples to measure temperatures in the cooking zone, at the thermostat bulb and at the exit of the exhaust flue. The cooking zone thermocouple was situated in the geometric center of the cooking oil media. See Figure 2-2.

Methods

*Figure 2-2.
Fry vat thermocouple
placement for testing.*



Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft³. The gas meter and the thermocouples were connected to an automated data acquisition unit that recorded data every five seconds. A Cutler-Hammer calorimeter was used to measure the heating value during each days testing.

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.

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 elements are operating (such as preheat). For the purpose of this test, the fryer was filled with water to the fry vat’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.

Methods

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 reloaded 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 as 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 $\pm 10\%$. The results from each test run were aver-

Methods

aged, 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 73,470 Btu/h (a difference of 2.0% 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. AGA Food Service Equipment's, model Infinity G2842 fryer was ready to cook in 9.2 minutes and consumed 10,660 Btu's during the preheat event. 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 4,010 Btu/h.

Results

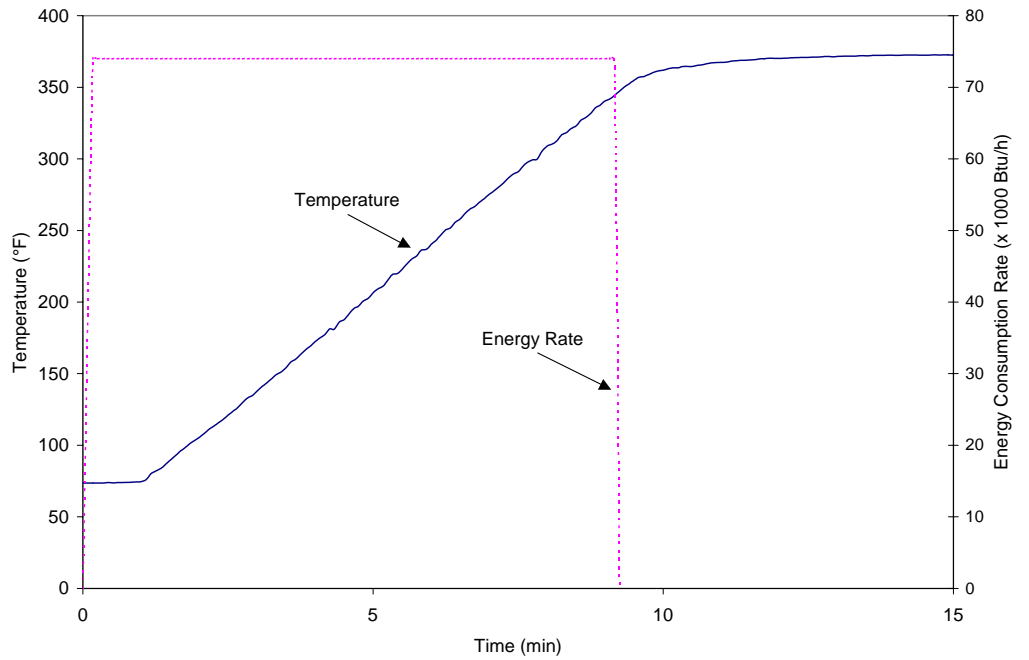


Figure 3-1.
Infinity G2842 preheat characteristics.

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)	75,000
Measured Energy Input Rate (Btu/h)	73,470
Percentage Difference (%)	2.0
Preheat	
Time to 350°F (min)	9.2
Energy (Btu/h)	10,660
Preheat Rate to 350°F (°F/min)	29.8
Idle	
Burner Energy Rate @ 350°F (Btu/h)	4,010
Controls/Blower Electric Energy Rate (W)	30

