Institiúid Teicneolaíochta Cheatharlach
INSTITUTE of TECHNOLOGY CARLOW
At the Heart of South Leinster

Report on the efficiencies of the Castle Chafer versus the Traditional chafer

December 2015

Contents

	Pages
Abstract	2
Introduction	3
Methodology	4
Experimental Design	4
Test Procedure	4
Chafer Trials	5
Data Analysis	5
Efficiency	5
Comparison Study of Castle Catalytic Gas Burner V Traditional Gel Burner	6
Thermal Insulation properties of Castle chafer	8
Results	9
Thermal images of Castle Chafer and Catalytic burner	10
Thermal images of Traditional chafer and Gel Burner	11
Health and Safety	13
Recommendations	13
Conclusions	13
Appendix 1	14

Abstract

The traditional chafer and burner system has been around for hundreds of years, using fuels such as wood and oils and then denatured alcohols and currently gas as a chafing fuel is coming into vogue. The real necessity that faces the user of chafing dishes and fuels is that it works and works safely, efficiently, is practical, user friendly and environmentally acceptable, and mostly that it’s economical. This is the challenge facing the Castle Burner and Tradition is the challenge facing the Castle Chafer

The objective of this report was to examine the efficiency of the Castle products as compared to the traditional chafing products. The examination yielded the results and it was impossible in the examination not to experience the safety and other aspects of the Castle products in the face of the numerous accidents reported around the word relating to chafing fuels and dishes.

1. Introduction

Traditional chafer dishes or chafers as they are called have a structure that is made up of, a frame, a water pan, a food pan and a lid. They can be round, oval or square and are generally made of stainless steel. Irrespective of the shape of the chafer being used the principle process remains the same in that water is used as the medium to transfer heat from an energy source which is usually a chafer burner to the food pan to keep a food product hot.

There are a number of heat sources used with chafers that are based on an alcohol as a fuel , Ethanol, Methanol and Diethylene glycol are the most common although recently electrical and gas powered burners have come on the market. The stereotype fuels used come in a high viscosity alcohol gel (200 proof) and are sold in a steel can with a re-sealable plug lid with burning times of two, four and six hours. Diethyelene glycol which is in liquid form requires a wick to facilitate burning and has a screw lid to prevent spillages. The relative heat of combustion of Ethanol, Methanol is 1300kJ/mol. 726KJ/mol. respectfully.

Competitor products use gas as a fuel has a shorter burn time and can be regulated and is refillable. Eco burners Chafo is gas fuelled and refillable. In real terms these are the competitor burners.

More recently the use of Ecofuels in chafer burners is developing; these are based on Brazilian cane sugar and marketed by Ecoflame International, while Ecofuel worldwide are suppliers of a chafer burner fuel based on an enzyme derived glycol from fructose.

A more recent and innovative approach to the Chafer process for keeping food products hot involves a redesign of both the Chafer dish itself and the use of a Catalytic burner that uses gas fuel more efficiently. The traditional use of water as a medium to transfer the heat to the food product is no longer used and the Catalytic gas burner supplies the heat energy more directly and efficiently.

This report is the investigation of the performance of these new design concepts compared to the traditional Chafer design and gel fuels under the following:

1. Comparison of heat output of traditional burners versus the Castle catalytic burner
2. Measure the energy efficiency – fuel v heat produced
3. Evaluate the heating profile of the Castle Chafer v traditional chafer
4. Measure the thermal insulation properties of the Castle Chafer and offer recommendations
5. Advise on hazard identification in terms of SOP.

2. Methodology

2.1 Experimental Design

Comparing the heat output of the traditional chafer burner (Ethanol) v Castle Catalytic Chafer Burner (gas)

The energy content of a fuel is the amount of heat produced by burning 1 gram of the fuel and it is measured in joules per gram (J/g). Heat is a form of energy (actually energy flow) and it is normally measured in calories. 1 cal. =4.186 Joules.

It is difficult to measure the amount of heat produced by a fuel directly. The method used in these trials was based on burning a fuel to heat water. The energy lost by the fuel can then be calculated by finding the heat gained by the water as measured by the change in temperature.

The heat gained by the water $Q = dT*m*c$

Where dT is the change in temperature, m is the mass of the water and c is the specific heat constant of the water.

