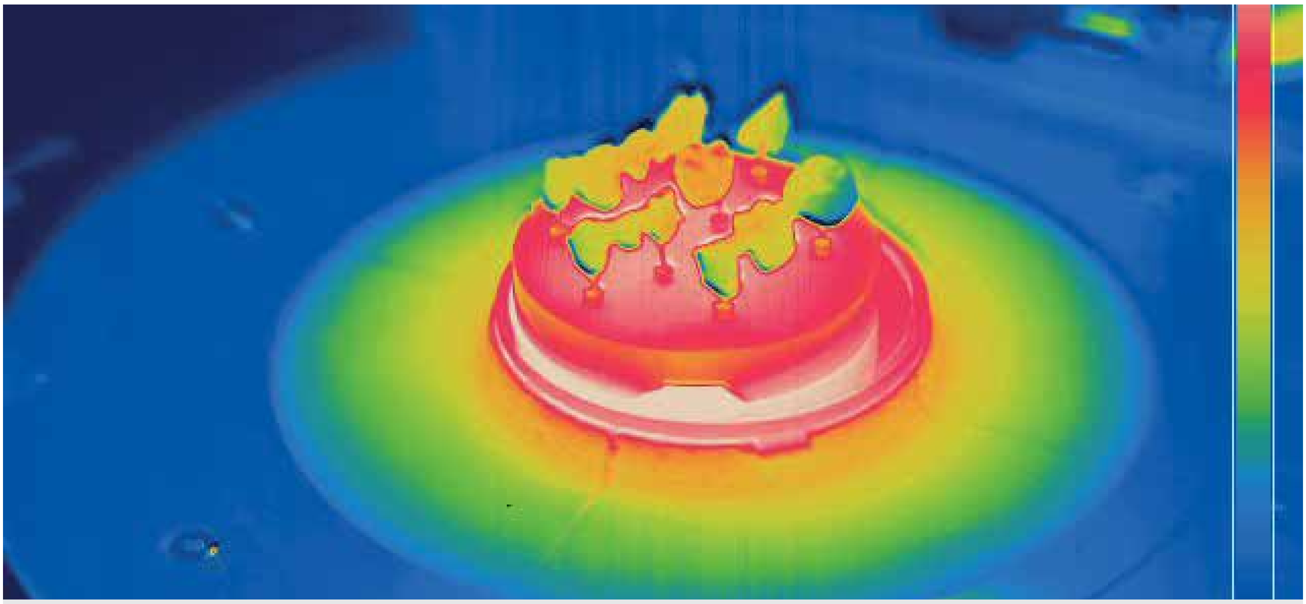
special
update
01/2014
equipment

Infrared technology arrives in the world of dental ceramic furnaces

Ivoclar Vivadent has stirred a sensation in dentistry by integrating thermal imaging technology into its dental furnaces. This innovative technology opens up a new world of possibilities. At the same time, however, questions arise concerning the operation and handling for dental lab applications. This specialised article is intended to answer these questions.



Topic: **Infrared technology in dental ceramic furnaces**

Author: Robert Grünenfelder, Head of Department, Equipment Systems & Project Manager Programat P510
Ivoclar Vivadent AG, Bendererstrasse 2, FL-9494 Schaan

What is an infrared (IR) camera?

An infrared camera detects infrared radiation, evaluates it and produces a thermal image. The procedure used to produce images with an infrared camera is called thermal imaging. The produced thermal images are based on temperature measurements which are not visible to the human eye, as the emitted light lies within the infrared range (IR radiation). The human eye is only capable of detecting visible light (visible radiation), which represents only a small part of the electromagnetic radiation spectrum. There are many other types of light (or radiation) which are invisible to the human eye (Fig. 1).

On the one end of the visible spectrum range at 400 nm, we are not able to detect ultraviolet light. Similarly, on the other end of the range at 700 nm, the infrared light remains hidden from the human eye.

