(19) DANMARK

(10) **DK/EP 3082643 T3**

Patent- og Varemærkestyrelsen

(12) # Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***A 61 C 13/00 (2006.01)*** ***A 61 C 13/20 (2006.01)*** ***F 27 B 17/02 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2019-08-12**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2019-05-22**

(86) Europæisk ansøgning nr.: **14830521.2**

(86) Europæisk indleveringsdag: **2014-12-18**

(87) Den europæiske ansøgnings publiceringsdag: **2016-10-26**

(86) International ansøgning nr.: **EP2014078387**

(87) Internationalt publikationsnr.: **WO2015091744**

(30) Prioritet: **2013-12-18 DE 102013226497**

(84) Designerede stater: **AT CH DE DK FR GB IT LI**

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(54) Benævnelse: **Fremgangsmåde til planlægning af en sintring af en tandprotesedel**

(56) Fremdragne publikationer:

EP-A1- 2 620 733
WO-A1-2014/016320
US-A- 4 796 688
US-A1- 2011 147 968

Method for planning a sintering of a dental prosthesis part

Description

Technical scope

The invention relates to a method for planning a sintering of a dental prosthesis part, a 3D model of the dental prosthesis part to be produced already having been constructed.

Prior art

Multiple methods for planning sintering processes are known in the prior art. Prior to carrying out the sintering using a sintering furnace, the user can pick out a specific program with a suitable temperature profile for the dental prosthesis part produced, the user taking into consideration the material used and the dimensions of the dental prosthesis part.

DE 10 2011 056 211 B3 discloses a device and a method for sintering sinter, in particular dental frameworks, a shell being covered by a closure element, the frame of the shell being connected to a protective gas supply. The heating rate, the holding temperature and a cooling time are able to be set manually.

EP 2 620 733 A1 discloses a dental device, such as a dental firing oven, having at least one operating program, having a storage facility and having at least one recording device, such as a camera. The object is able to be recorded by means of the camera and the object is able to be displayed in the recorded form with the aid of a display device. Multiple predetermined reference objects are contained in a data bank, an associated operating program being triggered when a specific number of features of a reference object match the image of the recorded object.

US 2009/0079101 A1 discloses a sintering furnace having a thermally insulated camera and a temperature measuring device. At a temperature profile, the heating rate is 140°C per minute, a holding temperature is 1400°C and a cooling rate is 50°C per minute.

DE 10 2008 013 555 A1 discloses a sintering furnace for producing dental prosthesis parts, the dental prosthesis parts being sintered along a sintering section. The dental prosthesis parts are exposed to different temperatures when moving through said sintering section. The sintering section is therefore divided into individual sintering segments which can be regulated to different temperatures. The carriers with the dental prosthesis parts to be sintered are moved along the sintering section with the aid of a slider. Different temperatures can be set for each of the sintering section segments. As a result, different temperature progressions can be set for the sintering of different ceramics.

Further sintering furnaces and corresponding methods are disclosed in US 2011/0147968A1, US 4,796,688A, EP 2 620 733 A1 and WO 2014/016320 A1.

A disadvantage of said methods is that the user is able to set incorrect temperature profiles as a result of operating errors such that this can lead to production faults in the dental prosthesis part to be produced. A temperature profile at too high a heating rate can result, for example, in the case of oxide ceramics, in cracks on the surface of the dental prosthesis part.

The object of the present invention consists, consequently, in providing a method for planning a sintering so that such operating errors are prevented.

Representation of the invention

The invention relates to a method for planning a heat treatment of a dental prosthetic part, wherein a 3D model of the dental prosthetic part to be produced already exists. A temperature profile for the heat treatment, such as sintering, crystallization or glazing, of the dental prosthetic part is determined automatically with the aid of a computer as a function of determined geometric parameters of the dental prosthetic part to be produced and of determined material parameters of the dental prosthetic part to be produced, wherein the material parameters of a material selected for producing the dental prosthetic part are a thermal conductivity, a thermal shock resistance, a maximum heating rate and/or a temperature limit value for a phase transformation of the material.

With an increasing thermal conductivity of the material used, the dental prosthetic part can be fully sintered more rapidly such that the holding time of the temperature profile is able to be reduced.

With a high level of thermal shock resistance of the material, the heating rate can also be increased without causing damage to the dental prosthetic part during the sintering process.

It is possible according to the present method to identify or determine a theoretically maximum heating rate for the respective dental prosthetic part. Mechanical characteristic values of the material used, such as a linear expansion coefficient, an E-modulus, strength, a Poisson’s ratio, a fracture toughness, an initial crack length or a form factor, and thermodynamic characteristic values, such as a volume-related thermal capacity or a thermal conductivity, and the geometric parameters of the dental prosthetic part are used to determine said maximum heating rate.

In the case of said method, the design of the dental prosthetic part has already been carried out so that a 3D model of the dental prosthetic part exists. The dental prosthetic part to be produced can be, for example, a full prosthesis for an implant, a dental prosthesis, a full crown, a partial crown, a bridge produced from multiple whole teeth or an inlay. The suitable temperature profile is determined on account of determined selection criteria as a function of geometric parameters and/or of the material parameters of the selected material. The temperature profile can be determined, for example, by automatically selecting the temperature profile from a plurality of different temperature profiles of a data bank or by calculating an individual temperature profile. The temperature profile can include at least one heating step or also multiple heating steps, the important point being that a maximum heating rate, which is a function of the material used and importantly a function of the wall thickness of the dental prosthetic part, is not exceeded, for this could result in cracks on the surface of the dental prosthetic part or even in the upper layers of the dental prosthetic part flaking off. This is because, during the sintering process, the outer layer of the dental prosthetic part can shrink more rapidly than the inner layers of the dental prosthetic part so that mechanical stresses result. Once the dental prosthetic part has been heated up at the established heating rate, a holding temperature is held for the duration of a determined holding time, a cooling phase then following. The cooling phase can be effected, for example, by opening a door of the sintering furnace used so that cool air is able to flow in. The holding temperature and the holding time are chosen such that the dental prosthetic part to be produced is certainly fully sintered but without any over-sintering being effected. In the case of over-sintering, it is possible for a size of a particle of the material used, which is to be sintered, to exceed an established limit value so that this can result in the dental prosthetic part having less strength.