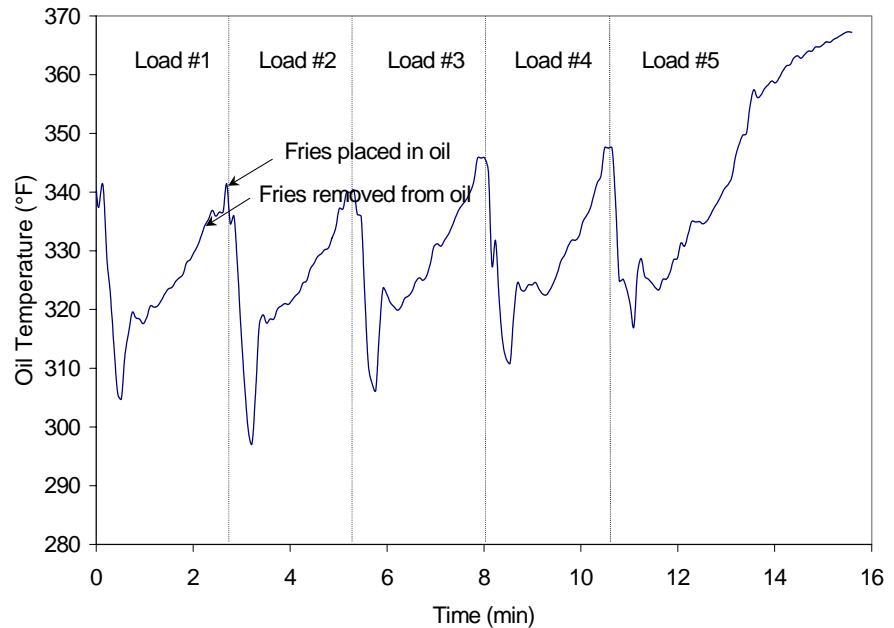
Results

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. Figure 3-2 shows the temperature of the cook zone during the heavy-load tests.



*Figure 3-2.
Frying medium
temperature during a
heavy-load test for the
Infinity G2842 fryer.*

Results

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 cook zone temperature during the heavy-load test was 323°F. The heavy load cook time for the fryer was 2.67 minutes with a recovery time of less than 10 seconds. The Infinity G2842 had a heavy-load production capacity of 63.6 lb/h. 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 illustrates the temperature response of the Infinity G2842 fryer while cooking a 3-pound load of frozen French fries.

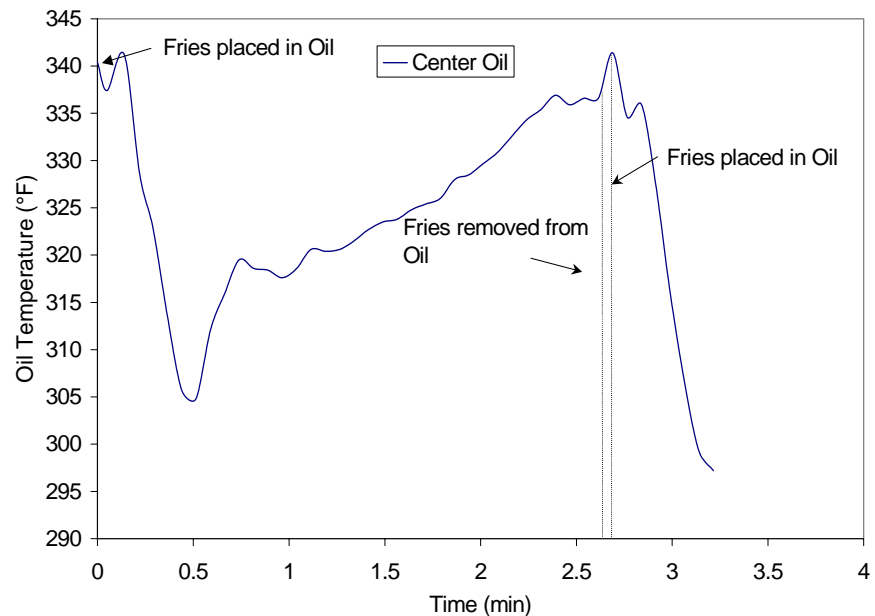


Figure 3-3.
Fryer cooking cycle
temperature signature.

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

Results

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. The Infinity G2842 fryer had medium and light load production capacities of 36.0 lb and 19.4 lb, 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.

The average heavy-load cooking energy efficiency was 57.7%, with an uncertainty of 3.3%. The medium- and light-load cooking energy efficiencies were determined to be 54.1% and 44.1%, respectively. Table 3-2 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests.