In this test two different fuels are explored and compared. Olympia chafing fuel gel 200g can which is Ethanol based and a D2 Butane Battery 70/30 Butane /Propane fitted with a Castle Catalytic burner head. Two other fuels of known energy content were also tested to assist in the determination of heat loss in the experimental setup and the determination of correction values. These were Paraffin Wax and Methanol.

The test equipment consisted of an insulated copper calorimeter and outer water jacket. 100ml of water was used and four/six Omega standard RTDs which were continuously monitored and logged by two Alba data logger systems.

Two tests were carried out simultaneously, one on each fuel. The setup consisted of the 2 calorimeter assembly which was mounted on customised jigs to give a space of 45mm between the burner head and the assembly.

2.1 Test Procedure

The Castle Catalytic burner head had no calibration scale or gas flow indicator and a course calibration was carried out using the circumference of the knob divided into equal divisions, this knob rotated twice 360 degrees plus approx. another 20 degrees. The divisions were marked from 1 to 6 and the second rotation 7 to 12*. An evaluation of the calibration was carried out.

The fuel containers were labelled and weighed to three decimal places. The balances were calibrated with a certified weight prior to weighing.

The RTDs were calibrated using ice and water at 100 ^{o}C. Before each test run the spacing of the burner head was checked.

Both tests were started simultaneously and the temperature of the water raised to 60 ^{o}C on average from ambient. The time taken was logged. The fuel containers were again weighed at the end of each test and the amount of fuel used was calculated.

Standard fuel with known energy content was run twice after each experiment.

2.3 Chafer Trials

The traditional chafer was setup by using 3 litres of water at 44.5 ^{o}C in the water pan and 1.5 litres AT 44.5 ^{o}C in the food pan. Two gel burners were used.

The Castle Chafer was assembled and 1.5 litres of water at 44.5^{o}C placed in the food pan. The Catalytic burner was set to maximum.

The test runs were carried out simultaneously for forty minutes at a sampling interval of two minutes. This experiment was repeated four times. The rate of heating, the temperature rise and fuel used were recorded.

3. Data Analysis

The heat energy output of each fuel was measured ten times. The energy content of the fuel was calculated mathematically by applying the equation above. The results were averaged over the ten trials. The rate of heat energy transfer was also calculated from the logged data. The efficiency of each fuel was then calculated. The experimental heat loss correction was applied to the results based on the results of the two control tests and the heat rise in the calorimeter water jacket

The energy efficiency in this case is in the form of thermal energy, which is the conversion of the energy in the fuel used into heat. This efficiency may vary per application and device. The data obtained relating to energy transfer, rate of energy transfer and economy were tested in their application to the traditional chafer and the Castle chafer design using the same data parameters as used in the laboratory trials on the fuels.

4. Efficiency

The efficiency of a fuel is important but a lot depends on the efficiency of both the burner and the appliance that is using the heat produced. If the appliance is not an efficient conduit for an efficiently burnt fuel, then the overall combination is inefficient and less economical. The performance of the combined Castle Catalytic burner and Castle chafer when tested across all parameters, rate of heating, total heat transferred and time and fuel requirements (Appendix 1) indicate that it is a more efficient and economical system than the traditional chafers and gel. The focused flame of the Castle burner and the ease of setup of the Castle chafer are more used friendly than any of the alternatives on the market. Overall the combined Castle Catalytic burner and Castle Chafer tested at a 77% efficiency level compared to a 23% efficiency for the traditional system.