An advantage of said method consists in that operating errors when manually selecting a suitable temperature profile are ruled out so that, as a result, production errors can be prevented.

A further advantage of said method consists in that, with consideration to the geometric parameters and/or the material parameters, it is possible to select a suitable temperature profile which comprises as short a duration as possible at as high a heating rate as possible and as short a holding time as possible so that, as a result, the duration of the heat treatment of the dental prosthetic part is shortened.

In an advantageous manner, the geometric parameters of the dental prosthetic part can advantageously be a maximum lateral wall thickness, a maximum occlusal wall thickness, a ratio of the maximum occlusal wall thickness and the maximum lateral wall thickness, a maximum cross section of the dental prosthetic part, a total volume of the dental prosthetic part, a maximum total length of the dental prosthetic part and/or a maximum cross-sectional change of the dental prosthetic part.

The maximum lateral wall thickness refers to the lateral wall thickness of the dental prosthetic part, for example at the labial surfaces in the case of incisors or the buccal surfaces in the case of molars. The maximum occlusal wall thickness refers to the wall thickness of an occlusal surface of the dental prosthetic part. The maximum cross section of the dental prosthetic part refers to a cross section perpendicularly to a tooth axis of the dental prosthetic part.

A suitable temperature profile is selected therefore on the basis of said geometric parameters, in particular a determined heating rate and a determined holding time at a holding temperature being determined.

In an advantageous manner, the temperature profile can be determined such that with increasing maximum lateral wall thickness, with increasing maximum occlusal wall thickness, with increasing maximum component cross section and/or with increasing total volume of the dental prosthetic part, a heating rate of the temperature profile decreases, a holding time of the temperature profile increases and/or a holding temperature of the temperature profile decreases.

In the case of an increasing wall thickness, the mechanical stresses during the sintering process also increase such that the heating rate has to be decreased in order to prevent damage to the dental prosthetic part.

In the case of an increasing component cross section or in the case of an increasing total volume of the dental prosthetic part, the holding time increases as it takes longer to sinter the dental prosthetic part fully.

In an advantageous manner, the temperature profile can be determined such that a heating rate of the temperature profile increases with increasing thermal conductivity and/or increasing thermal shock resistance.

As a result, the heating rate can be increased as a function of the thermal conductivity and of the thermal shock resistance of the higher material such that the total duration of the sintering process is able to be shortened.

In an advantageous manner, the heat treatment can comprise sintering, crystallization, a combination of sintering and glazing, or a combination of crystallization and glazing.

The sintering can be applied to oxide ceramics such as zirconium dioxide or aluminium oxide, and to non-precious metal alloys such as a CoCrMo-alloy.

Crystallization is effected, in particular, in the case of glass ceramics with the material system lithium disilicate.

Dental restorations which have been produced from sintered-on oxide ceramics in particular zirconium dioxide and aluminium oxide are finish-sintered. Blanks of metal, in particular produced from CoCrMo-alloys, pressed from powder and sintered on, after further mechanical processing by grinding or milling also have to be sintered to form dental restorations.

All metal or ceramic base materials can be veneered or glazed after sintering by means of further firing processes. Painting, which is fired in the same furnace process, can also be effected together with the glazing as a so-called surface finish.

The advantage of glass ceramics, furthermore, is that they can be crystallized, painted and glazed in the same firing process.

In an advantageous manner, the selected material to produce the dental prosthetic part can be zirconium dioxide, wherein the dental prosthetic part to be produced is a single tooth, a full crown, a partial crown or an inlay. The total volume of the dental prosthetic part corresponds, in this case, to at most the volume of a molar, wherein the maximum lateral wall thickness and/or the maximum occlusal wall thickness are below a limit value of 6 mm. With consideration to said factors, a first temperature profile for a sintering at a heating rate between 100°C/minute and 400°C/minute, with a holding temperature between 1500°C and 1600°C and a holding time between 5 minutes and 10 minutes is determined.

As a result of the relatively thin wall thickness and the small total volume of the dental prosthetic part, a relatively high heating rate is made possible such that the total duration is shortened. The small total volume also makes it possible to sinter the dental prosthetic part more rapidly so that the holding time chosen is relatively short and, as a result, the total duration of the sintering, consequently, is additionally shortened. The first temperature profile therefore enables a rapid sintering for relatively small dental prosthetic parts.

In an advantageous manner, the selected material can be zirconium dioxide, wherein the dental prosthetic part to be produced is a bridge consisting of at most six connected teeth or consisting of at most six individual teeth. With consideration to said factors, a second temperature profile for a sintering at a heating rate between 70°C/minute and 200°C/minute, with a holding temperature between 1450°C and 1550°C and a holding time between 20 minutes and 40 minutes is determined.

The second temperature profile is chosen for dental prosthetic parts with a total volume of at most six teeth, a longer holding time than in the case of the first temperature profile being necessary for fully sintering the dental prosthetic part.

In an advantageous manner, the selected material can be zirconium dioxide, wherein the dental prosthetic part to be produced comprises more than 6 individual teeth, wherein a third temperature profile for a sintering at a heating rate between 10°C/minute and 70°C/minute, with a holding temperature between 1500°C and 1600°C and a holding time between 100 minutes and 140 minutes is determined.

