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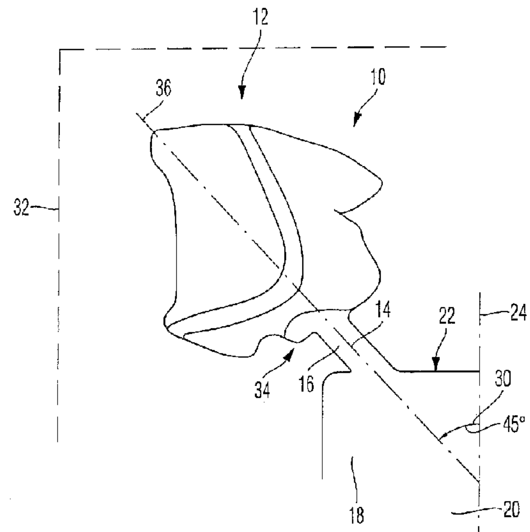
(54) Titre : PROCEDE DE FABRICATION D'UNE RESTAURATION DENTAIRE AINSI QUE DISPOSITIF DE PRODUCTION DE PRODUIT CERAMIQUE DENTAIRE
(54) Title: PROCESS FOR MANUFACTURING A DENTAL RESTORATION AS WELL AS DENTAL CERAMICS PRODUCTION DEVICE



(57) Abrégé/Abstract:
Dental restorations are designed and produced based on scan of mouth using CAD software module and a removable material. A positive model is molded and removed via a muffle with a pressing channel and feeder channels. The feeder channel and the pressing channel form a tree-like arrangement, the pressing channel forming the trunk and the feeder channels forming the branches, the dental restorations at tips of the branch. The feeder channel extending at an angle between 0° and 130° away from the pressing channel axis. A flow resistance of the dental material is set by dimensioning the feeder channel. A site at the thickest wall of the positive model is the docking site of the feeder channel, and the module aligns positive model to elongate the axis of the feeder channel and maximize an axial length of the positive model.

Abstract

Dental restorations are designed and produced based on scan of mouth using CAD software module and a removable material. A positive model is molded and removed via a muffle with a pressing channel and feeder channels. The feeder channel and the pressing channel form a tree-like arrangement, the pressing channel forming the trunk and the feeder channels forming the branches, the dental restorations at tips of the branch. The feeder channel extending at an angle between 0° and 130° away from the pressing channel axis. A flow resistance of the dental material is set by dimensioning the feeder channel. A site at the thickest wall of the positive model is the docking site of the feeder channel, and the module aligns positive model to elongate the axis of the feeder channel and maximize an axial length of the positive model.

Date Reçue/Date Received 2021-07-27

Patent Application

Process for Manufacturing a Dental Restoration as well as Dental Ceramics Production Device

The invention concerns a process for manufacturing a dental restoration as well as a dental ceramics production device.

It has been known for a long time to work according to the principle of the expendable mould in the manufacturing of dental restorations. For this purpose, a positive model of the dental restoration is first manufactured in a suitable fashion, for instance also in accordance with the preferences of the dental technician or the dentist, which is done out of wax or out of another substance that can be incinerated without leaving residues, such as a polymer.

Date Reçue/Date Received 2021-07-27

This positive model is then connected with what is referred to as a muffle base via a conveyor channel which can, for example, consist of the same material as the positive model of the dental restoration as a pin-shaped element. This muffle base consists of a disc consisting of a plastic material, from which a peg-shaped projection rises up whose front surface is used as the base of the conveyor channel.

After the positive model has been applied together with the conveyor channel, a small radius can possibly also be attached at the transition between conveyor channel and dental restoration on the one hand, and the front surface of the muffle base on the other hand, respectively, which is usually referred to as merging.

A silicone ring is then slipped over the disc-shaped muffle base, which is provided with a recess, and a self-hardening casting compound is cast into the inside space thus formed. This can, for instance, consist of plaster or other suitable materials.

After hardening, the silicone ring is removed or rolled off, and the muffle base is pulled off. In this process, the connection between the front surface and the conveyor channel or the conveyor channels is loosened while the wax components still remain in the hardened muffle for the moment.

The muffle is then heated, which is done to a temperature that makes it possible to remove the wax components without any residues being left. This can happen in what is referred to as a pre-heating furnace, for example, that provides a temperature of 700°C.

Subsequent to this, the muffle with the cavities which now remain in place of the positive model, or the cavity which now remains in place of the positive model, is turned around, such that the channel that corresponded to the peg of the muffle base lies free on top. This channel is at the same time the pressing channel, and a blank made of a material is inserted into it which is suitable for shaping the dental restorations, such as of a dental ceramics material.

A pressing furnace is provided with a pressing plunger which enters into the pressing channel and further heats up the blank together with the muffle in accordance with a predetermined pressing programme, for example to a range of 1100°C in case of a silicate or feldspar ceramic material, or to 1600°C in case of an oxide ceramic material.

In accordance with an exactly predetermined pressing programme, pressure and heating are than controlled in unison with each other, such that the blank enters the cavity or the cavities via the conveyor channels when melting, and there the dental restoration is produced, if possible without any bubbles.

The process described here has been known for at least 30 years and is in wide-spread use today.

Lately, it has been practised in many cases to take a scan of the patient's mouth for manufacturing the positive model, and via a CAD software the desired dental restoration is designed and produced.

It has also been suggested already to use a generative process for the production of the positive model after the computer-controlled moulding, i.e. for instance to produce the positive model by means of rapid prototyping. Reference is to be made by way of example to DE 103 32 802 A1.

Per se, such rapid prototyping processes, which are basically suitable for dental technology also with respect to resolution, such as for instance stereolithography, have also been known for quite a long time, which means since the 1980s.

In the field of dentistry, the use of the technology of rapid prototyping for the manufacturing of models has at least been known for about 20 years in accordance with WO 95/28688 A1, to which models the positive model mentioned above belongs as well.

Despite the basically obvious advantages of computer-assisted design which have been known for quite a long time, this technology has not been able to gain universal acceptance.

It has also been suggested already to produce the dental restoration part, instead of manufacturing it by means of pressing, with the help of a casting process. This technology too has basically been known for a long time.

It has been suggested in recent times in this respect to produce a positive model with the help of computer assistance, which is in a generative fashion, in order to thus avoid the necessity of the step of milling. In this suggestion, the problem played a role that during milling, complex inside corners can only be put into practice with great difficulty. The casting of a mould cavity in a muffle makes it possible to provide the dental restoration at a central position inside the muffle. At this position, the muffle usually has a rather low temperature gradient, for the muffle is typically heated with the help of a heating which annularly surrounds it, wherein, if necessary, an additional heating is provided from underneath too. In the outside area of the muffle, the temperature gradient is usually considerably larger, especially with the fast heating of the muffle with the help of the dental furnace, which is aimed at.

The production of the dental restoration thus suggested, however, has two essential disadvantages, such that it is not astonishing that this suggestion has not gained acceptance: First, in case of a central arrangement, only one single dental restoration can be produced with the help of a muffle, which is extremely inefficient. Second, the quality of the surface is distinctly better and closer to nature with pressed dental ceramics.

In contrast to this, the invention is based on the task of providing a process for manufacturing a dental restoration as well as a dental restoration production device, which allow the creation of a dental restoration of high quality and in a very efficient fashion, wherein the process and the device should be particularly suitable especially if lithium disilicate is used as the dental ceramics material.

In an aspect, there is provided a process for manufacturing dental restorations, comprising: designing a dental restoration based on a scan of a mouth, using a CAD software; producing a positive model of the dental restoration using a residue-free removable material, by ablation or generatively, wherein the positive model is molded and removed via a muffle, the muffle being provided with a pressing channel connected via a feeder channel to a cavity corresponding to the positive model for the dental restoration; wherein a blank of dental material introduced into the pressing channel is heated and pressurized so that the blank deforms and the dental material enters and fills the cavity through the feeder channel, wherein, during molding or subsequently thereto, the feeder channel is automatically created by a module of the CAD software for the positive model based on dimensions of the muffle in relation to the size and shape of the positive model, wherein the module defines an interior space within the muffle for arranging the dental restoration therein, wherein the feeder channel is connected to the pressing channel such that the pressing channel and the feeder channel form a tree-like arrangement, the pressing channel forming a trunk of the tree-like arrangement and the feeder channel forming a branch of the tree-like arrangement, the dental restoration being provided at a tip of the branch, the feeder channel extending at an angle between 0° and 130° away from an axis of the pressing channel, wherein a flow resistance of a ceramic material used as a dental material is set by dimensioning the feeder channel, and wherein a site having the thickest wall thickness of the positive model is selected as a docking site of the feeder channel on the dental restoration and the module aligns the positive model with respect to the feeder channel to elongate an axis of the feeder channel and maximize an axial length of the positive model.