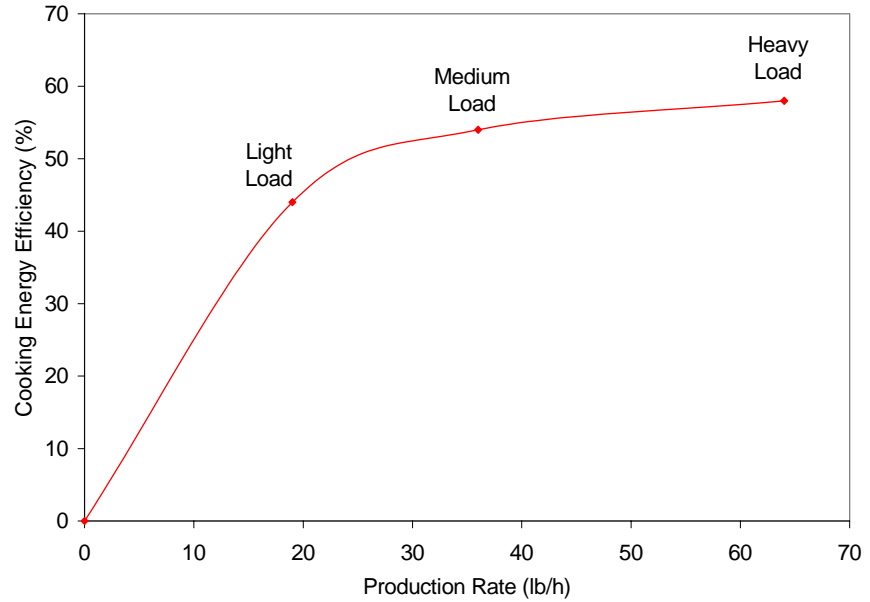
Results

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

	Heavy Load	Medium Load	Light Load
Load Size (lb)	3.0	1 ½	¾
French Fry Cook Time (min)	2.67	2.36	2.17
Average Recovery Time (sec)	<10	<10	<10
Production Rate (lb/h)	63.6 ± 2.2	36.0 ± 0.3	19.4 ± 0.4
Energy Consumption (Btu/lb)	591	588	585
Gas Cooking Energy Rate (Btu/h)	63,000	37,860	24,770
Controls/Blower Electric Energy Rate (W)	50	50	50
Energy per Pound of Food Cooked (Btu/lb)	994	1,005	1,281
Cooking-Energy Efficiency (%)	57.7 ± 3.3	54.1 ± 3.1	44.4 ± 2.6

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.

Results



*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 Infinity G2842 are 14,760 Btu/h, 35,120 Btu/h, and 53,810 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 G2842 fryer would be 20,000 Btu/h.

Results

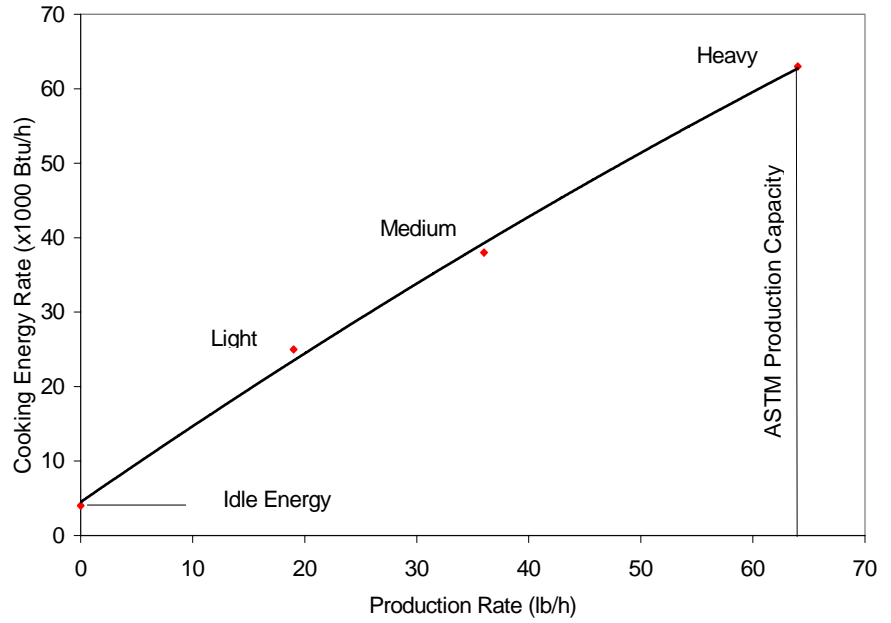


Figure 3-5.
Fryer cooking energy consumption profile.

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

4 Conclusions

AGA Food Service Equipment's, Infinity G2842 gas Fryer with its unconventional fry vat capacity of 29.5 lb, powered pr-mix burner and patented heat exchanger design, represents a concerted effort by the manufacturer to bring a top performing deep fat fryer to the marketplace. This effort has been rewarded with ASTM test results that make the Infinity G2842 a real competitor for space on any kitchen's hotline.

The fryer was quick to reach full operational capacity, approximately nine minutes. The low idle energy rate of 4,010 Btu/h also ensures that operators will minimize operating costs when the appliance is not being used for cooking.