The third temperature profile is chosen for relatively large dental prosthetic parts with a total volume of more than six teeth, the heating rate being significantly decreased compared to the first temperature profile and to the second temperature profile in order to prevent cracks on the surface of the dental prosthetic part. The holding time is clearly increased compared to the first temperature profile and to the second temperature profile in order to ensure full sintering of the dental prosthetic part.

In an advantageous manner, the selected material can be aluminium oxide (Al_2O_3), wherein a fourth temperature profile for a sintering at a heating rate between 10°C/minute to 70°C/minute, with a holding temperature between 1500°C and 1600°C and a holding time between 100 minutes and 140 minutes is determined.

The fourth temperature profile is suitable for the material aluminium oxide, the heating rate and the holding time being chosen as in the case of the third temperature profile independently of the size of the dental prosthetic part.

In an advantageous manner, the 3D model of the dental prosthetic part to be produced can be graphically displayed by means of a display device, wherein specific subregions of the 3D model that exceed a specific limit value with respect to the labial wall thickness or the occlusal wall thickness are graphically marked.

The display device can be, for example, a monitor which displays the constructed 3D model of the dental prosthetic part to be produced in a graphic manner. The regions where the wall thickness exceeds the determined limit value, such as, for example, to the amount of 3 mm, are graphically marked. In this way, the user is able to recognize which subregions of the 3D model do not meet the geometric parameters for the first temperature profile or for the second temperature profile. The user, such as a dentist or dental technician, is then able to adjust said marked subregions correspondingly.

In an advantageous manner, the user can manually adjust the marked subregions by means of virtual tools or the marked subregions are automatically adjusted by means of the computer such that the value for the labial wall thickness or the occlusal wall thickness is less than the limit value. As a result, quicker sintering using the first temperature profile instead of the second temperature profile can be carried out for the dental prosthetic part to be produced according to said adjusted 3D model.

The user can therefore adjust the marked regions such that the value for the wall thickness, for example 3 mm, is less than the limit value. As a result, the geometric parameters for the first temperature profile are met so that the sintering is able to be carried out with the first temperature profile such that this leads to a shortening of the total duration of the sintering process compared to the sintering with the second temperature profile.

The determining of the suitable temperature profile can be effected in an advantageous manner by means of a selection from multiple temperature profiles which are stored in a data bank.

The different temperature profiles can be stored, for example, in a storage unit which is arranged in a microcomputer, which is integrated into the sintering furnace. As an alternative to this, said storage unit can also be integrated in a computer which is arranged outside the sintering furnace.

The characteristic data of the temperature profiles, such as the heating rate, the holding time and/or the holding temperature can be graphically displayed by means of a display device. The display device can be, for example, a display which is adjusted to the sintering furnace. In this case, the selection is made automatically by means of a computer, the characteristic data of the selected temperature profile being able to be displayed graphically.

In an advantageous manner, the determining of the suitable temperature profile can be effected as a result of calculating an individual temperature profile which is calculated with consideration to the geometric parameters and/or the material parameters of the dental prosthetic part to be produced.

As a result, therefore, an individual temperature profile is calculated with consideration to the geometric parameters and/or the material parameters. In this case, known mathematical methods, such as interpolation, can be used.

The invention additionally relates to a system for carrying out a method for planning a heat treatment of a dental prosthetic part by means of a sintering furnace comprising a computer, wherein a 3D model of the dental prosthetic part to be produced already exists. A temperature profile for the sintering of the dental prosthetic part can be determined, in this case, automatically with the aid of a computer as a function of determined geometric parameters of the dental prosthetic part to be produced and of determined material parameters of the dental prosthetic part to be produced.

The system therefore enables the above-named method to be carried out, a suitable temperature profile for the respective dental prosthetic part being determined automatically with the aid of the computer as a function of the geometric parameters and of the material parameters.

An advantage of said system consists in that operating errors by the user, such as a dentist or dental technician, are prevented when manually selecting a suitable temperature profile.

In an advantageous manner, the system can comprise a display device, wherein the 3D model of the dental prosthetic part to be produced can be graphically displayed by means of the display device, wherein specific subregions of the 3D model that exceed a specific limit value with respect to the labial wall thickness or the occlusal wall thickness can be graphically marked.

By marking the subregions which do not meet the determined geometric parameters, such as the wall thickness, for example for the first temperature profile, it is possible for the user to estimate the dimensions of said subregions and consequently the necessary adjustments to the 3D model in a better manner.

In an advantageous manner, the system can comprise operating means, wherein the user manually adjusts the marked subregions by means of virtual tools using the operating elements, or the marked subregions are automatically adjusted by means of the computer such that the value of 6 mm for the labial wall thickness or the occlusal wall thickness is less than the limit value. As a result, more rapid sintering can be carried out using the first temperature profile instead of the second temperature profile for the dental prosthetic part to be produced according to said adjusted 3D model.

As a result of adjusting the 3D model in said manner, the sintering can therefore be carried out using the first temperature profile instead of the second temperature profile so that, as a result, the total duration of the sintering is shortened.

In an advantageous manner, the system can comprise a storage unit, the determining of the suitable temperature profile being effected by means of a selection from multiple temperature profiles which are stored in the storage unit in a data bank.

In an advantageous manner, the determining of the suitable temperature profile can be effected by calculating an individual temperature profile with the aid of the computer, the individual temperature profile being calculated with consideration to the geometric parameters and/or the material parameters of the dental prosthetic part to be produced.

Brief description of the drawings

The invention is explained by way of the drawings, in which

fig. 1 shows a sketch for illustrating the present method,

fig. 2 shows a 3D model of the dental prosthetic part with marked regions, fig. 3 shows multiple temperature profiles for carrying out a sintering process.