As the human eye is unable to detect infrared light, a simple trick is used to make it "visible". In order to represent infrared light, false-colour images are shown on the camera's display. The coloured regions of the false-colour images allow the human eye to "see" this temperature information. Thus, thermal imaging is an imaging technique which renders invisible thermal (infrared) radiation visible to the human eye.

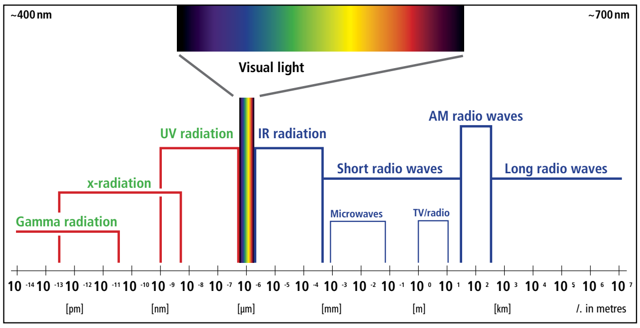
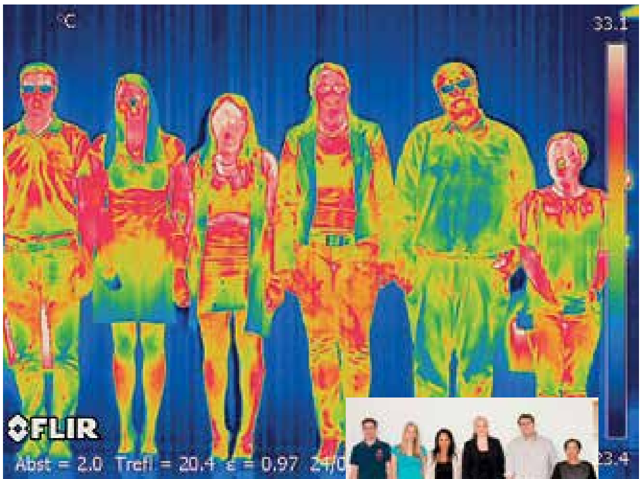


Fig. 1: Overview of the radiation spectrum

Figure 2 shows the thermal radiation of a group of people using the false-colour technique. The head region shows the greatest heat radiation (red area). The smaller picture (Fig. 3) displays the same group in the light spectrum which is detectable by our eyes. In general, the blue colour is used for cold areas and red for hot areas.



Figs 2 and 3:
A group of people displayed using the false-colour spectrum and without the false-colour spectrum

Thermal imaging technique: How does it work?

Every object and every living being with a temperature above the absolute zero radiates infrared energy. Absolute zero is defined at –273.15 °C or 0 °K. Even objects which we perceive as very cold (Fig. 4) radiate infrared energy.

The warmth of the sun's light, of a campfire or of a hot cooking plate represents this kind of radiation. This means that, even though we cannot see it, our skin can feel the heat. Thus, the warmer an object, the more infrared energy it radiates.

Let's test this phenomenon. Press your palms onto the surface of a wall for a couple of seconds. Some of your body heat is thereby transferred to the surface of the wall (Fig. 5).

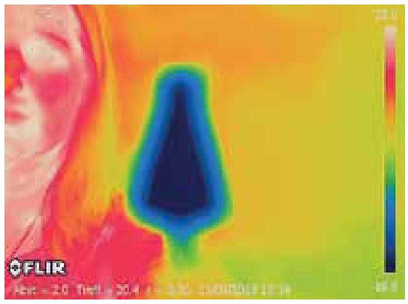


Fig. 4: Even ice cream emits "heat".

Now remove your hand. Some of the heat remains on the surface and emits radiation (Fig. 6).

Fig. 5: Hand placed on a wall

Fig. 6: Radiation of residual heat after removal of the hand

What does the infrared camera measure?