In another aspect, there is provided a dental ceramic manufacturing device, comprising a CAD/CAM device for providing a press mold for the manufacture of dental ceramics, wherein the CAD/CAM device has CAD software for determining a

Date Reçue/Date Received 2021-07-27

shape of a dental restoration based on scan of a mouth, and has a CAM device for determining configuration of a plurality of dental restorations for the mouth via a muffle, wherein the CAD software comprises a module for automatically determining an angular position and dimensions of a respective feeder channel between a central pressing channel and a respective cavity for shaping a respective one of the dental restorations within a respective inner space within the muffle, wherein an angle of incidence of the respective dental restoration in relation to a respective feeder channel axis of the respective feeder channel at a docking site of the feeder channel on the respective dental restoration is selected at a thickest part of the respective dental restoration, and is settable such that the respective feeder channel axis extends through a greatest possible length of the respective dental restoration starting from the thickest part, and wherein the respective feeder channel is connected to the central pressing channel such that a plurality of feeder channels and the central pressing channel form a tree-like arrangement, the central pressing channel forming a tree trunk and the feeder channels forming branches, the dental restorations being provided at tips of the branches, and wherein a flow resistance of a ceramic material used as a dental material for forming the dental restorations is adjustable by dimensioning the respective feeder channel.

In accordance with the invention, it is intended to produce the dental restoration in a virtual space inside the muffle with the help of a special module of the CAD software for the production of the positive model of the dental restoration and determine the position in accordance with the particular criteria presented herein. With the help of this, an embodiment of positive models suitable for a multitude of tooth shapes and types of dental restorations is created in a surprisingly simple fashion, which models extend over the conveyor channels in a fashion resembling a tree. The pressing channel insofar basically forms the trunk of this "tree", and the conveyor channels form the branches at the top of each of which one dental restoration is usually provided. Preferably, both the conveyor channel and the dental restoration itself extend with their main axes, respectively, along an isotherm, which leads to the lowest temperature gradients within the cavity for the dental restoration during the process of pressing.

As a result of the automatic production of the conveyor channel and the dental restoration, faults occurring so far, which have often lead to compensation claims against the producers, can be avoided completely, and also the number of dental restorations produced at the same time can be optimised.

For example, it is possible to define a minimum distance between neighbouring dental restorations, such as 3 mm, and to position the dental restorations with the help of the positive models produced insofar by means of rapid prototyping in such a fashion that they are displaced in space in relation to one another, on different levels, and in a circle, without there being the risk of a deterioration in quality. The "multiple-layer arrangement" of dental restorations resulting insofar is preferred in particular with newer pressing furnaces which

Date Reçue/Date Received 2021-07-27

are provided with underneath heating for the muffle, as a result of which the isotherms of the muffle extend in a different fashion than with a mere annular heating.

In accordance with the invention, it is particularly favourable that the pressing process can be optimised especially also with a number of dental restorations created in parallel. Such the flow resistance of the heated ceramic material which is used for creating the dental restoration can be adapted by means of dimensioning of the respective conveyor channel.

The adaptation is preferably put into practice in such a fashion that the dental restorations, i.e. the corresponding cavities in the muffle, are completely filled at the same time. With smaller volumes of the dental restoration, one will correspondingly have a thinner and/or longer conveyor channel produced by the module, and will vice versa, with a bridge with a number of segments of a correspondingly large volume, have the conveyor channel or the conveyor channels put into practice shorter and/or thicker.

While it has so far been advised not to produce different dental restorations in the same pressing step – in particular with silicate ceramics –, it is possible without any problems, in accordance with the invention, to produce at the same time even very large and very small dental restorations, which further contributes to an increase in efficiency in accordance with the invention. Especially restorations made out of lithium disilicate with a very low shrinkage can thus be provided in a particularly quick and economic fashion.

The measures of the alignment of the dental restoration (and the cavity and the positive model, each respectively) in accordance with the invention include the selection of the position with the largest wall thickness of the dental restoration as the docking site of the conveyor channel at the dental restoration, and then aligning the dental restoration in such a fashion that its longitudinal axis corresponds to the axis of the conveyor channel. This measure surprisingly results in a dental restoration which can be produced particularly favourably which makes it possible to produce the positive model generatively by means of rapid prototyping, for instance with the help of stereolithographic processes, and also in the absence of any bubbles.

When casting the positive model with the help of liquid casting material, such as plaster, there is regularly the risk of cavities remaining which are not filled by the casting compound; the risk existing insofar is minimised by the alignment in accordance with the invention.

On the other hand, there is the risk in the process of pressing that bubbles remain in the ceramic material which entail a deterioration of quality; by means of the inclined arrangement in accordance with the invention, in combination with the feature mentioned above, this risk is minimised as well in accordance with the invention.

The conveyor channel preferably extends in an inclined fashion away from the pressing channel and its axis and extends insofar in an inclined fashion through the muffle, since the axis of the pressing channel regularly coincides with the axis of the muffle arbor.

In accordance with the invention, it is also intended to adapt the inclination in a certain way to the type of heating of the muffle. In case the muffle is heated from underneath, the overall possible angular range of between slightly more than 0° and 120° or 130° in relation to the axis of the muffle or the pressing channel, respectively, is available. In the case of an annular heating, in contrast, it is preferred to keep the axis at an angle of between 40° and 65°, preferably between 45° and 60°, based on the narrower area of the isothermal corridor.

In accordance with the invention, it is particularly favourable that what is referred to as a virtual inside space can be determined as a result of the predetermined limits of distance, i.e. a predetermined distance to the pressing channel and a predetermined distance to the outer wall of the muffle, and also upwards and downwards, within which limits the module has to arrange the dental restorations including the conveyor channels. As a result of that, it is made sure that the muffle does not crack due to too low wall thicknesses, and also that the marginal conditions with regards to isothermality are adhered to.

In this connection it is to be understood that the possible matching of temperatures within an area referred to as being isothermal strongly depends on the ceramic material to be pressed. For instance, feldspar ceramics can have a larger range of isothermality or range of paramoi thermality, i.e. a range of similar temperatures, than lithium disilicate ceramics. Also these marginal conditions can be taken into account with the help of the module in accordance with the invention, such that a displacement of levels with the corresponding compaction of the arrangement of dental restorations observed in a tangential direction not only in case of heating from underneath, but also depends on the material

In accordance with the invention, it is also favourable to automatically adapt the arrangement and also the number of conveyor channels to the type and number of dental restorations. If, for example, a bridge of eight segments with, for instance, three conveyor channels which end each at the respective thickest position of the corresponding teeth as the docking sites, extend in a slightly curved fashion, the inside space of the curve thus produced can be used for placing another dental restoration together with the corresponding conveyor channel within the virtual inside space.

In a favourable embodiment, it is intended that the alignment of the dental restorations is modified in such a fashion that it extends basically still in elongation of the conveyor channel axis, which is essentially with the maximum length of the virtual axis through the positive model, however slightly tilted in the direction of the primary flow direction, i.e. in most cases in the occlusal direction. This leads to a slightly lower degree of re-direction of the flow at the docking site, which further reduces the tendency to form bubbles. For instance, the re-direction of the primary flow direction out of the conveyor channel can thus be reduced from 30° to 20°, such that the dental restoration is positioned in such a fashion that it is tilted by 10° in relation to the maximum length of the virtual axis.

In a particularly preferred fashion in accordance with the present invention it is intended that the dental restorations are positioned around the pressing channel, but still slightly spaced apart from its front surface. Between the front surface and the dental restorations, the conveyor channels then extend which are determined each by the module, and the module spreads the dental restorations preferably in a uniform fashion in this area in an inclined fashion in front of the front surface of the pressing channel. If the dental restorations and conveyor channels are mentally connected with each other, they essentially form a taper or a truncated cone insofar, with the front surface as the trunc surface, and extend only slightly, still in the area of isothermality, outside the taper surface.