Exemplary embodiments

Fig. 1 shows a sketch for illustrating the present method for planning a heat treatment of a dental prosthetic part 1 using a sintering furnace 2. The sintering furnace comprises, in this case, insulation elements 3 and heating elements 4 in order to regulate the temperature inside a firing chamber 5. The heat treatment of the dental prosthetic part 1 such as a sintering, a crystallization or a glazing is carried out by the chamber 5 being heated by means of the heating elements 4 in a first step. Once a specific charging temperature has been obtained, for example 300°C, the chamber 5 is opened in a second step by a base 6 being moved into a lower end position 7. In a third step, the user, such as a dentist or a dental technician, positions the dental prosthetic part 1 to be sintered on the base 6. In a fourth step, the chamber re-closes by the base being moved into an upper end position again, as shown by the arrows 8. In a fifth step, the chamber 5 is heated further to a holding temperature by means of the heating elements 4 and said holding temperature is held for the duration of a specific holding time. A cooling phase is effected in a sixth step. The cooling phase can be effected, for example, by shutting off the heating elements or additionally by opening the chamber 5 by the base being moved into the lower end position 7.

When carrying out the present method for planning the heat treatment, a 3D model 9 of the dental prosthetic part 1 already exists. Consequently, therefore, the design of the dental prosthetic part has already been completed. The 3D model 9 is shown graphically with the aid of a display device 39, such as a monitor. The 3D model 9 of the dental prosthetic part 1 comprises determined geometric parameters, such as a lateral wall thickness 10, an occlusal wall thickness 11, a maximum cross section 12 which is shown by the one broken line, and a total volume 13 of the dental prosthetic part. Furthermore, the material from which the dental prosthetic part to be produced is to be made has already been established in the design. Oxide ceramics, such as zirconium oxide, aluminium oxide, or non-precious metal alloys, such a CoCrMo alloy, can be used, for example, as the material. The maximum cross section 12 of the dental prosthetic part can be determined, for example, perpendicularly to a tooth axis 14 to which an axis of symmetry of the dental prosthetic part can correspond. The lateral wall thickness 10 can be determined, for example, perpendicularly to the tooth axis 14 in the labial region or in the buccal region of the dental prosthetic part. The occlusal wall thickness 11 can be determined, for example, parallel to the tooth axis 14 on an occlusal surface 15 of the 3D model 9. A suitable temperature profile 16 is determined automatically with the aid of a computer 17 by using the geometric parameters 10, 11, 12, 13 and the material parameters of the selected material.

The computer 17 can be, for example, a microcomputer, a microchip or a conventional PC. The computer 17 can be arranged externally outside the sintering furnace 2. As an alternative to this, the computer 17 can also be integrated into the sintering furnace 2 with the display device 39.

The temperature profile 16 is shown as a graph of a temperature 17 as a function of the time 18. In a first phase 19, the chamber 5 is heated up to a pre-drying temperature 20 at a first heating rate, in a second phase 21 the pre-drying temperature is held for a first holding time, in a third phase 22 the temperature in the chamber 5 is heated up to a charging temperature, for example to 300°C. In a fourth phase the chamber 5 is charged with the dental prosthetic part 1 to be sintered so that there is a slight drop in the temperature. In a fifth phase 23, the temperature in the chamber 5 increases at a second heating rate up to a second holding temperature 24. In a sixth phase 25, the heating elements 4 are controlled such that the holding temperature 24 is held for a duration of a specific holding time. In the seventh phase 26, the dental prosthetic part 1 is cooled. The suitable temperature profile 16 is determined therefore with the aid of the computer 17 as a function of the geometric parameters, in particular of the maximum lateral wall thickness 10, the maximum occlusal wall thickness 11 and the total volume 13, and as a function of the material parameters of the selected material. The heating rates for the heating phases 19, 23, the holding temperatures 20, 24 and the holding times of the phases 21, 25 are established, in particular, in this case.

Whether the designed 3D model 9 of the dental prosthetic part 1 meets the determined requirements with reference to the geometric parameters, such as the lateral wall thickness or the occlusal wall thickness, can then be checked with a so-called plausibility check. In this case, subregions 27 and 28, shown by a dotted line, which do not meet the established limit values of the geometric parameters, can be marked. For example, subregions 27, 28 which exceed a limit value of 6 mm with reference to the occlusal wall thickness can be marked. Said marked subregions 27 and 28 can then be modified either manually by the user with the aid of a virtual tool 29, such as a cursor, or automatically with the aid of the computer 17 such that the limit values with reference to the geometric parameters are met. The control of the virtual tool 29 can be effected with the aid of connected input means, such as a keyboard 30 and a mouse 31. An adjusted 3D model 32, which is shown by a broken line, is generated as a result of adjusting or modifying the 3D model 9. The dental prosthetic part 1 to be sintered is then produced in a fully automatic manner from a blank 34 with the aid of a CAM processing machine 33 by way of the adjusted 3D model 32. Once the dental prosthetic part 1 to be sintered has been produced, the sintering is effected with the aid of a sintering furnace 2, as described above.

The advantage of said method consists, therefore, in that a determining of a suitable temperature profile 16 and a plausibility check and a possible adjustment of the 3D model 9 can already have been effected prior to the production of the dental prosthetic part with the aid of the CAM processing machine 33 and prior to the sintering of the dental prosthetic part 1 with the aid of the sintering furnace 2.

The determining of the temperature profile 16 can be effected, in this case, for example, by means of a selection from multiple temperature profiles which are stored in a storage unit 35. Said storage unit 35 is integrated into the computer 17. As an alternative to this, the temperature profiles can be stored in a second storage unit 36 which is integrated into the sintering furnace 2.

