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special update equipment

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Scientific Information

Subject: **Thermo Shock Protection**

Title: **Control the closing process of ceramic furnaces with the Thermo Shock Protection (TSP)**

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The drying and closing process represents the beginning of every firing cycle of dental ceramics. The basis for a good result is already laid at this point. Errors during drying result in unsatisfactory outcomes since a series of subsequent firing cycles is required. The product family of the Programat furnaces offers various possibilities to control the closing process. In case of the standard closing procedure, the furnace head is closed by means of a defined closing movement within a given time. Consequently, many things are left to chance. With the new Thermo Shock Protection (TSP) function, the standard closing process is actively controlled and chance is turned into control, similar to the antilock braking system (ABS) in cars.

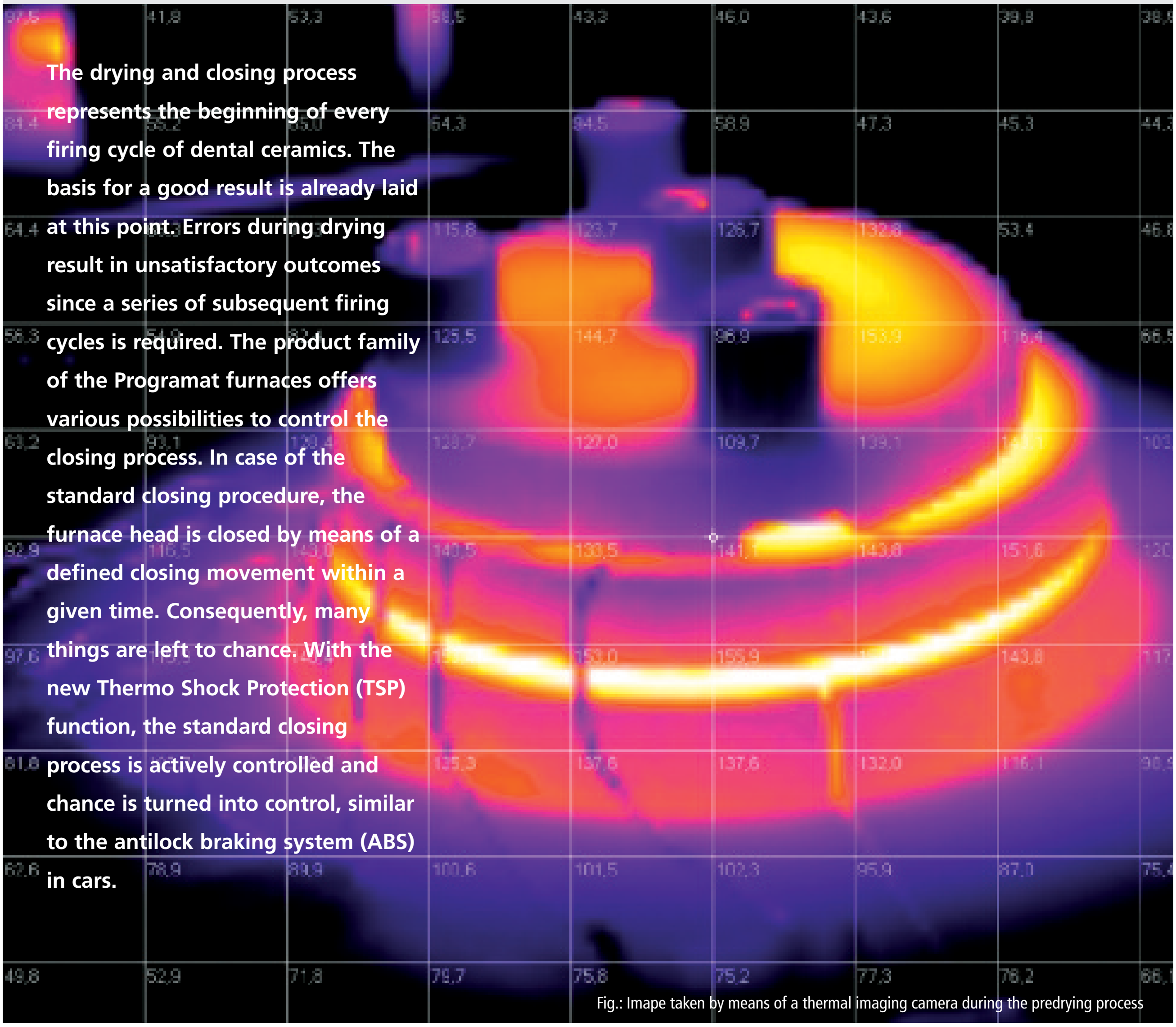

Fig.: Imape taken by means of a thermal imaging camera during the predrying process

