THE IMPORTANCE OF NEW TECHNOLOGIES AND THEIR IMPACT ON INDUSTRIAL DEVELOPMENT, SERVICE ACTIVITIES AND UNEMPLOYMENT

Review article

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Abstract:

New information and communication technologies have found their application in all fields of activity (manufacturing, construction, wholesale and retail, transport and storage, information and communication, education, health care and social care and other activities). CAD / CAM applications are used in the industry for design, prototyping, finished products and realization of production programs, and in service activities such as health care-dentistry is a process that achieves the final treatment of the teeth through fine grinding of finished ceramic blocks in order to achieve more efficient work. CAD / CAM technology essentially allows the creation of two-dimensional, three-dimensional, five-dimensional models and their materialization with numerically controlled machines. In order to function more efficiently, reduce costs, increase the efficiency of the processing industry and services, achieve customer satisfaction and ultimately make a profit, many companies and dental offices in the world have focused on the implementation of modern IT solutions in everyday practice. From dedicated ceramic blocks, a dentist can quickly provide a service (precise bridging and crown compensation) using CAD / CAM technology (computer assisted-designed / computer-assisted production). The advantages of this technology are presented in this paper. There are many systems like PoverMill, PoverShape, DeskProto 3D CAM, DeskProto V 7.0 in the industry as well as Cercon, Celai, Cerec, Lava, Everest, which represent the imperative of modern dentistry.

Key words*: design, new products, 3D scanning, prosthetics, ceramic blocks, bridges and crowns*

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INTRODUCTION

CAD / CAM applications are used to design products and programs for production processes, specifically CNC processing. CAM software uses models and circuits created in the CAD software for generating toolbars that provide machine tools to convert design into physical parts. CAD / CAM software is used for the design and production of prototypes, finished parts and production programs.

CAMWorks with machine intelligence is the most advanced CAM programming software available for faster, more efficient and faster product search. CAMVorks is the latest generation of best-in-class CNC software solutions that allow its users to program smarter and faster machines. CAMVorks offers true machine processing that automatically adjusts changes in the part of the model, which eliminates the redirection of CAM time for updating the design.

Since it is integrated into the design environment, CAMVorks allows the user to: Keep association between design patterns and tools to ensure that the latest design changes are reflected in the toolbar; Removing past file transfers using standard file formats such as IGES and STEP; Use only one file for storing CAD and CAM data that drastically reduces file management; Work with the same familiar user interface that provides a short curve of learning; Use wood and commands for CAMVorks machining by pressing the button and generating toolbars without leaving the design environment; CAMVorks provides users can work with multiple platforms including their own integrated CAD / CAM platform. CAMVorks Milling software for programming G-code CNC mill machine is available in various configurations, so today you can buy exactly what we need now and add to your CAM system how business grows.

Today in service activities, contemporary practice implies increased use of information and communication technologies. There are numerous advantages to facilitate work in service activities, but also in the use of dental services that become increasingly demanding in terms of aesthetics, with a clear desire for a minimum stay and residency in the dental office. Namely, when it is necessary to replace the removed pathologically modified tissue and produce fixed prosthetic inlays, inlays, crowns and veneers are indicated, or when the need for missing teeth is required, and therefore the bridges are truncated, it comes in principle to the application of CAD / CAM technology.

In the early nineties, more than 70% of private dental practices in the United States used computers (Casanova, AV Marshall, V.1986), it is undoubtedly the advantage of such an organization's work to increase the speed of work, communicate with patients, and reduce the storage space (Gilboe, D. B. Scott, D. A.1991). An important role is also to reduce the possibility of entering wrong, illogical or incomplete data (Chasteen, J. A.1992). This computer application today is the most common form of use in our profession. The use of computers in therapy is a challenge for enthusiasts and visionaries who have developed a whole new field: computerized dentistry CAD / CAM systems are the pinnacle of computer technology with a lot of realized and potential applications in dentistry. CAD / CAM systems in dentistry consist essentially of three components (Rekov, D.1987): The first component is a device that reflects the preparation of teeth and other supporting tissues and is responsible for the digitization of spatial data (CAI - Computer Aided Inspection); The second component consists of a computer that plans and calculates the form of a body of reconstruction, which is equivalent to the CAD area; The third component is a numerically controlled rodent machine that produces a tooth restoration from the basic shape, the corresponding CAM area. As a rule, additional treatment is recommended, such as polishing or individual preference of a dental technician or doctor (Todorović, A.2005).

1. THE DEVELOPMENT CAD / CAM SYSTEM

With the development of software packages (CAD, CAM and others) and computer-controlled machines (CNCs) and entire plants in the process industry, as well as efforts to meet the individualized needs of consumers, some of the crucial points of delineation of preparation and production sharpness.