The lens of the infrared camera focuses the infrared energy of an object through a filter onto a detector (chip). A conventional digital camera does not feature such a filter (Fig. 7). Subsequently, the chip sends the received information to the sensor electronics which evaluate the data using a special software. Finally, the image is projected on the display.

Using the false-colour technique, an infrared camera is able to generate a comprehensive image. Depending on the resolution of the chip, even the slightest temperature differences are visible. Thus, the infrared camera detects the temperature of an object and not the colour as do conventional cameras.

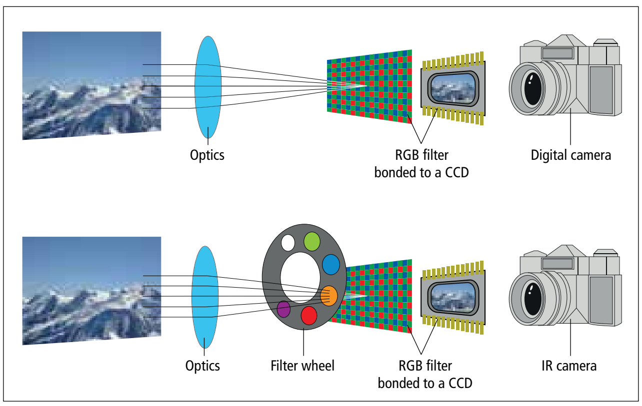


Fig. 7: The technical principle of the digital camera and the IR camera

Which other industries use this kind of technology?

Infrared technology is frequently used in civil engineering, for example, to check the insulation of roofs or for the analysis of brick-work and windows. Furthermore, cracks in walls or leaks in plumbing can be localised using this technology.

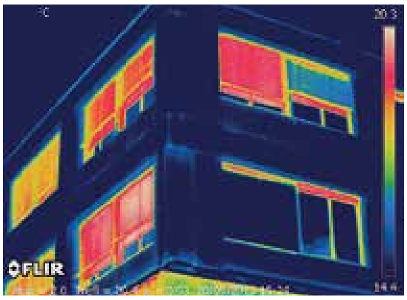


Fig. 8: Use of the infrared camera in civil engineering

Even the fire brigade uses thermal imaging for the detection of smouldering pockets in fires or for finding people in buildings filled with smoke and therefore low visibility.


Fig. 9: Fire brigade with infrared camera

Similarly, the automobile industry started using infrared technology a couple of years ago. For example, installed infrared cameras detect the heat of people or animals on or near roads at dawn or during the night. These thermal images are captured by a special software, transferred into an image and shown on the car's dashboard display (Fig. 10). This feature allows the driver to detect potential risks in time and to prevent accidents.
IR technology is also successfully employed in many other areas such as the aviation industry, medical technology and quality assurance.


Fig. 10: Use of IR cameras in the automobile industry

Where is the infrared camera positioned in the Programat P510?

In the Programat P510, the infrared camera is positioned in the rear section of the furnace head opening mechanism, behind the cover (Fig. 11). In order for the lens to be able to detect the objects in the furnace, a recess in the cover is required. In this position, the IR camera is protected from the heat in the firing chamber and can optimally detect the chamber contents during the predrying process.

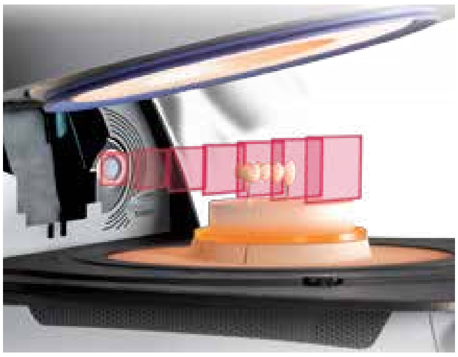


Fig. 11: IR sensor positioning in the Programat P510

Since the IR camera cannot be directly integrated into the firing chamber due to thermal engineering reasons, an object's temperature can only be measured with the furnace head open or closed up to 30 mm. The critical processes for the ceramic take place during the predrying process with an open furnace head. At this stage, the IR camera is used.