An axisymetric arrangement of the muffle and the pressing channel is preferred here in accordance with the invention, and is actually indispensable for achieving an optimum result of the pressing process based on the embodiment in accordance with the invention. However, the muffle is not restricted to a cylindrical muffle – as is most wide-spread –; also a muffle which is pear-shaped observed from the side, or is cloverleaf-shaped observed from the top, can basically be used in accordance with the invention.

As a result of the constant transitions or radii between the conveyor channels and the pressing channel, which are intended in a preferred embodiment, on the one hand and also the dental restoration on the other hand it is prevented that muffle material existing there is subjected to excessively high pressure during the pressing process and accordingly cracks. Such flow transitions are in addition favourable as far as the flow is concerned and reduce the counter pressure in pressing during the shaping process to the necessary minimum amount.

As an additional issue for the alignment of the dental restoration, i.e. the selection of the docking site, the module can take into account that the passage length through the dental restoration is maximised. For this purpose, the software creates the shortest vector to the position of the dental restoration farthest away from the docking site and maximises this length for the exact selection of the docking site.

The alignment of the dental restoration relative to the conveyor channel axis is then selected in such a fashion again that the mental axis between the centre of the docking site and the remotest point of the dental restoration form a virtual axis which extends in elongation of the conveyor channel axis.

Also this arrangement can preferably be displaced slightly in the occusal/incisal direction, for example by 10° or 15°, in order to minimise the re-direction of the flow.

It is furthermore intended in a fashion preferred in accordance with the invention to align open surfaces, i.e. surfaces in proximity of the basal surface, of the dental restoration radially outwards with relation to the pressing channel axis. This solution is favourable both with respect to avoiding the formation of small bubbles and with respect to the effect of temperature gradients.

In a favourable embodiment, the centre of mass at the thickest position of the wall of the dental restoration can also be of assistance in determining the angle orientation of the latter in relation to the conveyor channel axis; the dental restoration can preferably be aligned in such a fashion too that the elongation of the conveyor channel axis extends through that.

In another favourable embodiment, it is intended that the module determines the length of the conveyor channel depending on total weight. Here, the length of the conveyor channel preferably always amounts to distinctly less than the length of the main extensional direction through the dental restoration, and amounts – depending on its size and weight – to between 30 % and approximately 70 % of the length of the main extensional direction.

The conveyor channels can also be stored in a library, and the module can then select which of the conveyor channels from the library existing in advance will suitably be employed here.

While for the realisation of the positive model, the production by means of rapid prototyping is preferred, for instance with the help of stereolithography or of FDM, it is also possible in case of structures of easier design which are less complex, to produce the positive model by means of computer-controlled milling. In this, basically known blanks, for example made out of a polymer, polyacrylics or wax, can be employed which are realised in the shape of discs with a height of 20 mm or 25 mm.

Instead of this pancake cylinder, an upright cylinder can also be put into practice as a milling blank, which can then have a height of 50 mm, for instance.

In accordance with the invention, it is particularly favourable that with the help of a corresponding furnace-related specification, the module can provide an angle corridor for the realisation of the dental restorations, which makes it possible to always place the dental restorations within an isothermal corridor. The virtual space predetermined insofar is moreover predetermined in the horizontal direction by a minimum marginal distance of, for example, 10 mm to the outer wall of the muffle, and also to the pressing channel, which corresponds to the muffle arbor. For the more precise setting of the conveyor channel, the module takes into account in particular also the volume of each associated dental restorations and thus sets the length and thickness of the conveyor channel based on this. In addition, the size of the muffle can be determined based on the number of dental restorations to be manufactured, wherein the standard sizes of 100 g, 200 g and 300 g of muffles of corresponding known dimensions can be kept ready.

In an advantageous embodiment, it is intended herein with only very few dental restorations to be produced to put into practice a conveyor channel as a dummy channel. This channel serves for the purpose of damping an abrupt increase in pressure towards the end of the pressing process in order to further reduce the risk of the muffle cracking.

In another favourable embodiment, it is intended to provide the base of the conveyor channel in a standardised fashion. This can have a projection which positively engages with the muffle arbor and is stored in the conveyor channel library as the zero point of the virtual inside space for providing the conveyor channels. For example, the muffle base, i.e. the muffle peg projecting from the disc-shaped base, can be provided with a central recess which positively accommodates the corresponding projection of the conveyor channel base.

At the conveyor channel base, the conveyor channel or the multitude of conveyor channels is then preferably built up. The conveyor channel base is insofar a disc which is provided with a positive-connection element, for instance a projection, which can be engaged with the muffle arbor, or makes possible another connection.

Alternatively, an apron can also be provided at the outer circumference of the conveyor channel base, which encloses the muffle arbor.

From the upper surface of the conveyor channel base, the conveyor channel or the multitude of conveyor channels extends away laterally in an inclined direction. The angle of the conveyor channel axis is put into practice in accordance with the above defaults, and the desired marginal distances, i.e. the distances between the dental restorations on the one hand and the margins of the muffle on the other hand, can be set with the help of the selection of the place of the starting point of the conveyor channel on the conveyor channel base determined in accordance with the defaults.

If the conveyor channel is in a position inclined by 45°, for instance, the vertical position of the dental restoration can be increased in that the starting point of the conveyor channel is displaced radially inwardly. As a result of this, the conveyor channel is virtually automatically – provided the angle is constant – elongated. The flow-related effects of this elongation can, however, in turn be compensated by enlarging the diameter of the conveyor channel, in accordance with the invention.

Based on the conveyor channel angle optimised with regards to the isothermal corridors, the dental restorations can accordingly and in accordance with the invention have alternating larger and smaller vertical heights, observed from the side, in order to thus provide a space-optimised tree of dental restorations

Further advantages, details and features of the invention result from the subsequent description of several embodiments with reference to the drawings which show:

Fig. 1 a schematic view of a positive model of a dental restoration, together with the conveyor channel which was already automatically produced by a module of a CAD software, which conveyor channel emanates from a pressing channel;

Fig. 2 a modified embodiment of the positive model of the dental restoration in accordance with Fig. 1, with a different angel of the conveyor channel;

Fig. 3 a third exemplary version of a dental restoration or a positive model, respectively, which is manufactured by means of applying a process in accordance with the invention;

Fig. 4 a modified embodiment of the production in accordance with Fig. 3;

Fig. 5 a schematic depiction of a positive model equipped with conveyor channels for use in a dental restoration production device in accordance with the invention;

Fig. 6 another depiction of a positive model for use in a dental restoration production device in accordance with the invention;

Fig. 7 a schematic depiction of the alignment of the positive model in a process in accordance with the invention;

Fig. 8 a schematic depiction of the alignment of another positive model and additionally its position in virtual space; and

Fig. 9 a schematic depiction of another positive model and its conveyor channels, including their position in virtual space.

In Fig. 1, a positive model 10 of a dental restoration 12 is depicted together with its position in space. As can be seen, an axis 14 of a conveyor channel 16 extends straight through positive model 10, starting from a muffle arbor 18 or a pressing channel 20, respectively, or, to be more precise, starting from their front surface 22, which is at a predetermined angle to an axis 24 of muffle arbor 18 or pressing channel 20, respectively, which here amounts to 45°.

With the help of this depction, the essential steps of the process in accordance with the invention are to be explained now.

For putting into pactice the process in accordance with the invention, the position of the tooth of the dental restoration is, or the positions of the teeth of the dental restorations are, first recorded. This includes the position of the tooth inside the mouth, i.e. for example 21, 22 etc., additionally the type and number of dental restorations – i.e. for example bridge, crown, inlay, veneer, prefacette etc. – and also the pressing conception. This also includes the pressing programme for the subsequent pressing process in the pressing furnace; this is selected in the dental restoration production device in accordance with the invention with the help of a menu item. With this selection, it is possible to optionally determine whether the dental furnace is, for instance, provided with a standard annular heating or an additional underneath heating for the muffle, each of which comprises different angle defaults of angle 30 from axis 14 to axis 24.

Based on this pressing concept, a corresponding library of conveyor channels – including their possible angles – is additionally offered.

With setting the pressing concept, the selection of materials of the ceramics to be used (for example oxide or silicate ceramics) results as well.

Before or possibly also after these determinations, the dental restoration is determined in such a fashion that it matches its neighbouring teeth in their shapes, arrangement inside the oral cavity and so on, based on a digital scan of the patient's mouth. From this, the volume of the respective dental restoration is automatically calculated, from which also the overall volume of the dental restorations results which are to be produced at the same time in accordance with the invention.