Process planning translates information on product design (geometric input) into process stages and instructions on efficient production. Similar to other product development and design features, process planning has been developed with the help of computers in computer aided process planning (CAPP). CAPP supported by a number of tools supported by a computer can be more efficient in using resources for production by simplifying and improving process planning. CAPP is based on Group Technology (GT) coding and classification to identify a number of features or parameters of product or product elements. These attributes allow the system to select the basic process plan for the family of parts and perform a large part of the planning. The rest of the work ends with the planner by fine-tuning the plan.

The next stage in development is generating CAPP. Generic process planning determines decision-making rules based on group divide technology, and also uses coding technology. The resulting process plan requires minimal manual interaction and modification (for example, dimension input). A pure generating system that can produce the entire process plan based on the classification of pieces and other design data is a goal for the future. This type of pure generating system will involve the use of artificial intelligence to create process plans and will be fully integrated into the CIM environment.

A further step at this stage is dynamic, generating CAPP, which will take into account the capacity of machines and plants, the ability to create tools, work centers and equipment layout, as well as the status of equipment (eg, maintenance jam) in the development of process plans. Dynamically, generating CAPP will require tight integration with production resource planning systems, will monitor the current situation by acquiring data from the plant's operation. CAPP will directly provide data to process controllers or, in less automated environment, provide charts about the state and schedule of equipment and material flows related to the process of the process under consideration.

Computer Aided Draughting (in some Designs Source) (CAD) or Computer Drawing has revolutionized the design process. Compared to traditional work techniques, manufacturers can work more efficiently using the CAD system because they can achieve better design faster and with lower cost. The designer can easily use the CAD system to generate multiple, complex, objects, and positioning them according to the requirements. Furthermore, the CAD system has the ability cancel entities, allows the user to choose a wide variety of frequently used parts from the formed interactive database. This improves the quality and reliability of the subject of work as well as the speed of their manufacture.

Many CAD systems are capable of providing geometric data when forming solid models and prototypes, thus integrating with RP techniques. It is commercially viable to integrate CAD with CAM (Computer Aided Manufacture) where possible. CAM software uses geometric data from the CAD program to generate instructions for controlling and managing automatic machines and tools (CNC lathes, drills, etc.).

The development of CAM software has enabled CAD / CAM to adapt to the improvement of the industry. A historically viewed, drilled paper tape (matrix) was used to program the Numerically Controlled (NC) machines, while later models used machine codes (for example, ASCII) that typed in the text editor (***. Txt). In both cases, the program controlled the speed of movement of cutting tools, depth of cutting, etc. Modern CAD / CAM systems automatically generate the movement of tools based on 3D CAD data and allow for the previous simulation of the machining process on the computer screen. CAD / CAM extension is a complete integration of all aspects of production and services using data generated by a computer. This is a process known as Computer Integrated Manufacture (CIM). The industry that accepts the philosophy of flexible production uses the most developed CIM systems in order to incorporate all production information into a locally available database. Quality control and quality assurance can be incorporated into CIM systems.

Digital production is a term that represents a wide network of digital models and methods that describe each aspect of the product life cycle. It represents the integration of various product design tools (CAD), process planning (CAPP), time management and business applications, plant design, ergonomics, robot simulation, analysis software, process simulation, CAM software and other applications used for planning and optimizing processes and facilities of a real enterprise.

In order to provide NC instructions to CAM equipment, basic decisions must be made concerning the use of equipment, tools and sequences of operations. This is a CAPP function. Without some elements of CAPP, CAD / CAM integration would not be possible.

The benefits of CAPP are: Reducing effort on process planning; Direct savings on the labor force; Material saving; Reduction of scratch; Tool saving; Reduction of work in the process.

In the market economy, product development will be the answer to the projected market needs, and this should usually be identified in the form of a short design, which will be the basis for further product development.

This is a very wide description of the engineering process and the detail at each stage is categorically different in terms of the number of people involved and by the nature and complexity of the product. Consideration should be given to the fact that the projecting process, for example aircraft engines or computer systems, is a very complex process involving large teams and is narrowly limited by technical factors. In some areas, the product can be the result of the work of one designer (designer) or a small team, or may be conditioned by someone factors that have a dominant role.

The architecture of the CAD system is shown in Figure 1 and it describes the design as a series of phases, in this case the progress from the requirements through the conceptual design and the design project to detail design. In this case, however, the different phases of the design process are generalized into a common pattern in which design models are developed through the process of analysis and evaluation, leading them to processing and finishing the model. In the early stages of design, a temporary solution is suggested by the designer (designer). This is an estimate relative to a certain number of viewpoints in order to achieve a suitable design in relation to what is being sought. If the proposal is unusable, then the proposal is modified. The process is repeated until the project is good, where it can develop more in depth and the phase of the preliminary design can begin.