Comparison Study of Castle Catalytic Gas Burner V Traditional Gel burner

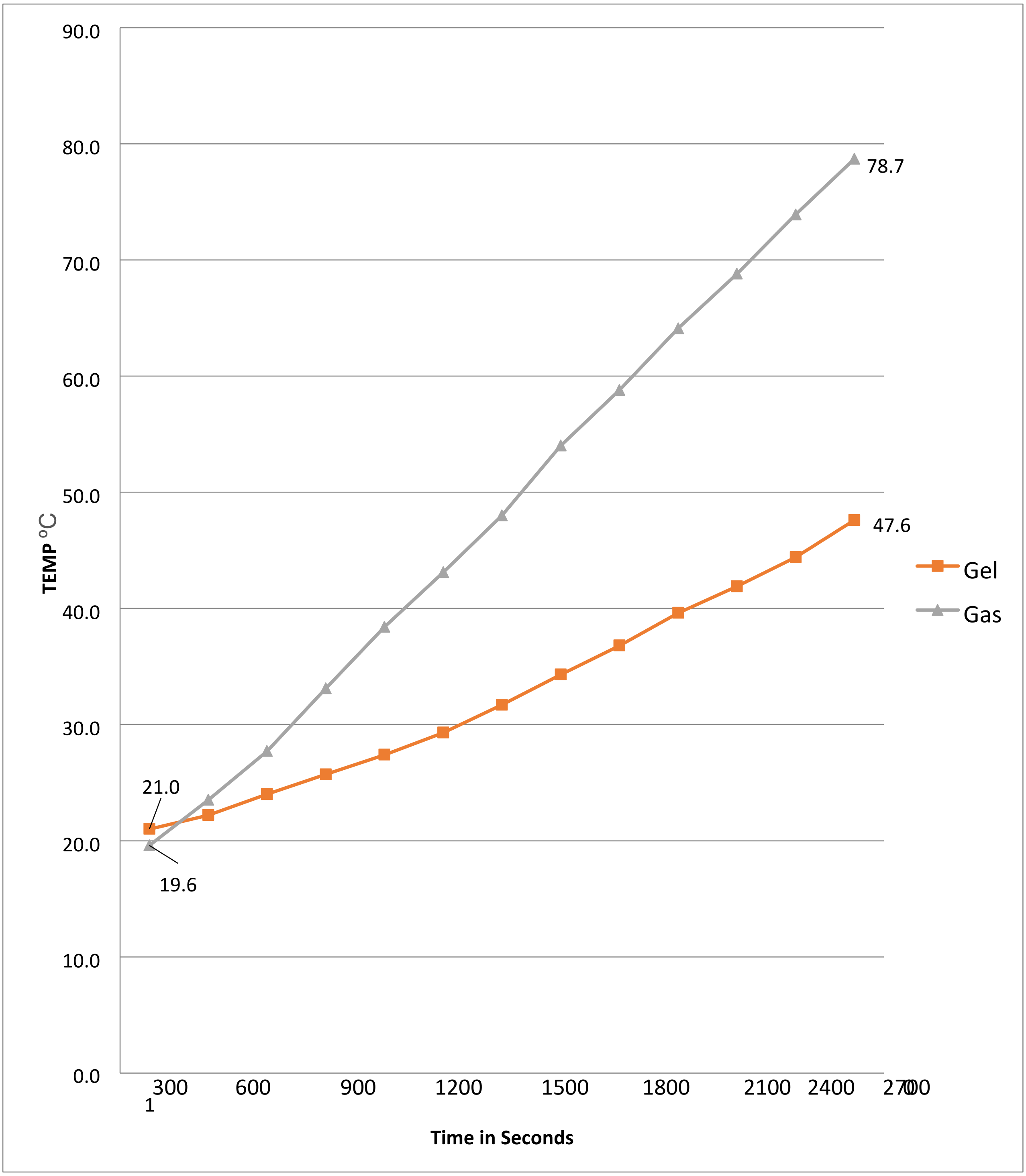


Fig 1

This chart is based on the results of ten test runs on each burner 100 ml of water in the calorimeter.

One gel and Castle Chafer at full open.