The determining of the suitable temperature profile can also be effected by calculating an individual temperature profile which is calculated with the aid of the computer 17.

The present method for planning a heat treatment can also be effected for multiple dental prosthetic parts and multiple heat treatments before the sintering process is started. In this case, an order overview can be set up which includes multiple orders. An order, in this case, can include the characteristic data such as the name of the patient, the type of dental prosthetic part such as full crown, partial crown or bridge, the material for producing the dental prosthetic part, the type of heat treatment such as sintering, crystallization or glazing and the type of suitable temperature profile. The orders with said characteristic data can be displayed, for example, with the aid of a display 37 which is integrated in the sintering furnace 2. As an alternative to this, the orders could also be displayed with the characteristic data with the aid of the display device 39. The user is able to select the respective order with the assigned temperature progression with the aid of a control panel 38 prior to carrying out the sintering process. The sintering is then carried out automatically, therefore, with a suitable temperature profile.

Fig. 2 shows the 3D model 9 of the dental prosthetic part 1 from fig. 1, the regions 27 and 28 which exceed a limit value, for example of 6 mm, with reference to the occlusal wall thickness, being marked.

Once the 3D model 9, which is shown by the broken line, has been adjusted or modified, an adjusted 3D model 32 is generated. The dental prosthetic part 1 is then produced by way of the adjusted 3D model 32 with the aid of the CAM processing machine 33 from fig. 1.

Fig. 3 shows multiple temperature profiles for carrying out a sintering process, the temperature 17 being recorded in °C as a function of the time 18 in minutes. A first temperature profile 40 comprises a heating rate 41 of 100°C/min, a holding temperature 42 of 1580°C and a holding time 43 of 6 minutes. A second temperature profile 44 comprises a heating rate 45 of 100°C/min, a holding temperature 46 of 1510°C and a holding time 47 of 30 minutes. A third temperature profile 48, which is shown by a dot-dash line, comprises a heating rate 49 of 25°C/min, a holding temperature 50 of 1510°C and a holding time 51 of 120 minutes. A fourth temperature profile 52, which is shown by a dot-dash line, comprises a pre-drying phase 53, the temperature being heated up to a pre-drying temperature 54 and being held for 20 minutes. The heating-up phase then follows at a heating rate 55 of 100°C/minute up to a holding temperature 56 of 1510°C. Said holding temperature 56 is then held for a duration of a holding time 57 of 30 minutes, a cooling phase then following this. A fifth temperature profile 58 comprises a heating rate 59 of 300°C/min, a holding temperature 60 of 1580°C and a holding time of 6 minutes.

The first temperature profile 40 is suitable, in particular, for small dental prosthetic parts with a thinner wall thickness, for example less than 6 mm, and a small total volume, the high heating rate 41 and the short holding time 43 of 6 minutes enabling a short sintering duration. The second temperature profile 44 is suitable for medium dental prosthetic parts with a maximum wall thickness of in excess of 6 mm and consisting of no more than six individual teeth. The third temperature profile 48 is suitable for large dental prosthetic parts, such as bridges produced from more than six teeth. The fourth temperature profile 52 is suitable for materials where a pre-drying process is necessary prior to the sintering process.

The 3D model 9 from fig. 1 and fig. 2 can therefore be modified by the user or automatically with the aid of the computer such that the requirements or the limit values for a specific temperature profile are met. Fig. 2 shows that the 3D model 9 has been adjusted such that the occlusal wall thickness 11 does not exceed a limit value of 6 mm. Consequently, therefore, the sintering process for the dental prosthetic part 1 to be produced according to the adjusted 3D model 32 can be carried out with the first temperature profile 40 instead of with the second temperature profile 44. The advantage of said adjustment, therefore, consists in the duration of the sintering process being shortened.

List of references

1	Dental prosthetic part
2	Sintering furnace
3	Insulation element
4	Heating element
5	Firing chamber
6	Base
7	End position
8	Arrow
9	3D model
10	Lateral wall thickness
11	Occlusal wall thickness
12	Cross section
13	Total volume
14	Tooth axis
15	Occlusal surface
16	Temperature profile
17	Computer
18	Time
19	First phase
20	Pre-drying phase
21	Second phase
22	Third phase
23	Fifth phase
24	Holding temperature
25	Sixth phase
26	Seventh phase
27	Subregion
28	Subregion
29	Virtual tool
30	Keyboard
31	Mouse

32	Adjusted 3D model
33	CAM processing machine
34	Blank
35	Storage unit
36	Second storage unit
37	Display
38	Control panel
39	Display device
40	First temperature profile
41	Heating rate
42	Holding temperature
43	Holding time
44	Second temperature profile
45	Heating rate
46	Holding temperature
47	Holding time
48	Third temperature profile
49	Heating rate
50	Holding temperature
51	Holding rate
52	Fourth temperature profile
53	Pre-drying phase
54	Pre-drying temperature
55	Heating rate
56	Holding temperature
57	Holding time
58	Fifth temperature profile
59	Heating rate
60	Holding temperature

PATENTKRAV

1. Fremgangsmåde til planlægning af en varmebehandling af en tandprotesedel (1), hvorved der allerede foreligger en 3D-model (9) af tandprotesedelen (1), som skal fremstilles, **kendetegnet ved, at**, i afhængighed af bestemte geometriparametre (10, 11, 12, 13) for 3D-modellen (9) og af bestemte materialeparametre for tandprotesedelen (1), som skal fremstilles, der automatisk ved hjælp af en computer (17) bestemmes en temperaturprofil (16) for varmebehandlingen af tandprotesedelen (1), hvorved materialeparametrene for et til fremstilling af tandprotesedelen (1) udvalgt materiale er en varmeledningsevne, en termochok-modstandsevne, en maksimal opvarmningshastighed og/eller en temperaturgrænseværdi for et faseskift af materialet.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** geometriparametrene (10, 11, 12, 13) for 3D-modellen (9) af tandprotesedelen (1) er en maksimal lateral vægtykkelse (10), en maksimal okklusal vægtykkelse (11), et forhold mellem den maksimale okklusale vægtykkelse (11) og den maksimale laterale vægtykkelse (10), et maksimalt tværsnit (12) af tandprotesedelen (1), et totalvolumen (13) af tandprotesedelen (1), en maksimal totallængde af tandprotesedelen (1) og/eller en maksimal tværsnitsændring af tandprotesedelen (1).