How many pixels does the camera have and how many points can be measured?

One thermal image of the IR camera of the Programat P510 consists of approx. 1,000 pixels. If a single, thin veneer is fired, at least 2 measuring points are placed on the dental object. If a larger molar restoration is processed, 12 or more measuring points can be placed on the object (Figs 12 and 13).
The surface of a measuring point depends on the distance. In the area of the firing tray, on which the dental restorations are placed, the surface of a measuring point is always smaller than 2.5 mm x 2.5 mm.

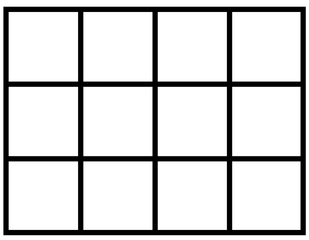


Fig. 12: Presentation of measuring points

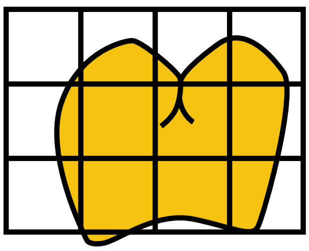


Fig. 13: Presentation of the measuring points on a molar

What is the challenge when predrying ceramic materials?

The predrying of ceramic materials is known to be the most critical phase in terms of the risk of crack formation and the final quality of the restoration.

To date, the predrying process of conventional furnaces has generally been regulated by means of a set time and temperature. Both parameters correspond with average empirical values, which are displayed in tables and are saved in firing programs.

Example:	*IPS e.max Ceram*
Closing time:	*6 minutes*
Predrying temperature:	*300 °C*

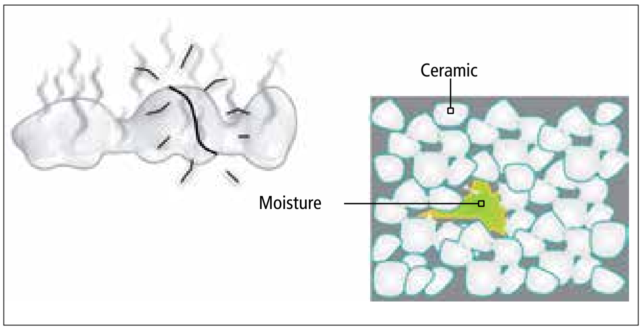


Fig. 14: Risk of fractures if the moisture in the ceramic evaporates too quickly

Based on these empirical data, it is assumed that IPS e.max Ceram is optimally predried after six minutes and all moisture has been removed from the ceramic. Then, the actual firing process starts. If the ceramic is still too moist after this predrying process, cracks can occur in the restoration if the residual moisture evaporates too quickly. Furthermore, if the ceramic layers placed by the dental technician are too moist and not compact enough, problems with the ceramic may occur if the heat input is too fast as the standard firing parameters do not adapt to individual situations.

If a number of large and small restorations are fired in one cycle, firing must be performed very carefully. For larger objects (Fig. 15), the closing time should be increased in relation to the standard settings. Only in this way can optimum results be achieved. If this detail is not considered, fractures and cracks can occur in the ceramic.

Fig. 15: Two examples showing different ways of loading the firing chamber

The new infrared technology accounts for these different circumstances and adapts the firing parameters to the respective situation. Based on the differences in temperature (Fig. 16), the system identifies the exact time when the moisture in the ceramic has evaporated and closes the furnace head. Subsequently, the software initiates the actual firing process. This procedure is not detectable by a conventional thermocouple nor by the human eye.