1. Introduction

The dental technician (DT) has a variety of possibilities to arrange the closing process. On the one hand, the firing object can be dried prior to the actual firing cycle within a stipulated closing time S by using the passive residual heat in the firing chamber. Another option is to control the residual heat to a limited extent during the closing process by actively heating the firing chamber to a set temperature. For this purpose, the Programat furnaces offer the predrying function. High-quality furnaces, such as the Programat PX1 or Programat P700 allow the user to individually set the predrying position and time. In the daily practice, however, dental technicians rely on the instructions of the manufacturer and on a closing process which is only controlled by the closing time but without active heating. Various negative influencing factors, such as too high a temperature in the firing chamber, may result in errors. By means of the TSP function which has been developed for the Programat P700 the important factors of influence can be specifically considered and actively controlled.

2. Uncontrollable boundary conditions during the closing process

Depending on the construction type of the furnace, the closing process is affected by uncontrollable factors, such as the currently stored heat quantity or heat energy in the furnace. The stored heat energy is high if a firing cycle with very high temperatures has been conducted beforehand. However, if the furnace has only been started up, there is hardly any heat energy in the insulation. Optimum drying during the closing process is decisively influenced by the heat quantity stored in the insulation. Too hot a firing chamber may damage the respective ceramic material, independent of the carrier material used, starting from the 1st wash firing of the opaquer up to glaze firing.

Experienced dental technicians try to avoid this fact by waiting for as long as they see fit until the temperature in the firing chamber has decreased to a certain level. If necessary, they will be advised by a note in the instructions for use (IfU) or an error message of the furnace if the start temperature is too high. Good furnaces show the ideal point in time to place the objects on the firing table by an acoustic signal. If the furnace head remains open, an alert sounds (Programat furnaces) when the temperature in the firing chamber falls below a certain minimum.

Further variables or factors (boundary conditions) which may influence the standard closing process are the following: position of the object on the firing table (e.g. in the center - towards the margin of the table - height of the firing object), the material of the firing table and firing tray, the type and size of the restoration, as well as the alloy (as an example for a framework material), the ceramic material used, the quantity and composition of the liquid or the actual time when the restoration is placed in the furnace to name only a few. Additional disturbing factors may be open windows in the laboratory or cold draught, if the furnace is unfavourably placed, or an air conditioner nearby. Some of these influencing factors, particularly the latter few, are determined by the dental technician. See also R. Strietzel (Dentallabor 4, 2006).

3. The main principle of TSP

The heat quantity stored in the firing chamber is directly related to the temperature measured in the firing chamber. Consequently, the furnace temperature indicates the heat quantity stored in the firing chamber. The influence of the heat quantity stored in the firing chamber is decisively determined by the distance to the object or restoration. The closing movement of a simple standard closing process is indicated by a path-time diagram of the manufacturer. The firing table or furnace head moves in sequential steps or continuously within the stipulated time but in the given manner until the firing chamber has reached its final closing position.

Different heat quantities in the furnace chamber result in different drying results. It may result in open pores or cracks in the opaquer or even boiling bubbles caused by explosive evaporation of liquid additives. That is exactly where the TSP function comes into play. When starting the program, the heat quantity available in the firing chamber is assessed and an optimum closing movement calculated on this basis. Subsequently, the furnace tries to position the object in the proximity of the firing chamber in an optimum fashion within the stipulated closing time S and to close the firing chamber. This means that the furnace waits for a long time until the object is moved closer to the initially hot firing chamber when a lot of heat is in the firing chamber. On the other hand, a wide open firing chamber will ensure that it cools down faster.

The figure below shows how the closing movement is changed with the TSP function active. It is again emphasized that the furnace head closes in the same closing time (S).