When cooking, the Infinity G2842 achieved high cooking energy efficiencies that place it in the top percentile of fryers that have been tested by the Food Service Technology Center. With a maximum production capacity of nearly 64 lb/h and virtually instant recovery (less than 10 seconds), the fryer can easily meet the demands of the busiest operating schedules. The fryer's heavy-load cooking energy efficiency, 57.7%, ensures that the majority of the appliance's energy is transferred to the food product. This holds true for partial loads, as was demonstrated during the medium-load cooking scenario, where the Infinity G2842 exhibited a cooking energy efficiency of 54.1%.

Its innovative design, highlighted by its 29.5 lb cooking oil capacity, may also minimize cooking oil costs. During the course of operation, each oil replenishment represents a greater percentage of the total oil; suggesting the potential for extended oil life and improved oil quality.

This attribute coupled with its respectable cooking performance, makes the AGA Food Service Equipment's, Infinity G2842 a serious contender in the competitive deep fat fryer market.

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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/ft³)

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 holding or maintaining 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.

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

Glossary

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 warm from the ambient room temperature ($75 \pm 5^\circ\text{F}$) 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 AGA Food Service Equipment's, Infinity G2842 gas fryer.

C Results Reporting Sheets

Manufacturer: AGA Food Service Equipment
Models: Infinity G2842
Date: August 2004

Test Fryers and Burners

Description of operational characteristics: AGA Food Service Equipment's, Infinity G2842 gas fryer is rated at 75,000 Btu/h. The Infinity G2842 features a powered pre-mix burner and patented heat exchanger design placed beneath a flat bottom fry vat. Additional features include an optional melt cycle.

Apparatus

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

Deviations: Due to specialized fry baskets, one set of fry baskets was used during the heavy-load cooking tests.

Energy Input Rate

Rated (Btu/h)	75,000
Measured (Btu/h)	73,470
Percent Difference between Measured and Rated (%)	2.0

Thermostat Calibration

Thermostat Setting (°F)	355
Oil Temperature (°F)	350

Results Reporting Sheets

Preheat Energy and Time

Starting Temperature (°F)	76.3
Gas Energy Consumption (Btu)	10,660
Duration (min)	9.2
Preheat Rate (°F/min)	29.8

Idle Energy Rate

Burner Energy Rate (Btu/h)	4,010
Control/Blower Energy Rate (W)	27.6
Total Idle Energy Rate @ 350°F (kW)	0.93

Heavy-Load Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	3.0
French Fry Cook Time (min)	2.67
Average Recovery Time (sec)	<10
Production Capacity (lb/h)	63.6 ± 2.2
Energy to Food (Btu/lb)	591
Cooking Energy Rate (Btu/h)	63,000
Control/Blower Energy Rate (W)	262.1
Energy per Pound of Food Cooked (Btu/lb)	994
Cooking-Energy Efficiency (%)	57.7 ± 3.3

Results Reporting Sheets

Medium-Load Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	1.5
French Fry Cook Time (min)	2.35
Average Recovery Time (sec)	<10
Production Rate (lb/h)	36.0 ± 0.3
Energy to Food (Btu/lb)	588
Cooking Energy Rate (Btu/h)	37,860
Control/Blower Energy Rate (W)	207.6
Energy per Pound of Food Cooked (Btu/lb)	1,055
Cooking-Energy Efficiency (%)	54.1 ± 3.1

Light-Load Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	0.75
French Fry Cook Time (min)	2.17
Average Recovery Time (sec)	<10
Production Rate (lb/h)	19.4 ± 0.4
Energy to Food (Btu/lb)	585
Cooking Energy Rate (Btu/h)	24,770
Control/Blower Energy Rate (W)	16.3
Energy per Pound of Food Cooked (Btu/lb)	1,281
Cooking-Energy Efficiency (%)	44.4 ± 2.6

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			
Test Voltage (V)	120	120	120
Burner Energy Consumption (Btu)	15,148	14,938	14,532
Control/Blower Energy Consumption (Wh)	10.6	13.1	12.7
Total Energy (Btu)	15,185	14,938	14,576
Cook Time (min)	2.61	2.70	2.69
Total Test Time (min)	14.3	14.2	13.9
Weight Loss (%)	29.5	30.3	30.3
Initial Weight (lb)	15.000	15.000	15.000
Final Weight (lb)	10.58	10.45	10.45
Initial Moisture Content (%)	66.4	66.4	66.4
Final Moisture Content (%)	46.5	44.7	47.1
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	9.95	9.95	9.95
Final Weight of Water (lb)	5.04	5.28	5.03
Sensible (Btu)	2,210	2,210	2,210
Latent – Heat of Fusion (Btu)	1,467	1,467	1,467
Latent – Heat of Vaporization (Btu)	5,114	5,347	5,106
Total Energy to Food (Btu)	8,791	9,024	8,783
Energy to Food (Btu/lb)	586	602	586
Total Energy to Fryer (Btu)	15,185	14,983	14,576
Energy to Fryer (Btu/lb)	1,012	999	972
Cooking Energy Efficiency (%)	56.2	58.5	58.5
Cooking Energy Rate (Btu/h)	63,470	62,990	62,550
Production Rate (lb/h)	62.8	63.2	64.6
Average Recovery Time (sec)	15.0	8.4	6.0