Also the position of the dental restoration in relation to the neighbouring teeth is determined by the CAD software, i.e. in a mesial/distal direction, in an occlusal/cervical direction, in the rotational position around the tooth axis and so on. This also includes the development of the wall thickness of the dental restoration and the positive model, respectively.

After the size of the muffle has been determined after total weight, based on a special module of the CAD software the position of positive model 10 in a virtual space 32 is determined in accordance with the invention.

In example 2, the total volume be 1.9 cm^3, such that a muffle of 200 g is sufficient; a corresponding muffle base with a corresponding muffle arbor 18 belongs to that.

Positive model 10 in accordance with Fig. 1 have a share in the total weight of 0.4 cm^3, while a total of 6 further positive models, which are not depicted here, extend in a circular fashion or tapered fashion and starting from muffle arbor 18 around the latter in virtual space 32 in a corresponding alignment to the alignment of positive model 10.

In the exemplary embodiment depicted, the pressing conception is determined for a pressing furnace with annular heating; as a result of this, the possible range of angle 30 is restricted to values between, for instance, 25° and 50°, and virtual space 32 is correspondingly smaller compared with a furnace with underneath heating.

The module now produces, based on a marginal distance to the margin of the muffle of, for example, 10 mm, an optimised arrangement of positive models 10 in space. By means of elongating conveyor channels 16, dental restorations 12 are displaced farther in the direction towards the outer circumference, however keeping in mind the marginal distances. The distance from front surface 22 to the upper end of virtual space 32 is also restricted in the exemplary case, here to 16 mm, and as the default length for the length of the conveyor channel, 3 mm to 8 mm are predetermined. The total length of dental restoration 12 along axis 14 and including the length of conveyor channel 16 amounts, in accordance with the default from the software module, to 16 mm in this exemplary embodiment, and the minimum distance of dental restorations 12 from each other amounts to 3 mm.

The selection of angle 30 results in the primary arrangement within a thermal corridor which has a similar temperature range. The alignment of dental restoration 16 with relation to axis 14 also contributes to this, and so does the selection of docking site 34 too. Angle 30 is determined in accordance with the alignment of the isothermal corridor specifically for the furnace.

In the exemplary embodiment depicted, docking site 34 has been selected where the wall thickness of positive model 10 and dental restoration 12, respectively, is at its maximum, in the exemplary case at a mesio-buccal cusp. The alignment of dental restoration 12 with relation to axis 14 is now done in such a fashion that a virtual axis 36 of the dental restoration, which extends through this from the position of the maximum wall thickness to the position of the dental restoration which is farthest away, i.e. the maximum longitudinal extension of the latter, coincides with axis 14 of conveyor channel 16, and insofar extends in elongation of the latter. As can be taken from Fig. 2 in comparison with Fig. 1, no co-axial, i.e. exactly coinciding, arrangement is meant herewith, but rather an elongation, for instance with a possible angular deviation of 15°, wherein with regards to optimisation reference is insofar made to the subsequent description.

Based on the marginal conditions existing insofar, conveyor channel 16 is now selected from the library of conveyor channels, and with the help of the module, the overall arrangement of positive models 10 including conveyor channels 16 is thus determined.

In a shaping step, the overall arrangement of positive models 10 and conveyor channels 16 is now produced by means of rapid prototyping, which – at least in the present case – is of tree-shaped arrangement.

The creation of the arrangement of positive models is done with the help of a material which is removable without leaving residues, such as polyacrylics or also any other suitable polymer which is suitable for rapid-prototyping procession and is characterised by particularly good shape accuracy.

When using the technology of stereolithography, thus an accuracy of manufacture of, for example, 50 µm can be guaranteed, which meets all requirements.

As can be taken from Fig. 1, the basal surface of the object extends in a downward/outward direction in relation to muffle arbor 18. The arrangement of dental restorations 12 and positive models 10, respectively, in a top view from above is done principally similar to a cake, such that the smallest width of positive models 10 is directed towards the inside, i.e. in the direction facing pressing channel axis 24.

The basic alignment of positive models 10 is done in the flow direction, i.e. corresponding to the elongation of axis 14.

In accordance with Fig. 2, virtual axis 36 of the dental restoration is slightly inclined in relation to axis 14 of conveyor channel 16. Hereby, is taken into account to minimise the re-direction of flow, such that the main flow of fluid dental material through the corresponding cavity happens slightly underneath the longitudinal fissure of the molar there, but in any case one stronger approximated to the occlusal direction than is visible from Fig. 1. In the direction not visible from Figures 1 and 2, i.e. transverse to the drawing layer, the alignment is done in that way that each of the main flow directions extends through the crown centre in any case.

As is also visible from Fig. 2, conveyor channel 16 extends starting from a position of front surface 22 lying rather far towards the outside. It is quite short, in the exemplary case only 3 mm, wherein it is to be understood that also a larger length of the conveyor channel is possible if a higher number of objects are to be accommodated in virtual space 32.

Larger lengths of the conveyor channels have, as is known, a larger flow resistance due to the existing wall friction. In order to compensate for this, the diameter of the conveyor channel is then enlarged in accordance with the defaults of the conveyor channel library.

While the positioning in accordance with Figures 1 and 2 intends that the occlusal surface is positioned inside, i.e. adjacent to pressing channel axis 24, and accordingly the basal surface in the outward/downward direction, it is also possible to reverse this arrangement. This alternative arrangement may be especially favourable in case of a mere annular heating of the pressing furnace since then the area of larger mass of the dental restoration lies within the area of higher temperatures. In addition, the tendency of the muffle to form cracks is reduced in those cases in which round surfaces extend in parallel with the walls, and in any case no sharp edges.

It is visible from Fig. 3 in what fashion a crown for a front tooth can extend. With this solution, only one single dental restoration is provided in a 100-g muffle, and due to the low total volume of only 0.3 cm^3 it is intended to put into practice a dummy channel 40 as an additional conveyor channel 16, which – created also by means of rapid prototyping – extends towards conveyor channel 16 of dental restoration 10.

From Fig. 3 – and further Figures – it is also visible that radii 42, 44 are provided on the input side of the positive model, which are favourable with respect to the flow and also prevent burrs of plaster, which would otherwise exist there, from breaking off as a result of the compression pressure and contaminating the dental restoration.

As is visible from Fig. 3, on front surface 22 of muffle arbor 18, a conveyor base 46 is formed which is also produced by means of rapid prototyping. Conveyor base 46 creates the connection between the different conveyor channels 16, and at the same time abuts on front surface 22 or is anchored there with the help of means of positive connection or with the help of an adhesive bond.

Docking site 34 is provided, in the arrangement in accordance with Fig. 3, in the incisal area, approximately centrally. This results in a maximised length of virtual axis 36 in such a fashion that it extends essentially in elongation of axis 14.

In this exemplary embodiment, stereolithography is preferably employed for rapid prototyping. This does not allow any negative layers, such that for technical reasons a displacement of conveyor channel 16 in a direction radially outwards – in relation to axis 24 – results. As a result, docking site 34 is displaced into the approximal area compared with Fig. 3, and axis 36 extends in a more inclined fashion than with Fig. 3 towards axis 14 of conveyor channel 16.

From Fig. 4, a correspondingly widened conveyor base 46 can be taken, and also in what fashion the material of conveyor base 46 can pass through an opening 48 in muffle arbor 18 and engage with it in order to put into practice a safe fixation of conveyor base 46.

In Fig. 5, the arrangement of a bridge 49 as a dental restoration is depicted. Conveyor channels 16 extend towards abutment teeth 50 and 52 in its occlusal area, while bridge segment 54 remains free of any conveyor channels.

Here as well, virtual axes 36 extend through the longest possible extension of abutment teeth 52 in elongation of axes 14 of conveyor channels 16. As a result of the higher volume of the dental restoration and its weight, respectively, only a 200 g muffle can be used here, and the conveyor channels are elongated to 5 mm in view of the more voluminous dimensioning.

Putting into practice a bridge does not exclude that at the same time and in the same muffle, single-tooth dental restorations or their positive models can be formed respectively;

such, for example, also dental restoration 12 in accordance with Fig. 6 can be shaped at a different angular position than bridge 49 in accordance with Fig. 5 at the same time.