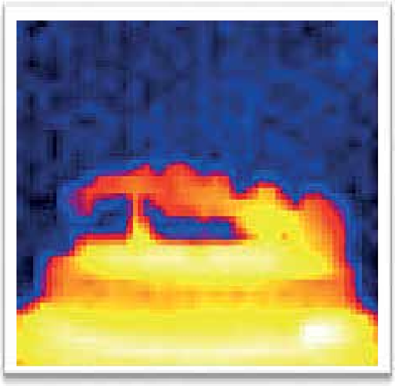


Fig. 16: The differences in temperature of a dental structure in false-colour design during the predrying process

Thus, cracks can be prevented. In contrast to conventional processes, this process can be accelerated if the restorations are of smaller dimensions.

Fig. 17: Opaquer fired with and without infrared technology

The new, touch-free infrared technique measures the temperature directly on the surface of the object in the firing chamber. Each firing cycle can be individually regulated.

What are the advantages of measuring the temperature directly on the object's surface using the infrared camera in comparison to the conventional method of determining the temperature using thermocouples?

In the conventional dental furnaces of various manufacturers, a thermocouple has so far measured the temperature in the firing chamber. In general, the thermocouple is situated in the upper section of the firing chamber. The ceramic object is usually positioned at a close distance to this thermocouple. The thermocouple measures the temperature with the furnace head closed (Fig. 18) and the temperature on the object is subsequently defined using a correction factor.

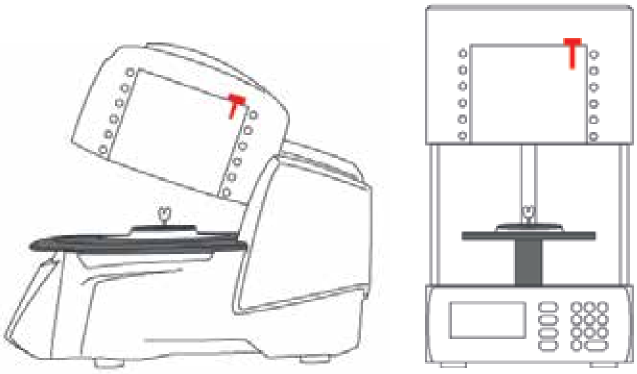


Fig. 18: Different types of furnaces with swivelling furnace heads or a lifting mechanism

However, during the predrying process, which takes place with the furnace head open, draughts can distort the temperature on the ceramic object and the thermocouple (Fig. 19). This may cause temperature deviations. The preset time (closing and predrying time), however, does not consider such possible deviations: The program runs by default. Fractures and cracks in the ceramic are inevitable.
This applies to all types of furnaces.

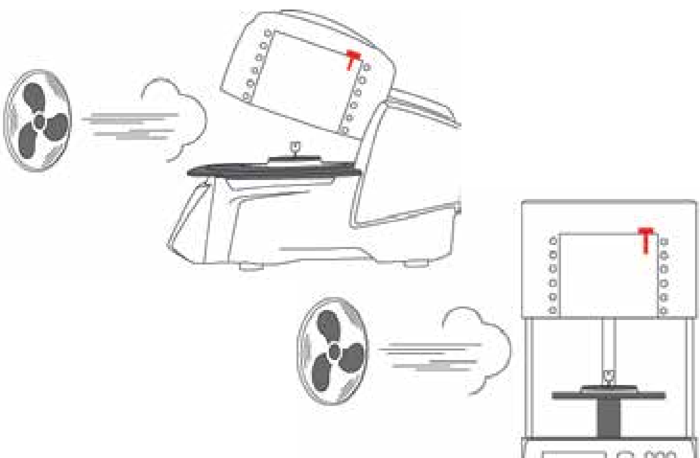


Fig. 19: Draughts may influence the temperature readings which are taken when the furnace head is open.

In contrast, the thermal imaging technique enables touch-free temperature measurement directly on the object in the firing chamber. The Programat P510 with infrared camera does not rely on a correction factor to estimate the temperature on the object with an open furnace head. Even if there are draughts, the IR technology always measures the correct temperature on the surface of the object in the firing chamber. This is the main advantage compared to those furnaces using conventional techniques (Fig. 20).