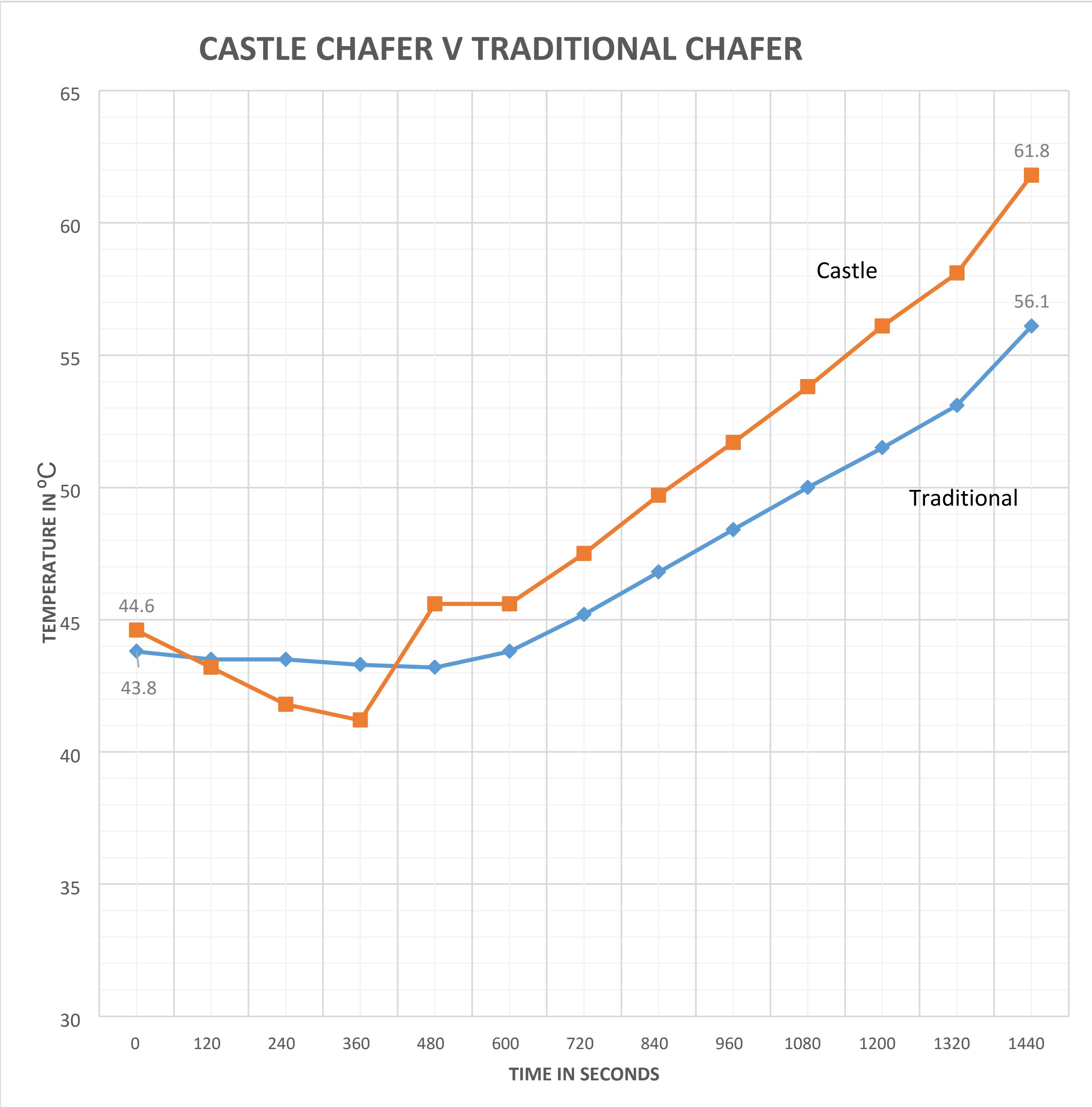


Fig2

This chart is based on the average of four test runs of 1.5 litres in food pan both chafers and 3 litres of water in the Traditional chafer water pan. Two gels and Catalytic burner at half. Water heated to 44 °C before test.