From Fig. 7, another arrangement of a dental restoration 12, which is a side tooth crown, in relation to its conveyor channel 16 can be taken.

As docking site 34, mesio-palatinal cusps 58 are selected, and the CAD software module now rotates dental restoration 12 and positive model 10, respectively, in such a fashion that length L of virtual axis 36 through dental restoration 12 is maximised.

When the dental material flows in, the filling process is done starting from the docking site in the flow direction essentially with a uniform front of dental material. This results in that basal area 62 is filled with dental material before area 64 is filled which is farthest away from docking site 34 and is also basal, however is positioned slightly more cervically.

The front of dental ceramic material therefore experiences some resistance first in area 62 which then gradually increases until also area 64 has been filled. This somewhat balanced increase in pressure is favourable for two reasons: on the one hand, it makes possible to reduce pressure slightly before the actual filling has taken place, in order to prevent an abrupt pressure peak when the filling process is completed. On the other hand, the risk of cracks in the muffle due to a pressure surge towards the end of the filling process is reduced, such that the end of the filling process is balanced.

From Fig. 8, it can be taken in what fashion another dental restoration 12 can extend in space. A tapered isothermal corridor 70 is depicted schematically, within which the multitude of dental restorations 12, one of which is depicted in Fig. 8, extend. Front surface 22 is adjacent to lower end 72 of corridor 70, and the upper end is formed by the upper end of virtual space 32.

Around each dental restoration 12 there extends an envelope space 74 which serves for the purpose of keeping the distance and prevents dental restoration 12 from being pressed to close to neighbouring dental restorations. This is depicted schematically as a rectangle in Fig. 8, in practice however, the smallest possible space which keeps a distance of 3 mm or 2 mm to dental restoration 12.

As can be taken from Fig. 8 with positive model 10 provided in the form of an inlay there, docking site 34 is attached in the upper third at the thickest position of the inlay. Axis 36 is positioned, maximising length L, in elongation of an axis of conveyor 16 which is not depicted here. The flow direction of the front of dental ceramic material extends in an approximal fashion centrally of the central fissure.

From Fig. 9, a corresponding alignment of a side tooth crown 49 applying three coordinate systems can be taken by way of example.

Based on muffle arbor 18 which forms the base of the first coordinate system, an isothermal corridor is calculated by the mould, as a trajectory path, along which dental restorations 12 are supposed to extend. At the same time, the possible arrangements of the dental restorations are restricted by virtual space 32.

Starting from muffle arbor 18, conveyor channels 16 extend at an angle of 45° to 60° to the horizontal since an annular heating is employed here.

The third coordinate system is spanned over envelope space 74 of crown 49, which is again depicted as a rectangle here, but in fact is an envelope of the dental restoration.

Flow direction L of the dental ceramic material through the cavities created by positive model 10 is in elongation of the axes of conveyor channels 16, however inclined at an angle of 12° compared with these.

At the bridge, the abutment is done in a basically known fashion at the incisal surfaces, which is again at the thickest position of each crown that forms docking site 34.

In the exemplary embodiment depicted, the length of conveyor channels 16 amounts to about half of length L of virtual axis 36. It is to be understood that this value can be widely adapted to the requirements and tends to be slightly larger with smaller dental restorations and slightly smaller with larger ones.

CLAIMS:

1. A process for manufacturing dental restorations, comprising:

designing a dental restoration based on a scan of a mouth, using a CAD software;

producing a positive model of the dental restoration using a residue-free removable material, by ablation or generatively, wherein the positive model is molded and removed via a muffle, the muffle being provided with a pressing channel connected via a feeder channel to a cavity corresponding to the positive model for the dental restoration;

wherein a blank of dental material introduced into the pressing channel is heated and pressurized so that the blank deforms and the dental material enters and fills the cavity through the feeder channel,

wherein, during molding or subsequently thereto, the feeder channel is automatically created by a module of the CAD software for the positive model based on dimensions of the muffle in relation to the size and shape of the positive model,

wherein the module defines an interior space within the muffle for arranging the dental restoration therein,

wherein the feeder channel is connected to the pressing channel such that the pressing channel and the feeder channel form a tree-like arrangement, the pressing channel forming a trunk of the tree-like arrangement and the feeder channel forming a branch of the tree-like arrangement, the dental restoration being provided at a tip of the branch, the feeder channel extending at an angle between 0° and 130° away from an axis of the pressing channel,

wherein a flow resistance of a ceramic material used as a dental material is set by dimensioning the feeder channel, and

wherein a site having the thickest wall thickness of the positive model is selected as a docking site of the feeder channel on the dental restoration and the module aligns the positive model with respect to the feeder channel to elongate an axis of the feeder channel and maximize an axial length of the positive model.

Date Reçue/Date Received 2021-07-27

2. The process according to claim 1, wherein an orientation of the dental restoration and the positive model within the muffle is determined by the module such that the greatest longitudinal extent of the dental restoration substantially extends along an isotherm.

3. The process according to claim 1 or claim 2, wherein the feeder channel is provided with radii and/or continuous transitions towards the pressing channel and towards the dental restoration.

4. The process according to any one of claims 1 to 3, wherein the module, based on the shape of the dental restoration and of the positive model, starting from a thickest portion having the thickest wall thickness, determines a primary flow direction for the dental material as the direction in which the flow cross-section is greatest at a predetermined distance from the thickest portion, wherein a longest axis is defined by the positive model in extension of the feeder channel axis, but deviating in the direction of the primary flow direction.

5. The process according to any one of claims 1 to 4, wherein the feeder channel, using the axis of the feeder channel extending through the dental restoration, determines an orientation of the dental restoration, and the orientation of the dental restoration is selected such that a passage length of the feeder channel through the dental restoration is maximized.

6. The process according to any one of claims 1 to 5, wherein the length of the feeder channel is determined by the module as a function of a size and weight of the dental restoration.

7. The process according to any one of claims 1 to 6, wherein the positive model is produced by milling and a milled blank is designed as a cylinder having a cylinder height corresponding to a space of between 15 mm and 50 mm.

Date Reçue/Date Received 2021-07-27

8. The process according to any one of claims 1 to 7, wherein the feeder channel is a blind channel.

9. The process according to any one of claims 1 to 8, wherein the feeder channel comprises a plurality of feed channels associated with a plurality of dental restorations.

10. The process according to claim 9, wherein the length and thickness of one of the feeder channels relative to other feeder channels are adjusted to match a volume of the dental restoration associated with the one feeder channel, and in such a way that during pressing, complete filling of the dental restoration takes place simultaneously, that feeder channels for larger dental restorations are set to a lower flow resistance and feeder channels for smaller dental restorations are set to a higher flow resistance.

11. The process according to claim 9 or claim 10, wherein simultaneous manufacture of the plurality of dental restorations is arranged substantially along an envelope of a cone and uniformly distributed around the pressing channel, the pressing channel substantially terminates at an apex of the cone.

12. The process according to any one of claims 9 to 11, wherein one of the dental restorations is formed as a crown or bridge and a basal surface of the crown extends in extension of the pressing channel axis with an open side of the crown facing away from the pressing channel.

13. The process according to any one of claims 9 to 12, wherein one of the dental restorations is formed as a prefacette or veneer; and a basal surface of the prefacette or veneer extends in a radially outward direction in relation to the pressing channel axis.

14. The process according to any one of claims 9 to 13, wherein an alignment of each one of the dental restorations with respect to the respective feeder channel axis through the respective dental restoration extends through a center of mass of the

respective dental restoration when the respective feeder channel axis is arranged at a thickest portion of the respective dental restoration.

15. The process according to any one of claims 9 to 14, wherein the module connects the respective feeder channel off-center with respect to the outer surfaces of the respective dental restoration.

16. The process of claim 15, wherein the respective feeder channel is connected substantially in extension of a labial or buccal surface.

17. The process according to any one of claims 9 to 16, wherein, upon arrangement of the plurality of dental restorations in a muffle, the module sets the feeder channels thereto such that the dental restorations are evenly spaced apart in an isothermal corridor, and spanning a polyhedron similar to a cone upon formation of imaginary connecting lines therebetween.

18. The process according to any one of claims 9 to 17, wherein the module accesses a feeder channel library indicating different profile designs, lengths, docking sites and angles of feeder channels based on sizes and types of dental restorations, and, based thereon, the module determines or suggests the feeder channels in terms of lengths, diameters and angles thereof.