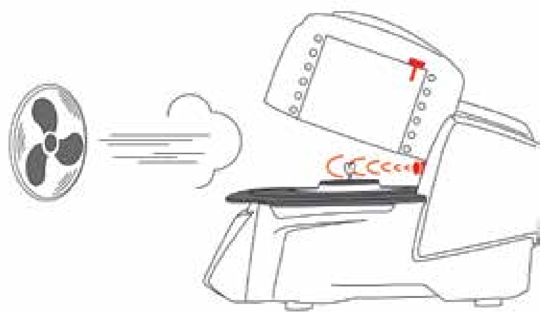


Fig. 20: Infrared technology measures the temperature directly on the surface of the object. Therefore, any possible draughts do not affect the measuring results.

How does the user benefit from this infrared technology?

The software identifies the optimum predrying and closing parameters for each firing cycle. The temperature is measured directly on the surface of the object. The position of the furnace head and the power of the heater are automatically controlled.

This results in the following advantages:
– higher process reliability
– improved quality of the firing results
– time savings of up to 25%

The reliability and safety of the predrying process is independent of the following:
– size of the object(s)
– number of objects in the furnace (high or low loading)
– surface moisture

What must be observed when positioning the objects?

The objects must be clearly visible to the infrared camera in order to be able to optimally manage the predrying process. Therefore, the objects in the furnace should be positioned correctly in front of the camera. The surface facing the camera should be relatively large to obtain optimum results (Fig. 21).

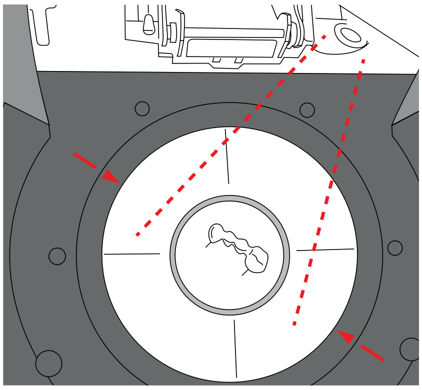


Fig. 21: The objects are positioned with the largest surface area facing the infrared camera.

If a number of restorations is placed on the firing tray, the restoration with the largest surface should always face the IR camera.
Due to their lower mass, smaller restorations are more likely to be predried than larger restorations (Fig. 22).

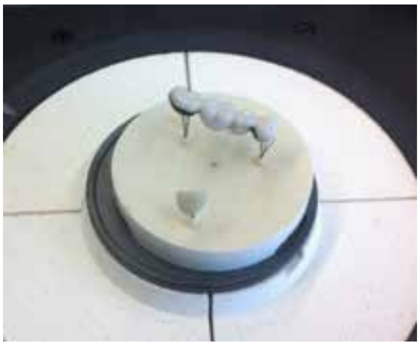


Fig. 22: Large objects must be positioned in the front, facing the IR directly.

You will find further information regarding the correct positioning of objects in the firing chamber as well as information regarding the processing of ceramic materials using the Programat P510 and its infrared technology in the Operating Instructions and the FAQs.

Summary

Infrared technology has taken on a pioneering role and become an integral part of many industries today. With the Programat P510, this innovative technology has now finally arrived in the dental furnace sector. Its advantages are obvious: increased process reliability, higher quality and in some cases even faster firing processes. And although new technologies frequently result in the need for changing established working procedures, the implementation of thermal imaging technology in the P510 has required only a few adjustments. Overall, the advantages of this technology clearly prevail. Therefore, the arrival of infrared technology in the dental furnace sector represents a great asset for the dental industry.

666669/2014-01-20/en

www.ivoclarvivadent.com
Ivoclar Vivadent AG
Bendererstr. 2 | 9494 Schaan | Liechtenstein | Phone: +423 235 35 35 | Fax: +423 235 33 60