3. Fremgangsmåde ifølge krav 2, **kendetegnet ved, at** temperaturprofilen (16) bestemmes således, at, ved en stigende maksimal lateral vægtykkelse (10), ved en stigende maksimal okklusal vægtykkelse (11), ved et stigende maksimalt komponenttværsnit og/eller ved et stigende totalvolumen (13) for tandkomponentdelen (1), en opvarmningshastighed (41, 45, 49, 55, 59) for temperaturprofilen (16) synker, en holdetid (43, 47, 51, 57) for temperaturprofilen (16) stiger, og/eller en holdetemperatur (42, 46, 50, 56, 60) for temperaturprofilen (16) synker.

4. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** temperaturprofilen (16) bestemmes således, at ved stigende varmeledningsevne og/eller stigende termochok-modstandsevne stiger en opvarmningshastighed (41, 45, 49, 55, 59) for temperaturprofilen (16).

5. Fremgangsmåde ifølge et af kravene 1 til 4, **kendetegnet ved, at** varmebehandlingen er en sintring, en krystallisering, en kombination af en sintring og en glasering eller en kombination af en krystallisering og en glasering.

6. Fremgangsmåde ifølge et af kravene 1 til 5, **kendetegnet ved, at** det udvalgte materiale til fremstilling af tandprotesedelen (1) er zirkoniumdioxid (ZrO_2), hvorved tandprotesedelen (1), der skal fremstilles, er en enkelt tand, en helkrone, mindst en delkrone eller mindst et indlæg, hvorved tandprotesedelens (1) totalvolumen (13) højst svarer til en kindtands volumen, hvorved den maksimale laterale vægtykkelse (10) og/eller den maksimale okklusale vægtykkelse (11) ligger under en grænseværdi på 6 mm, hvorved en første temperaturprofil (40) bestemmes for en sintring med en opvarmningshastighed (41) mellem 100 °C/minut og 400 °C/minut, med en holdetemperatur (42) mellem 1500 °C og 1600 °C, såvel som en holdetid (43) mellem 5 minutter og 10 minutter.

7. Fremgangsmåde ifølge et af kravene 1 til 5, **kendetegnet ved, at** det udvalgte materiale er zirkoniumdioxid (ZrO_2), hvorved tandprotesedelen, der skal fremstilles, er en bro med højst 6 forbundne tænder eller med højst 6 enkelte tænder henholdsvis delkroner, hvorved der bestemmes en anden temperaturprofil (44) for en sintring med en opvarmningshastighed (45) på mellem 70 °C/minut og 200 °C/minut, med en holdetemperatur (46) mellem 1450 °C og 1550 °C såvel som en holdetid (47) mellem 20 minutter og 40 minutter.

8. Fremgangsmåde ifølge et af kravene 1 til 5, **kendetegnet ved, at** det udvalgte materiale er zirkoniumdioxid (ZrO_2), hvorved tandprotesedelen, som skal fremstilles, omfatter mere end 6 enkelte tænder, hvorved en tredje temperaturprofil (48) bestemmes for en sintring med en opvarmningshastighed (49) mellem 10 °C/minut og 70 °C/minut, med en holdetemperatur (50) mellem 1500 °C og 1600 °C og en holdetid (51) mellem 100minutter og 140 minutter.

9. Fremgangsmåde ifølge et af 1 til 5, **kendetegnet ved, at** det udvalgte materiale er aluminiumoxid (Al_2O_3), hvorved en fjerde temperaturprofil (52) bestemmes for en sintring med en opvarmningshastighed (55) mellem 10 °C/minut og 70 °C/minut, med

en holdetemperatur (56) mellem 1500 °C og 1600 °C såvel som en holdetid mellem 100 minutter og 140 minutter.

10. Fremgangsmåde ifølge et af kravene 1 til 9, **kendetegnet ved, at** 3D-modellen (9) af tandprotesedelen (1), som skal fremstilles, repræsenteres grafisk ved hjælp af en display-indretning (39), hvorved der grafisk markeres bestemte delområder (27, 28) af 3D-modellen (9), som med hensyn til labial vægtykkelse eller okklusal vægtykkelse (11) overskrider en bestemt grænseværdi.

11. Fremgangsmåde ifølge krav 10, **kendetegnet ved, at** brugeren manuelt tilpasser de markerede delområder (27, 28) således under anvendelse af virtuelle værktøjer (29), henholdsvis at de markerede delområder (27, 28) automatisk ved hjælp af computeren (17) tilpasses således, at grænseværdien for den labiale vægtykkelse (10, 11) eller den okklusale vægtykkelse (11) underskrides, således at sintring af tandprotesedelen (1), som skal fremstilles efter denne tilpassede 3D-model (32), kan gennemføres med den første temperaturprofil (40) i stedet for med den anden temperaturprofil (44).