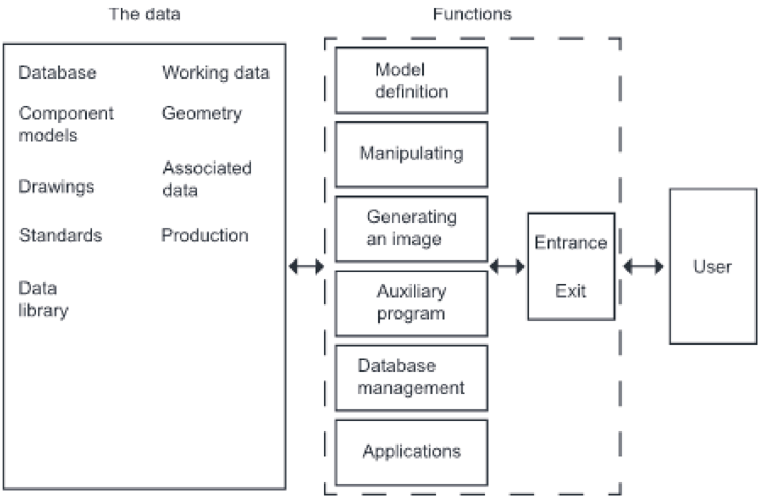

Figure 1: CAD architecture

At this stage, the project is purified, so that assessment and modification can be performed at a higher level of detail. Finally, the detail design phase contributes in a similar way to defining the design for production.

So far, CAD systems have been described in very general terms. More specifically, they may contain the following elements: hardware: a computer connected to a peripheral equipment; software: computer program (s) who works on hardware; data: the data structure created and manipulated by the software, human knowledge and activities.

2. ADVANCED METHODS AND DEVICES FOR CREATION OF GEOMETRY AND QUICK PRODUCTION OF PROTOTYPES

As classic scanning of photos or texts represents input sizes in various computer applications, and printing and drawing of the output form of computer applications, and while it is happening in a two-dimensional space, the development of new advanced peripheral edge technologies has shifted the boundaries toward a three-dimensional space. Indeed, industrial design has great benefits from these new methods that allow for a new dimension in the work of industrial designers. As CAD represented a major step forward compared to classical drawing based on orthogonal projection and paper, three-dimensional (3D) scanning and rapid prototyping make it an entirely new dimension in the presentation of the designer's ideas and concepts.

3D scanning

Under 3D scanning, we mean the collection of spatial data about the geometry of the observed object through devices that are broadly referred to as 3D scanners and which represent the relationship between the real object and the CAD model.3D scanning has its wide application in industry, control of geometry of manufactured parts, quality assurance, engineering design, anthropometry, construction, urban planning, geodesy, film industry and computer animation, protection of monuments and cultural heritage, archeology, medicine, etc.3D scanners are divided into two basic categories: contactless and non-contact scanners. The non-contact scanners include a range of technologies, such as Time of flight - scanner, triangular scanner, white light scanner, CT scan, magnetic resonance imaging (MRI), photogrammetry, and a number of others. The basic purpose of the 3D scanner is to create point clouds that represent the spatial coordinates of the points of the observed surface (Figure 2)

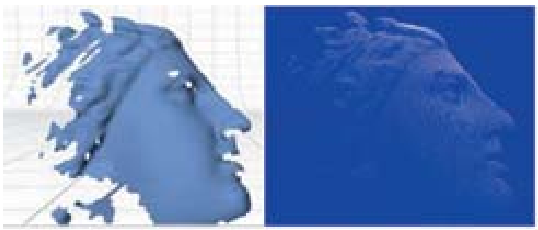

Figure 2: Sculpted Artemide sculpture and a cloud of dots

Contact scanners

Contact scanners (CMM - coordinate measuring machine) are one of the first 3D scanning technologies. Figure 3). They operate on the pipal principle, which, by touching the object, reads the coordinates of the touch point, and consists of a moving stand, whose coordinates are read at the micrometer level, both the pipeline itself and the control software which, with the control, has the ability to drag the basic geometric shapes through the observed points. The disadvantages of these scanners are the slow data collection and touch that can or damage the object (eg fragile archeological findings), or deform or shrink smaller parts.

Figure 3: CMM scanner and contact pipalo

Time of flight laser scanners

„Time of flight" laser scanners (Figure 4) is based on the reading of the time difference between the sent laser pulse pulse and the reflection of the reflected beam received by the detector. Based on the size of the time interval Δt and the known velocity of the laser beam (light velocity c), the distance as s = (c x Δt) / 2 is calculated.2. The moving mirror at high speed transmits the emitted air over the surface of the object and thus creates a cloud of dots. These scanners are suitable for very long distances, but they do not have much precision (the resolution is several millimeters). Typical application of these scanners is in the construction, ie conservation and restoration works, and the preservation of cultural heritage**.**