19. The process according to any one of claims 9 to 18, wherein an inner space for providing positioning of the dental restorations within the muffle is muffle size-dependent and enables a placement space of the dental restorations within the muffle such that each dental restoration maintains a distance of at least 2 mm from an outer wall of the muffle and, a height of the inner space is less in a radial inward direction than in a radial outward direction.

20. The process of claim 19, wherein the distance of at least 2 mm is 10 mm.

Date Reçue/Date Received 2021-07-27

21. The process of claim 7, wherein the cylinder height is about 40 mm.

22. The process of claim 10, wherein the flow resistance of each one of the feeder channels is selected in proportion to a weight of the dental restoration associated with the each feeder channel.

23. The process of any one of claims 1 to 22, wherein the positive model is designed and produced by rapid prototyping.

24. The process of any one of claims 1 to 23, wherein the removable material is a wax or polyacrylics.

25. The process of any one of claims 1 to 24, wherein the axis of the pressing channel extends along an isotherm in the muffle.

26. The process of any one of claims 1 to 25, wherein the length of the feeder channel is 30% to 50% of a length of the dental restoration.

27. The process of any one of claims 1 to 25, wherein the length of the feeder channel is 40% to 65% of a length of the dental restoration.

28. A dental ceramic manufacturing device, comprising a CAD/CAM device for providing a press mold for the manufacture of dental ceramics,

wherein the CAD/CAM device has CAD software for determining a shape of a dental restoration based on scan of a mouth, and has a CAM device for determining configuration of a plurality of dental restorations for the mouth via a muffle,

wherein the CAD software comprises a module for automatically determining an angular position and dimensions of a respective feeder channel between a central pressing channel and a respective cavity for shaping a respective one of the dental restorations within a respective inner space within the muffle, wherein an angle of incidence of the respective dental restoration in relation to a respective feeder channel axis of the respective feeder channel at a docking site of the feeder channel on the respective dental restoration is selected at a thickest part of the respective dental restoration, and is settable such that the respective feeder channel axis extends through a greatest possible length of the respective dental restoration starting from the thickest part, and

wherein the respective feeder channel is connected to the central pressing channel such that a plurality of feeder channels and the central pressing channel form a tree-like arrangement, the central pressing channel forming a tree trunk and the feeder channels forming branches, the dental restorations being provided at tips of the branches, and wherein a flow resistance of a ceramic material used as a dental material for forming the dental restorations is adjustable by dimensioning the respective feeder channel.

29. The dental ceramic manufacturing device according to claim 28, wherein the docking site of the respective dental restoration to the respective feeder channel is selected by the module at a portion where a ball with a largest possible diameter fits into the respective dental restoration, wherein the axis of the respective feeder channel extends substantially through the center of the ball.

30. The dental ceramic manufacturing device according to claim 28 or claim 29, wherein each one of the dental restorations is determined by the module in a space with regard to arrangement and orientation of the dental restoration such that a distance from an edge of the dental restoration to an outer wall of the muffle and adjacent dental restorations is above a predetermined value.

31. The dental ceramic manufacturing device according to any one of claims 28 to 30, wherein the docking sites of the respective dental restoration to the respective feeder channel in a vertical projection in relation to the muffle is selected such that a narrow site of the respective dental restoration is arranged adjacent to the pressing channel, and a wide site is arranged radially outward.

Date Reçue/Date Received 2021-07-27

32. The dental ceramic manufacturing device according to any one of claims 28 to 31, wherein at least one of each feeder channel and the respective dental restoration is provided with a code or an identification at a basal site or at a covered site, wherein the code facilitates assignment to respective order and/or respective patients.

33. The dental ceramic manufacturing device according to any one of claims 28 to 32, wherein each one of the dental restorations, as viewed in the direction of the pressing channel axis, in order to provide a continuous and layered build-up thereof, comprises enveloping surfaces which monotonously rise or at most remain outwardly constant, and are not lowered outwardly, as viewed from the docking site of the respective dental restoration in the side view thereof.

34. The dental ceramic manufacturing device according to any one of claims 28 to 33, wherein the CAM device uses a front surface of the pressing channel as the zero point of the inner space and polymerizes a feeder channel base directly onto the front surface, the feeder channels extending away from the front surface.

35. The dental ceramic manufacturing device of any one of claims 28 to 34, wherein the module determines the shape of the dental restoration and the angle and dimensions of the feeder channel based on a library of shapes of at least one of dental restorations and feeder channels.