12. System til gennemførelse af en fremgangsmåde til planlægning af en varmebehandling af en tandprotesedel (1) ved hjælp af en sintringsovn (2), omfattende en computer (17), hvorved der allerede foreligger en 3D-model (9) af tandprotesedelen (1), som skal fremstilles, **kendetegnet ved, at** en temperaturprofil (16) for sintringen af tandprotesedelen (1) ved hjælp af en computer (17) kan bestemmes automatisk som en funktion af bestemte geometriske parametre (10, 11, 12, 13) i 3D-modellen (9) og af bestemte materialeparametre for tandprotesedelen (1), der skal fremstilles, hvorved materialeparametrene for et materiale, der er udvalgt til fremstilling af tandprotesedelen (1), er en varmeledningsevne, en termochok-modstandsevne, en maksimal opvarmningshastighed og/eller en temperaturgrænseværdi for en faseændring af materialet.

13. System ifølge krav 12, **kendetegnet ved, at** geometriparametrene (10, 11, 12, 13) i 3D-modellen (9) af tandprotesedelen (1) er en maksimal lateral vægtykkelse (10), en maksimal okklusal vægtykkelse (11), et forhold mellem den maksimale okklusale vægtykkelse (11) og den maksimale laterale vægtykkelse (10), et maksimalt tværsnit (12) af tandprotesedelen, et totalvolumen (13) af tandprotesedelen (1), en maksimal

totallængde af tandprotesedelen (1) og/eller en maksimal tværsnitsændring af tandprotesedelen.

14. System ifølge krav 12 eller 13, **kendetegnet ved, at** systemet omfatter en display-indretning (39), hvorved 3D-modellen (9) af tandprotesedelen (1), som skal fremstilles, kan vises grafisk ved hjælp af display-indretningen (39), hvorved der grafisk kan markeres bestemte delområder (27, 28) af 3D-modellen (9), og som med hensyn til den labiale vægtykkelse eller den okklusale vægtykkelse overskrider en bestemt grænseværdi.

15. System ifølge krav 14, **kendetegnet ved, at** systemet omfatter betjeningsmidler (30, 31), hvorved brugeren manuelt tilpasser de markerede delområder (27, 28) under anvendelse af betjeningselementerne (30, 31) ved hjælp af virtuelle værktøjer (29) på en sådan måde, henholdsvis at de markerede delområder (27, 28) ved hjælp af computeren (17) automatisk tilpasses således, at grænseværdien for den labiale vægtykkelse eller den okklusale vægtykkelse (11) underskrides, således at sintringen af tandprotesedelen, der skal fremstilles i henhold til 3D-modellen (9, 32), kan udføres ved anvendelse af den første temperaturprofil (16) i stedet for den anden temperaturprofil (16).

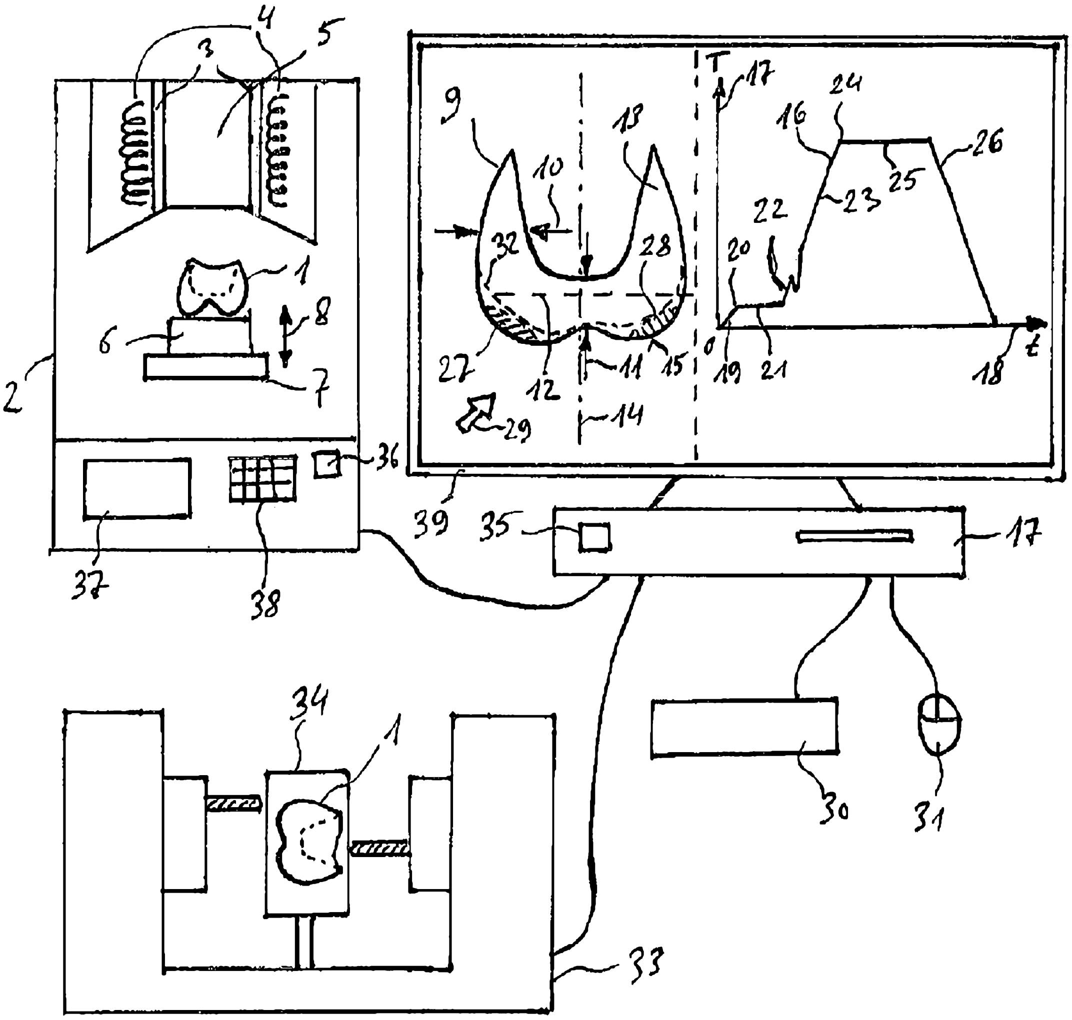
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Fig. 1