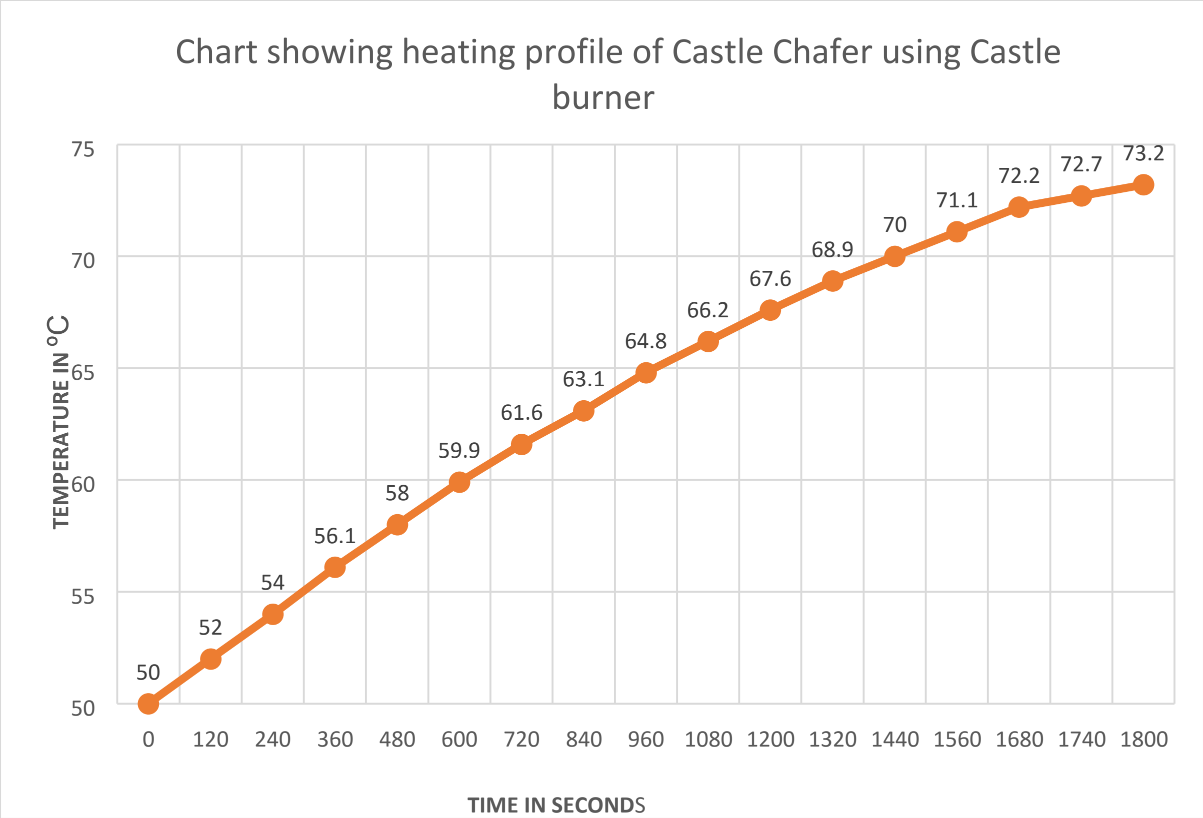


Fig2a Test with 1.5 litres of water heated to 50°C. Castle Catalytic burner at full.

5. Thermal Insulation properties of Castle chafer

Two tests were carried out in order to measure the thermal insulation properties of the Castle Chafer and for comparison on the traditional chafer, one was a heat loss test and the second was a heat gain test.

The first involved the heating of the chafers to 45°C and monitoring the heat loss over time .The second involved the placing of two kilos of ice in the food pan and monitoring the heat gain over time.

A number of thermal images were also taken of both furl burners and the heated chafers.