Date Reçue/Date Received 2021-07-27

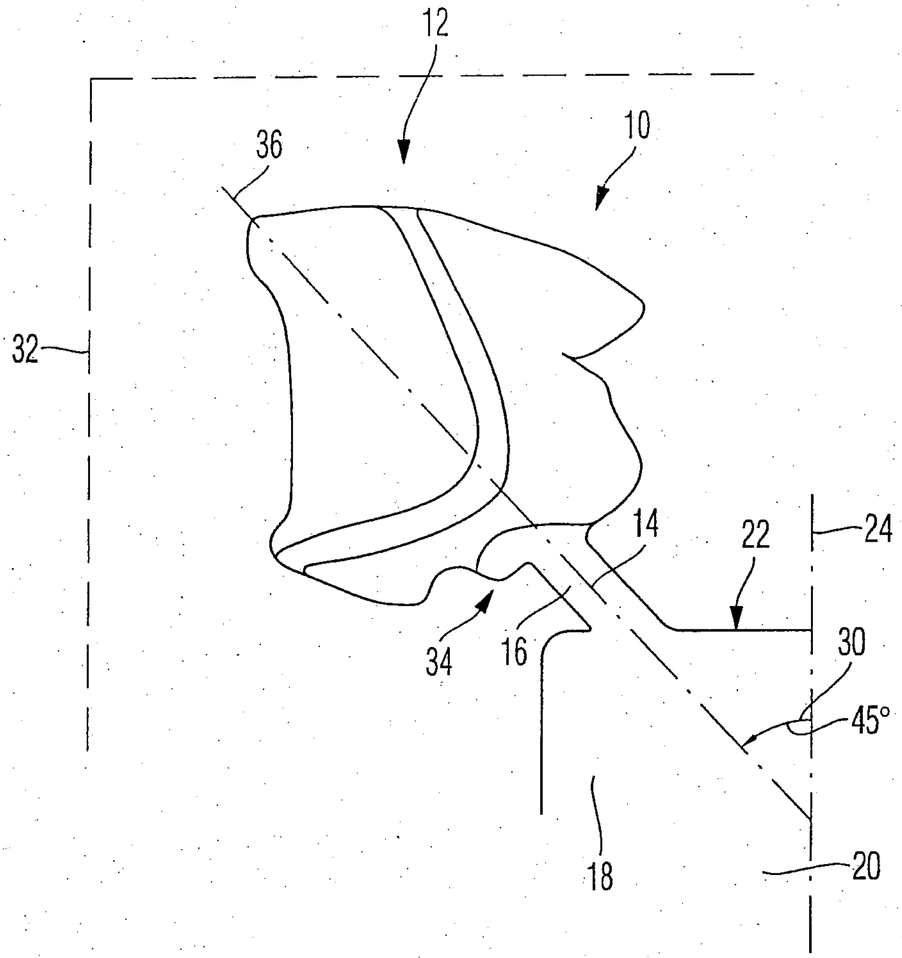


Fig. 1

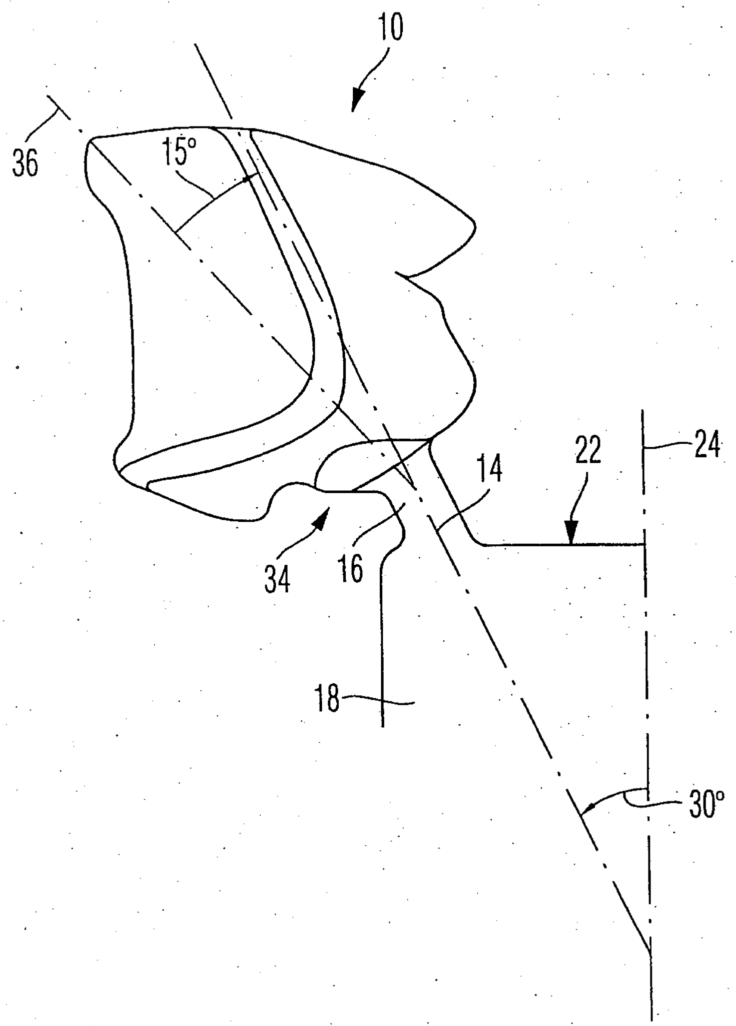


Fig. 2

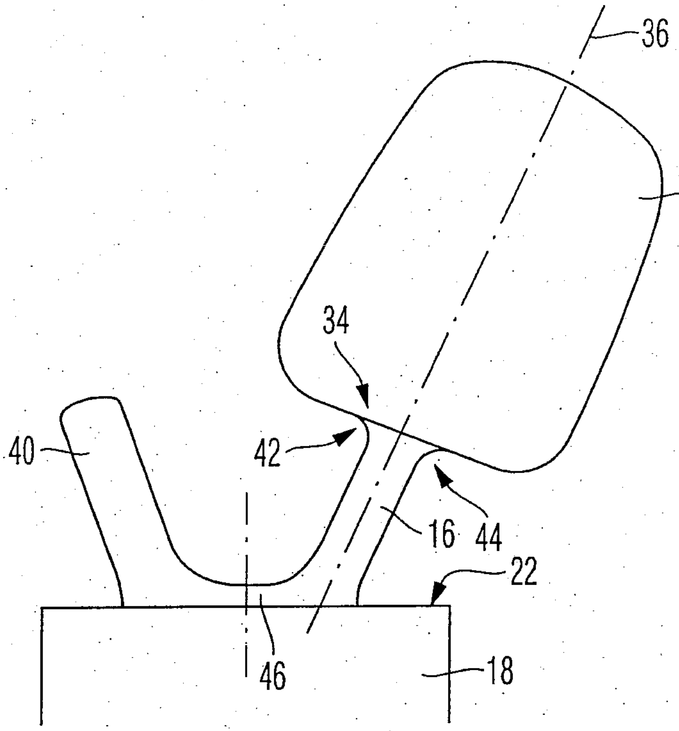


Fig. 3

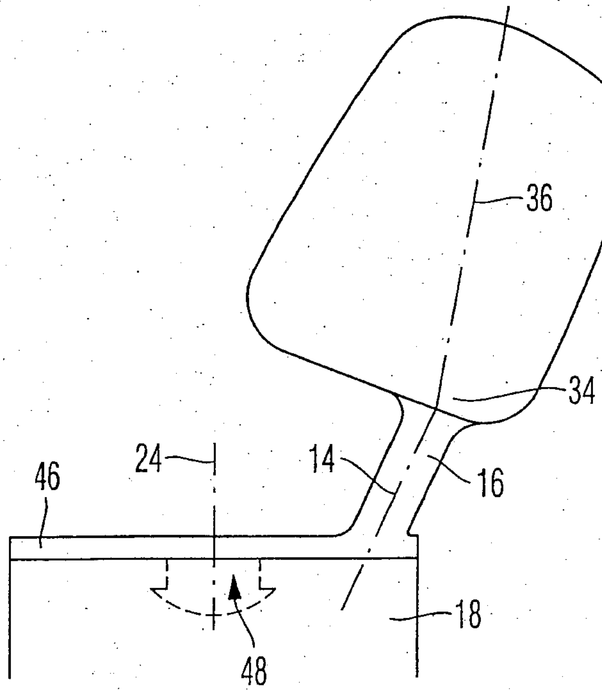


Fig. 4

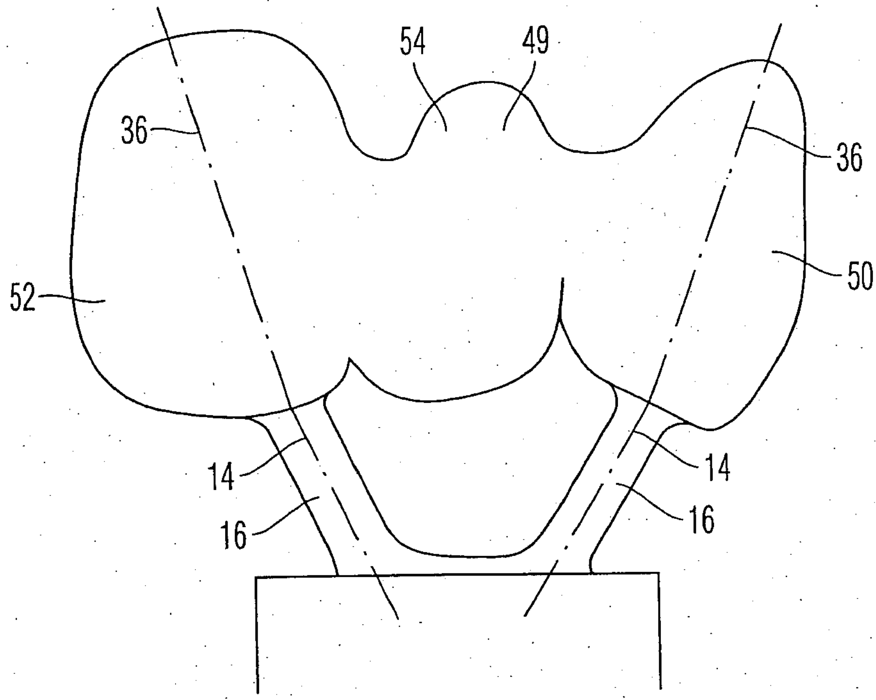


Fig. 5

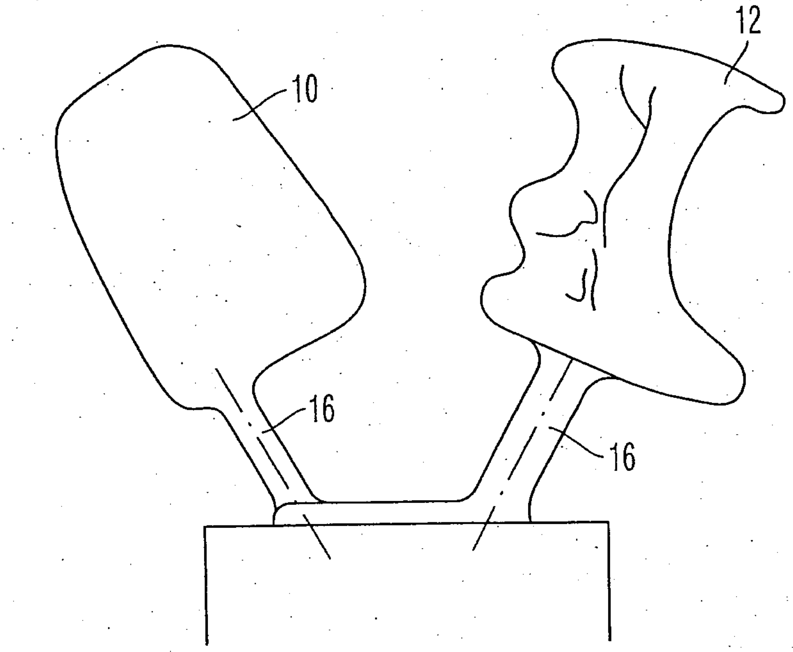