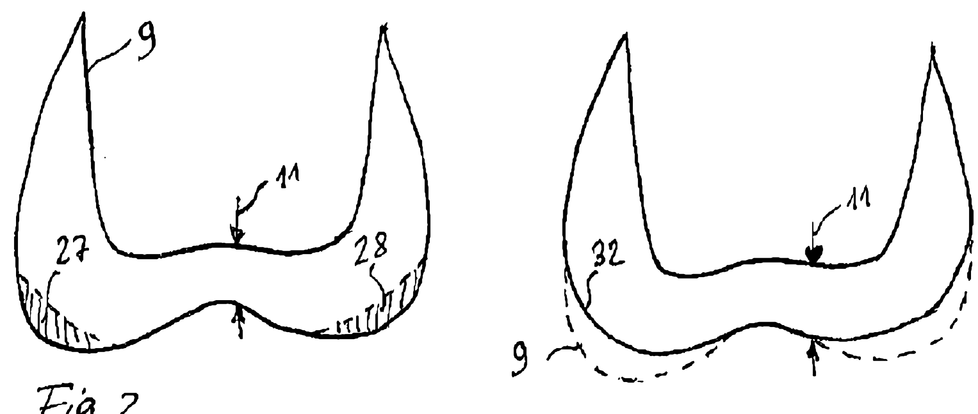
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Fig. 2

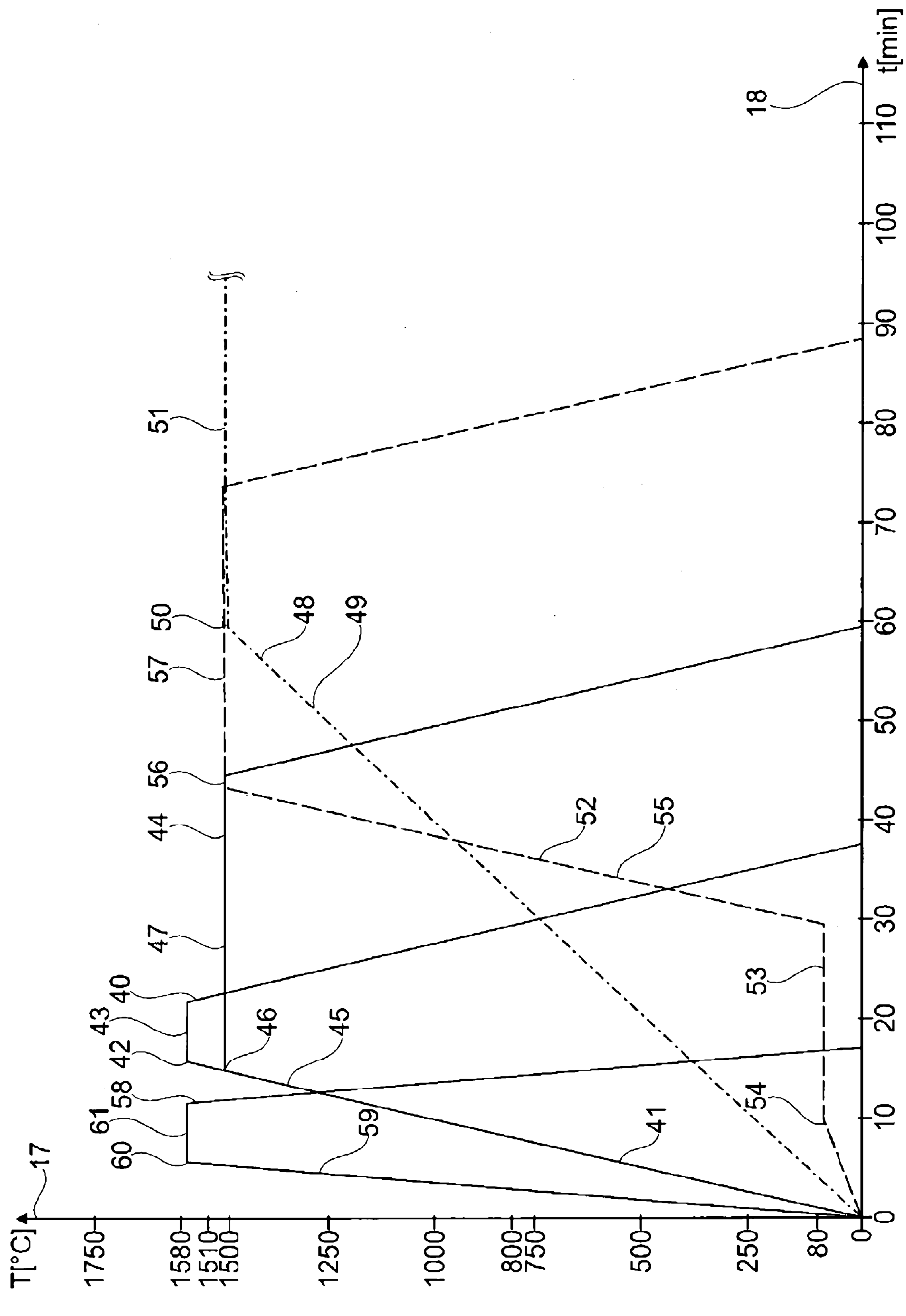
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Fig. 3