6 Results

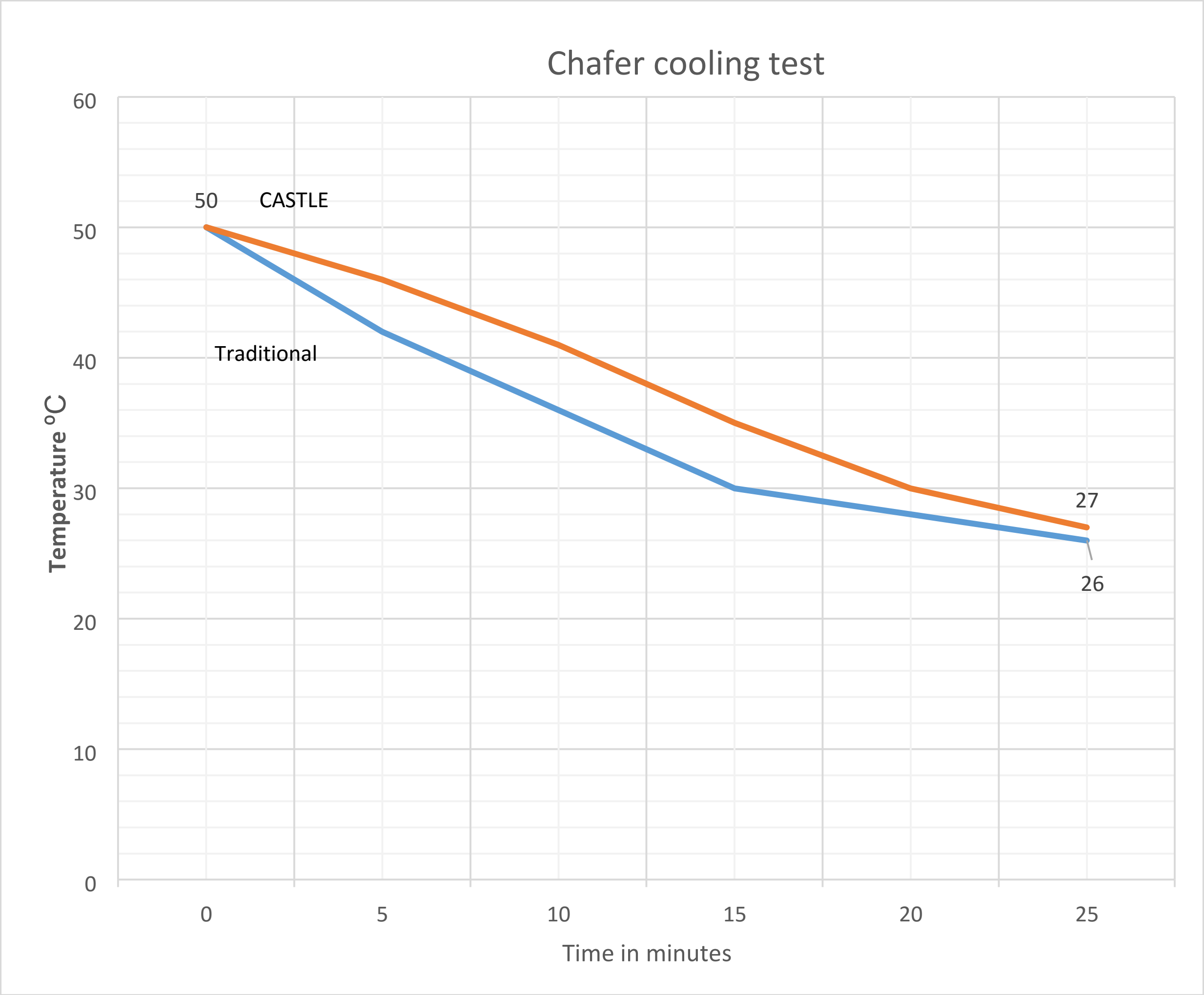
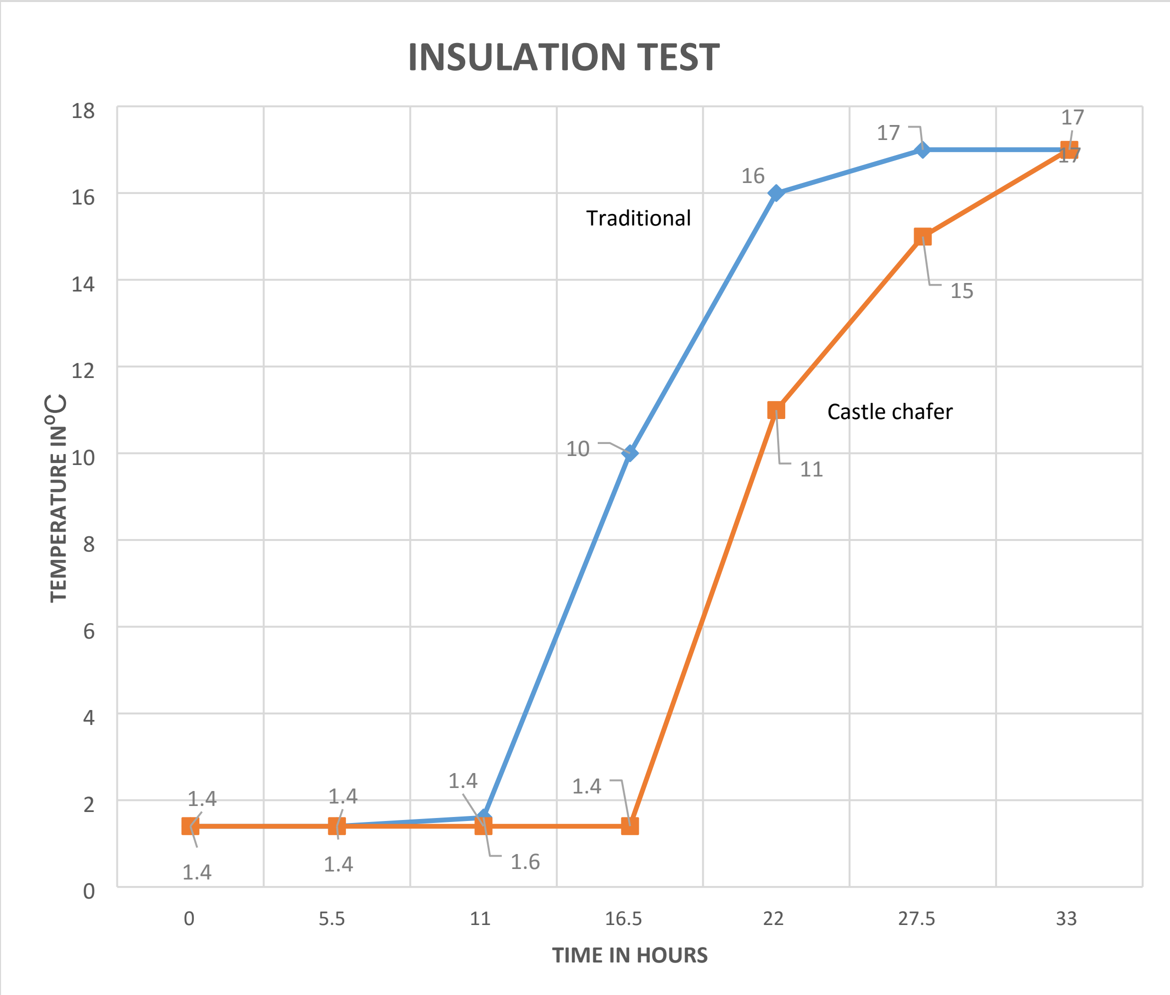