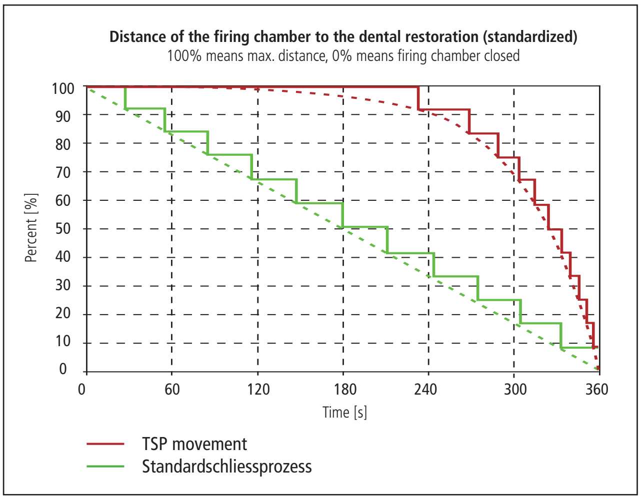

Fig. 1: Closing movement with and without TSP

4. Parameterization of TSP

A mathematic model for a suitable closing movement has been developed on the basis of various experiments with different heat quantities stored in the firing chamber of the furnace. Based on a desired standard situation (ideal conditions), the closing movement as a result of the furnace temperature upon start of the firing program is calculated in such a way that the heat quantity reaching the object leads to an optimum drying of the restoration.

Figure 2 shows the different temperature developments in dental restorations if the TSP function is not active. The temperature differences as a function of the temperature / energy in the firing chamber are clearly recognizable.

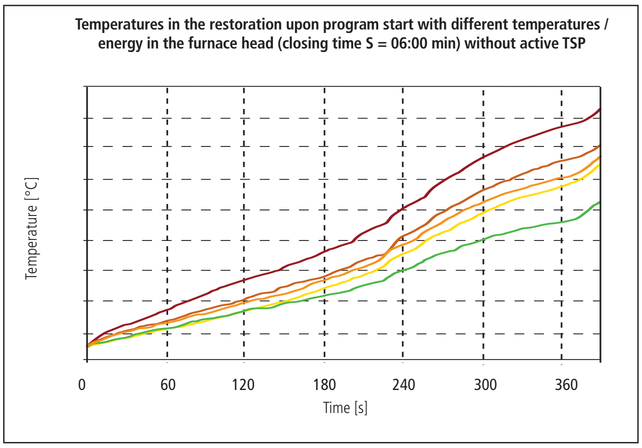

Fig. 2: Temperature differences in the object with different starting conditions without TSP

Figure 3 shows the repetition of the tests if the TSP function is used. The variation is considerably lower. All temperature curves are close to the set curve (green) over the entire closing cycle.

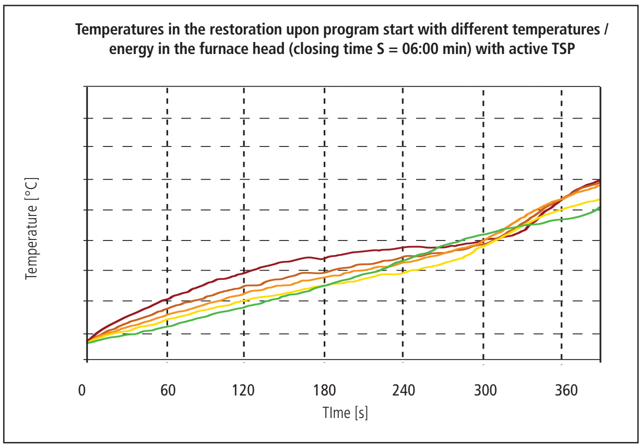

Fig. 2: Temperature differences in the object with different starting conditions with TSP

Measurements on different positions on the firing table confirm that the temperature differences on the firing table are also reduced if the TSP function is active.

5. Proven success in dental use

In general, the start of the (pre-)drying procedure is decisive for the firing cycle. The choice of the time-temperature axis can result in a damage of the firing object already at too high temperature increase rates and high temperatures when placing the object in the firing chamber. The handling of the respective ceramic / liquid mixture in use is of eminent importance. The subsequent course of the drying process is only secondary.

Too high a temperature irradiation which is mainly encountered in subsequent firing cycles results in a sealing of the surface. Entrapped moisture cannot escape. As a consequence, cracks and open pores or even boiling bubbles may be produced. Often, areas on which more material is applied (e.g. occlusal and/or interdental areas) are more frequently subject to cracks or delamination of the ceramic. This fact is clearly shown on the images below (4 and 6) without TSP function. Images 5 and 7 are in direct comparison to these figures, however, with active TSP.