Fig. 6

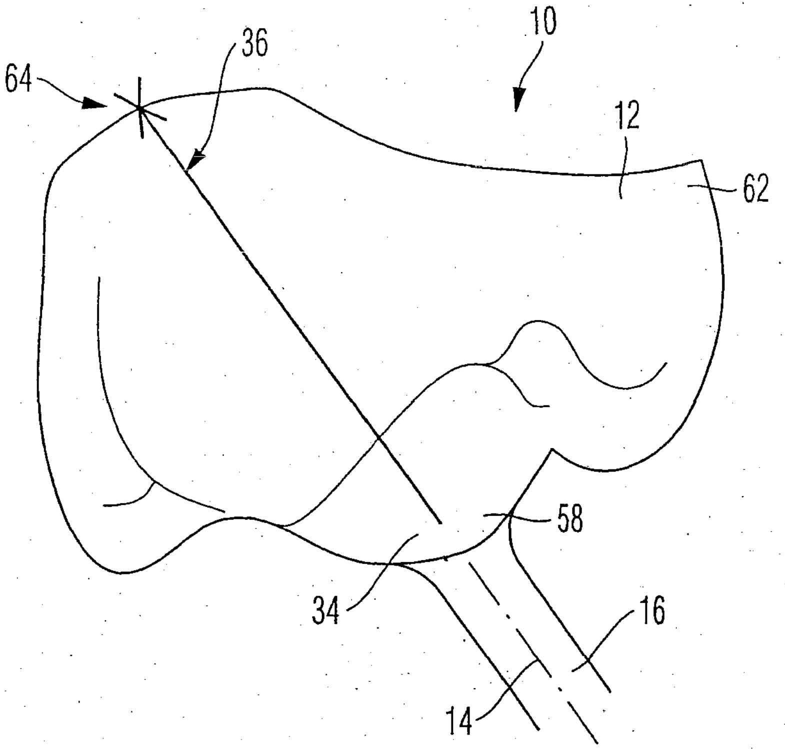


Fig. 7

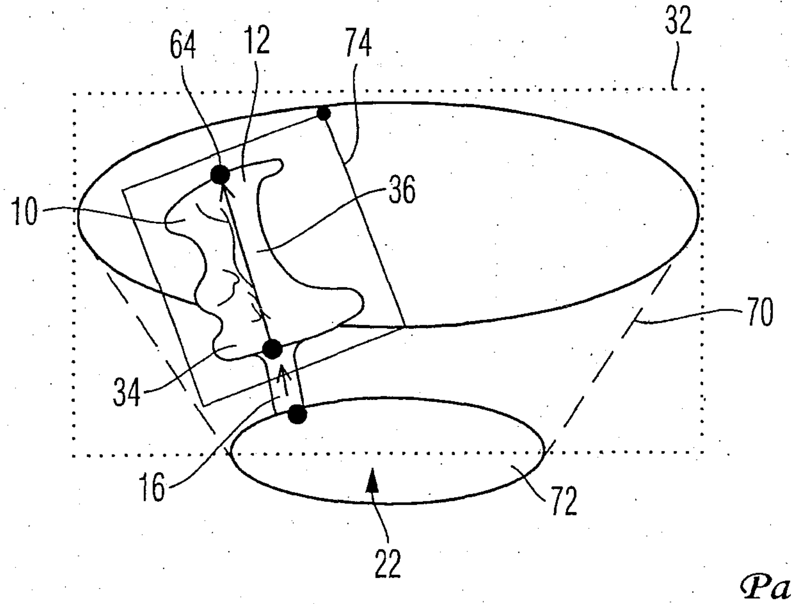


Fig. 8

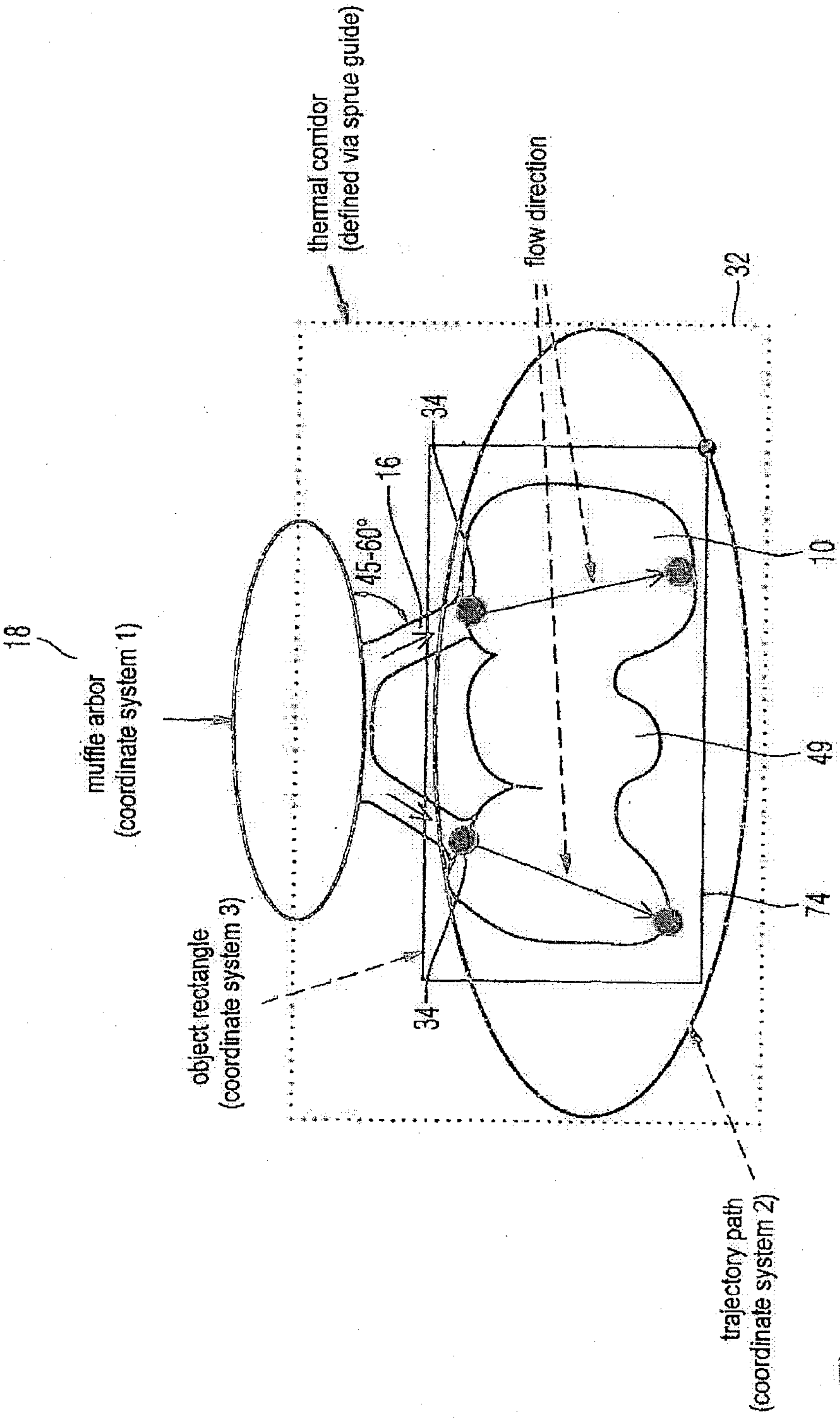


Fig. 9

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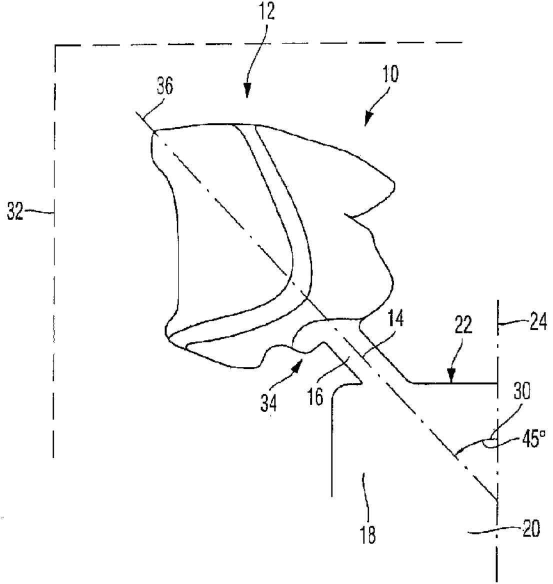
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