Fig 3

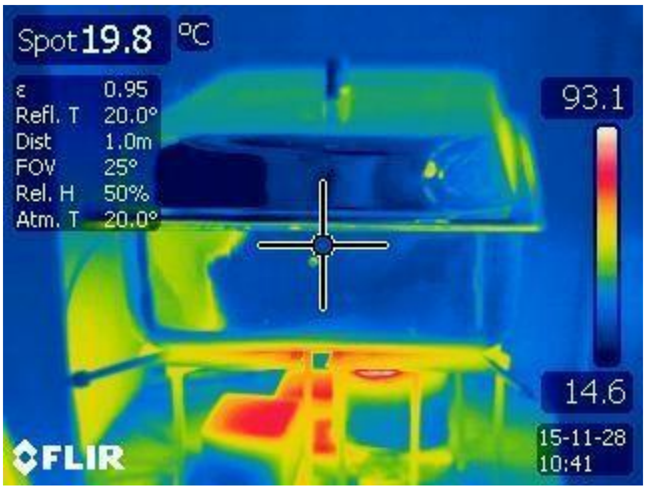


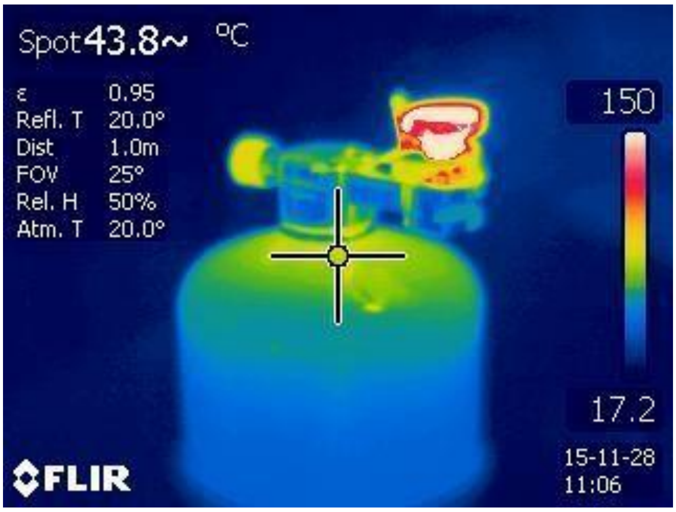
Test used 2 kilograms of ice

Fig 4

Test was logged overnight

Thermal images of Castle Chafer and Catalytic burner





Thermal images of Traditional chafer and gel burner


Spot 30.7~ °C
ε 0.95
Refl. T 20.0°
Dist 1.0m
FOV 25°
Rel. H 50%
Atm. T 20.0°
150
12.8
15-11-28
11:58
FLIR