Fig. 4: Opaquer firing without TSP, at T>560 °C. A lot of open pores and cracks

Fig. 5: Opaquer firing with TSP at T>560 °C. Perfect opaquer firing, no pores or cracks

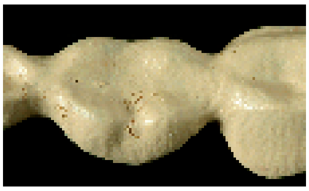

Fig. 6: Opaquer firing without TSP, at T>560 °C. Accumulation of cracks

Fig. 7: Opaquer firing with TSP, at T>560 °C. Perfect opaquer firing, no cracks

6. Abschliessend

The Thermo Shock Protection (TSP) function can be compared with the antilock braking system (ABS) in cars. In the rarest cases, experienced dental technicians will risk a poor firing result due to a provocative closing process, in the same way as a driver would provoke the activation of the ABS. Dental technical requirements may sometimes surpass the limits of feasibility in the standard closing process comparable to ice and snow during motoring. Similar to ABS, TSP offers the required reserves in such cases in order to achieve a successful and satisfying result all the same.

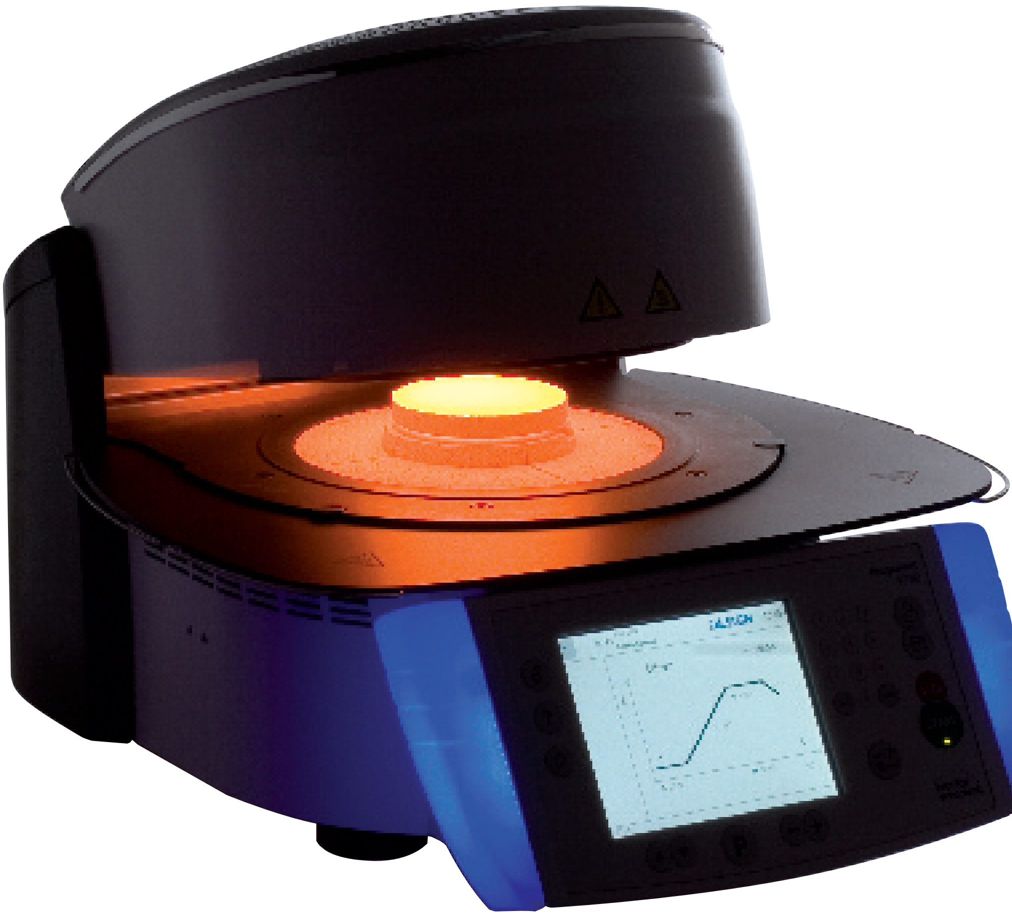

Fig.: Programat P700 during the cooling process

Literature:

Dr. R. Strietzel „Aufbrennen der Verblendkeramik“
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