Cooking-Energy Efficiency Data

Table D-3. Medium-Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Test Voltage (V)	120	120	120
Burner Energy Consumption (Btu)	7,975	8,023	7,636
Control Energy Consumption (Wh)	9.2	9.2	9.1
Total Energy (Btu)	8,006	8,055	7,667
Cook Time (min)	2.33	2.35	2.36
Total Test Time (min)	12.4	12.5	12.5
Weight Loss (%)	30.64	29.53	29.47
Initial Weight (lb)	7.500	7.500	7.500
Final Weight (lb)	5.20	5.29	5.29
Initial Moisture Content (%)	66.4	66.4	66.4
Final Moisture Content (%)	46.8	46.1	46.6
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	5.98	5.98	5.98
Final Weight of Water (lb)	2.54	2.54	2.51
Sensible (Btu)	1,105	1,105	1,105
Latent – Heat of Fusion (Btu)	733	733	733
Latent – Heat of Vaporization (Btu)	2,580	2,576	2,549
Total Energy to Food (Btu)	4,419	4,415	4,387
Energy to Food (Btu/lb)	589	589	585
Total Energy to Fryer (Btu)	8,006	8,055	7,667
Energy to Fryer (Btu/lb)	1,068	1,074	1,022
Cooking Energy Efficiency (%)	53.6	53.2	55.5
Cooking Energy Rate (Btu/h)	38,470	38,420	36,680
Production Rate (lb/h)	36.2	35.9	36.0
Average Recovery Time (sec)	<10	<10	<10

Cooking-Energy Efficiency Data

Table D-4. Light Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Test Voltage (V)	120	120	120	120
Burner Energy Consumption (Btu)	4,852	4,575	4,936	4,745
Control/Blower Energy Consumption (Wh)	7.4	7.4	7.5	7.4
Total Energy (Btu)	4,878	4,600	4,962	4,770
Cook Time (min)	2.13	2.18	2.18	2.20
Total Test Time (min)	11.4	11.6	11.6	11.7
Weight Loss (%)	29.16	30.07	29.44	29.67
Initial Weight (lb)	3.75	3.75	3.75	3.75
Final Weight (lb)	2.66	2.62	2.65	2.64
Initial Moisture Content (%)	66.4	66.4	66.4	66.4
Final Moisture Content (%)	43.5	47.4	48.0	47.7
Initial Temperature (°F)	0	0	0	0
Final Temperature (°F)	212	212	212	212
Calculated Values				
Initial Weight of Water (lb)	2.49	2.49	2.49	2.49
Final Weight of Water (lb)	1.32	1.24	1.22	1.23
Sensible (Btu)	553	553	553	553
Latent – Heat of Fusion (Btu)	367	367	367	367
Latent – Heat of Vaporization (Btu)	1,348	1,264	1,238	1,251
Total Energy to Food (Btu)	2,267	2,183	2,157	2,170
Energy to Food (Btu/lb)	605	582	575	579
Total Energy to Fryer (Btu)	4,878	4,600	4,962	4,770
Energy to Fryer (Btu/lb)	1,301	1,227	1,323	1,272
Cooking Energy Efficiency (%)	45.2	46.0	42.2	44.1
Cooking Energy Rate (Btu/h)	25,630	23,620	25,510	24,310
Production Rate (lb/h)	19.8	19.4	19.4	19.2
Average Recovery Time (sec)	< 10	< 10	< 10	< 10

Cooking-Energy Efficiency Data

Table D-5. Cooking Energy Efficiency and Production Capacity Statistics

	Cooking Energy Efficiency			Production Capacity
	Heavy-Load	Medium-Load	Light-Load	
Replicate #1	56.2	53.6	45.2	62.8
Replicate #2	58.5	53.2	46.0	63.2
Replicate #3	58.5	55.5	42.2	64.6
Replicate #4	--	--	44.1	--
Average	57.7	54.1	44.4	63.6
Standard Deviation	1.3	1.3	1.7	0.9
Absolute Uncertainty	3.3	3.1	2.6	2.2
Percent Uncertainty	5.7	5.7	6.0	3.5