Spot 18.8~ °C
ε 0.95
Refl. T 20.0°
Dist 1.0m
FOV 25°
Rel. H 50%
Atm. T 20.0°
34.1
12.1
15-11-28
11:31
FLIR

7. Health and Safety

The general regulation for the D2 gas pack are outlined below. Under EU law the supplier of the cartridges have to send in writing the MSDS or safety data sheet with all deliveries. In relation to the Castle Chafer and use of the Castle Catalytic Burner a number of SOPs or standard operating procedures need to be developed and relayed through a leaflet or on the product as to the safe handing, lifting and storage of both the Castle Chafer and the Castle Burner it is advised that a full risk assessment be carried out on the final developed product.

Pressurized container: Do not pierce or burn, even after use.
P377
Leaking gas fire: Do not extinguish, unless leak can be stopped safely. P403
Store in a well-ventilated place.
P410+412
Protect from sunlight. Do not expose to temperatures exceeding 50 °C/122°F.
P501
Dispose of contents/container in accordance with local regulations.
Supplementary Precautionary Statements
P210
Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
Other hazards

8. Recommendations

The 70:30 butane propane mix has been analysed at different stages in these trials by using a Gas Chromatograph Mass Spec. (available in hard copy). The results show that as the gas is used the ratio of the mixed gases remains the same virtually to the end, the trials did show that the internal pressure did fluctuate as the gas was used however. This may be solved by a regulator of some kind.

The practical design of the Castle Catalytic Burner should be modified or made available in a twin head burner with two heat focus points underneath the Castle Chafer. The mounting of the burner by slotting into the underside of the chafer is a design problem and needs to be addressed.

9. Conclusions

It is evident from both the laboratory trials and full chafer trials that the combination of the Castle Catalytic burner and Castle Chafer design are a more efficient combination than the traditional water pan chafer and gel alcohol system. Fig 2

The Castle Catalytic burner proved to be 3.5 times more efficient than the Gel alcohol fuel in the laboratory trials Fig 1. In the full trials of the Castle Chafer and Castle Burner against the traditional Chafer with two gels trials the efficiency difference was maintained almost exactly.

The Castle Chafer heated as almost twice the rate of the gel burners in the laboratory trials and in the full chafer trials it was 1.5 times.

The thermal profile of the Caste Chafer proved that it is more efficient at maintain its temperature below room level by up to 5 hours longer that the traditional chafer and it loses heat at a significantly slower rate Fig 4 and Fig 3 .

The thermal images show that heat loss is significantly lower both around the burner itself and through the sides of the chafer dish compared to the traditional burners and dish.

These parameters have also very significant health and safety implications.

Appendix 1

The DATA Castle Catalytic burner

Laboratory test

Temperature rise was an average of 52.40 °C

Average fuel use of **3.211** grams.

Rate of Temperature rise of **8.6** °C/min

Heat energy transferred average **20,500**J

Efficiency of fuel **6,370**J/g

Data for Castle chafer test

Castle chafer full test

Temperature rise average **17.6**°C

Average fuel used **24.236** g

Rate of Temperature rise **1.2**°C/min

Heat energy transferred **109,844**J/g

Efficiency of fuel **4,532**J/g

The DATA Ethanol Gel burner

Laboratory test

Temperature rise was an average of **48.4** °C

Average fuel use of **13.336** grams

Rate of Temperature rise **4.4** °C/min

Heat energy transferred average **19,890J**

Efficiency of fuel **1,491**J/g

Data for Traditional Chafer test

Traditional chafer full test

Temperature rise average **12.5** °C

Average fuel used **67.451** g

Rate of Temperature rise **0.7** °C/min

Heat energy transferred **71,121**J

Efficiency of fuel **1,054** J/g

The error calculations for the standards used was calculated at 8.4% heat lost to the experimental apparatus.