TOPLOTNE LASTNOSTI TITANA IN TITANOVE ZLITINE TiAl6V4 ZA UPORABO V ZOBOZDRAVSTVU

Področje: **Strojništvo**

Vrsta naloge: **raziskovalna naloga**

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POVZETEK

Proizvajalci dentalnih materialov v svojih potrdilih o kakovosti pogosto ne navedejo podatkov o toplotnih lastnostih. Toplotna prevodnost, specifična toplota in temperaturna prevodnost so ključne lastnosti materiala pri oblikovanju in analizi tehničnih sistemov, kjer ima temperatura oziroma temperaturna obremenitev glavno vlogo. Kljub izjemnemu napredku merilnih metod in tehnik je določitev toplotne prevodnosti z napako manjšo od 5 % še vedno izziv.

V naši raziskavi smo uporabili eden najnovejših in visokokakovostnih instrumentov za analizo toplotnih lastnosti, in sicer napravo Hot Disk TPS 2200. Ta naprava se uporablja za preučevanje različnih materialov, kot so čiste kovine, zlitine, minerali, keramika, steklo, prah, plastika, gradbeni materiali, biomateriali, tekočine in v našem primeru za določanje toplotnih lastnosti dentalnih materialov.

Naprava uporablja t. i. TPS metodo, ki velja za morda najbolj natančno in priročno tehniko za preučevanje toplotnih lastnosti materiala po mnenju inženirske stroke. S tem pridobimo podatke o toplotni prevodnosti, temperaturni prevodnosti in specifični toploti materiala v skladu s standardom ISO 22007-2. TPS metoda temelji na uporabi TPS senzorja, ki je sestavljen iz električno prevodnega materiala v obliki dvojne spirale, jedkane iz tanke nikljeve folije. Spirala je stisnjena med dvema tankima plastema iz izolacijskega materiala. Osnovno načelo merilnega sistema je, da senzor dovaja konstantno moč preizkušancu v določenem časovnem intervalu in spremlja povečanje temperature z uporabo uporovnega termometra. Dviganje temperature se odraža v povečanju upora v senzorju. Upor v senzorju se zabeleži in analizira, kar omogoča določitev toplotne in temperaturne prevodnosti že z eno samo meritvijo.

Izvedli smo meritve in analizo toplotnih lastnosti izbranih značilnosti dentalnih materialov, ki se pogosto uporabljajo v zobozdravstveni praksi, z uporabo metode Hot Disk na napravi Hot Disk TPS 2200 v skladu s standardom ISO 22007-2 v Laboratoriju za meritve na Katedri za materiale in metalurgijo Naravoslovnotehniške fakultete Univerze v Ljubljani.

Za preizkušance smo uporabili tehnično čisti titan (z vsebnostjo titana nad 99 %), zlitino TiAl6V4 in zlitino kobalta in kroma. Meritve smo izvedli pri sobni temperaturi in v temperaturnem območju med 0 °C in 50 °C, saj so zobje in zobni nadomestki najpogosteje izpostavljeni temperaturam v območju med 0 in 50 °C.

Titan se v zobozdravstvu uporablja zaradi svoje odpornosti proti elektrokemičnemu razkrajanju, kompatibilnosti s tkivi, nizke gostote in visoke trdnosti. Titan tvori zelo trdno oksidno plast, ki se razvije v nekaj nanosekundah. Zaradi te oksidne plasti je odporen proti koroziji in biokompatibilen. Komercialno čist titan se uporablja za zobne vsadke, zobne prevleke, mostičke, delne in cele proteze ter za ortodontske žice.

Prvi preizkušanec ima vsebnost titana večjo od 99 % in se uporablja za izdelavo kron in mostičkov manjšega razpona ter kot nadgradnja za vsadke. Ima visoko toplotno prevodnost. Tudi v tem primeru rezultati niso pokazali bistvenih odstopanj med nižjimi in sobno temperaturo znotraj napake meritve.

Drugi preizkušanec ima v primerjavi s tretjim drugačno kemično sestavo in vsebuje 89,8 % titana, 6 % aluminija in 4 % vanadija. Prisotnost aluminija in vanadija opazno zmanjšuje toplotne lastnosti materiala, vendar ima kljub temu relativno visoko toplotno prevodnost. Tudi v tem primeru ni bilo odstopanj med posameznimi meritvami.

Pri preučevanju rezultatov izvedenih meritev smo ugotovili, da temperatura samega preizkušanca nima vpliva na toplotne lastnosti v temperaturnem območju med 0 in 45 °C. Minimalne razlike med posameznimi meritvami lahko pripišemo napaki meritve.

Z izvedenimi meritvami smo dopolnili oziroma nadgradili že obstoječe certifikate o kakovosti dentalnih materialov z njihovimi toplotnimi lastnostmi, s tem pa prispevali k širšemu naboru

ABSTRACT

Manufacturers of dental materials often do not provide information on thermal properties in their certificates of quality. Thermal conductivity, specific heat and temperature conductivity are key material properties in the design and analysis of technical systems where temperature or temperature load plays a major role. Despite the remarkable progress in measurement methods and techniques, determining thermal conductivity with an error of less than 5% is still a challenge.

In our research, we used one of the latest and high-quality instruments for analyzing thermal properties, namely the Hot Disk TPS 2200 device. This device is used to study various materials such as pure metals, alloys, minerals, ceramics, glass, powders, plastics, construction materials, biomaterials, liquids and in our case for determining the thermal properties of dental materials.

The device uses t. i. The TPS method, which is considered to be perhaps the most accurate and convenient technique for studying the thermal properties of a material, according to the engineering profession. With this, we obtain data on the thermal conductivity, temperature conductivity and specific heat of the material in accordance with the ISO 22007-2 standard. The TPS method is based on the use of a TPS sensor, which consists of an electrically conductive material in the form of a double spiral etched from a thin nickel foil. The spiral is sandwiched between two thin layers of insulating material. The basic principle of the measuring system is that the sensor supplies a constant power to the test subject in a certain time interval and monitors the increase in temperature using a resistance thermometer. A rise in temperature is reflected in an increase in resistance in the sensor. The resistance in the sensor is recorded and analyzed, making it possible to determine the thermal and temperature conductivity with a single measurement.

We carried out measurements and analysis of the thermal properties of selected characteristics of dental materials, which are often used in dental practice, using the Hot Disk method on the Hot Disk TPS 2200 device in accordance with the ISO 22007-2 standard in the Laboratory of Measurements at the Department of Materials and Metallurgy of the Faculty of Science and Technology Faculty of the University of Ljubljana.

Technically pure titanium (with titanium content above 99%), TiAl6V4 alloy and cobalt-chromium alloy were used for the test pieces. The measurements were performed at room temperature and in the temperature range between 0 °C and 50 °C, since teeth and dental implants are most often exposed to temperatures in the range between 0 and 50 °C.

Titanium is used in dentistry for its resistance to electrochemical degradation, tissue compatibility, low density and high strength. Titanium forms a very solid oxide layer that develops in a few nanoseconds. This oxide layer makes it corrosion resistant and biocompatible. Commercially pure titanium is used for dental implants, dental crowns, bridges, partial and full dentures, and orthodontic wires.

The first trial has a titanium content of more than 99% and is used for the production of smaller span crowns and bridges and as an abutment for implants. It has high thermal conductivity. Even in this case, the results did not show significant deviations between lower and room temperature within the measurement error.

The second test specimen has a different chemical composition compared to the third one and contains 89.8% titanium, 6% aluminum and 4% vanadium. The presence of aluminum and vanadium noticeably reduces the thermal properties of the material, but it still has a relatively high thermal conductivity. In this case too, there were no deviations between individual measurements.

When studying the results of the measurements, we found that the temperature of the test piece itself has no effect on the thermal properties in the temperature range between 0 and 45 °C. Minimal differences between individual measurements can be attributed to measurement error.

With the measurements we completed or upgraded the already existing certificates on the quality of dental materials with their thermal properties, thus contributing to a wider range