Slika 4.: Time of flight laser scanners

Triangular scanners

Triangular Laser Scanners (Figure 5) consist of the source of the laser beam, and the lens and screen on which reflected air is projected. The lens is positioned so that it is located at a constant distance from the laser beam and at a constant angle with respect to the air. As the object is moved, the reflected beam moves on the screen. From these known sizes (the angle of the lens and the air, the distance of the lens from the air) and the position of the reflected beam on the screen, the unknown distance of the object is determined. More often it is not only about an air but about the laser beam, which reads the position of the entire line of points, and by crossing the beam across the object, the entire surface. How to do this in a way, it collects the geometry of the visible side of the object, often for smaller objects, a swivel base is used to rotate the object around its axis, resulting in a series of scanned surfaces, and from a known angle of rotation, it is easy to connect surfaces to a closed body. For larger objects that can not be placed on a rotating stand, scanning from different sides of the object is performed, and later by means of common markers (at least three for each adjacent scan), the adjacent scans are merged. The triangulation method is fast, and the scanning accuracy is high. Thus, e. g. NextEngine 3D Desktop Scanner (Figure 6) (www. nextengine. com) costs $ 3, 000, has a resolution of 0, 125 mm.

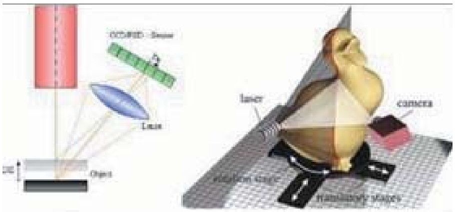

Figure 5: *Laser Air Triangulation Principle and laser beam*

Figure 6: *NextEngien Laser Triangulation Scanner and scanned geometry*

Scanner with structured light

Structured light scanners, also called White Light Scanners (white light scanners), are based on the principle of projection of the white light line and the reading of the projections obtained, most often by digital (CCD) cameras (Figure 7). Usually, the systems are based on two CCD cameras, which, at the same angle, with regard to the projector among them, the software recognizes the edge between the light and the darkness of the projected line, and based on the known viewing angle, the distance is determined. This group includes scanners based on the transition of the ray of light over the object, and from the dynamic change of the projected contour, the surface is reconstructed. There are many more common scanners based on a sample of a series of parallel lines of light and darkness. The advantage of this method is that the patterns can be projected very quickly with lines, and the geometry of the objects can be read out much faster than the triangulation laser scanners. It is a shame that their use is limited in daylight, and the rooms where the scanning is done should be dimmed, or scanning outdoors at twilight or at night. As the projector is stronger and, therefore, more expensive, this problem is less pronounced. Also, due to the characteristics of the optics, it is often necessary to calibrate the CCD camera before performing the measurement. Their resolution ranges up to the order of one micron. The robustness of scanning with this method is somewhat higher than in triangulation laser scanners, and the overlapping of the surface with white powder of titanium dioxide completely eliminates the problem of reflection around the edges, present in triangulation scanners. The price of these scanners is slightly higher than the triangulation laser, so the price of GOM's ATOS scanner (Figure 8) is around 70, 000 EUR or more (depends on the power of the projector and the type of lens).

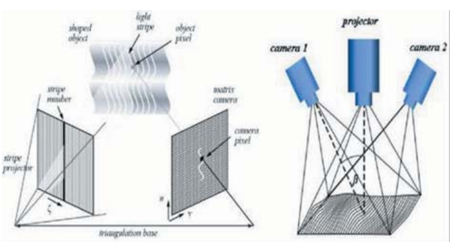

Figure 7: *Structured Projection Principle the line of the contour reading of the surface*

Figure 8: *ATOM GOM scanner and scanned Francis turbine rotor*

Computer tomography, microtomography and magnetic resonance

These are the methods that are mainly used in medicine and the study of the structure of the material. These methods provide successive cross-sections of objects of different composition, and later, 3D processing creates 3D geometry. The computer tomography (CT) of the three-dimensional image creates from a series of two-dimensional cross-sections of X-ray radiation (Fig.9). Microtomography is a tomography that allows the scanning of fine structures on a microniva, and in particular it has application in material science. Magnetic resonance (MRI) (Fig.10), unlike CT used by strong ionizing radiation, works on the principle of magnetic field and allows for greater contrast and better resolution in the recording of soft tissues. Unlike MRI, computer tomography has a greater use in determining the structure of various materials such as concrete, stone, metal foam, etc.

Figure 9: Metallic foam, a cross-section obtained by CT and reconstructed geometry from a series of CT cross sections

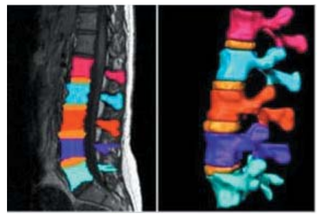

Fig. 10: The spine geometry obtained by reconstruction of MRI recording

Convert point clouds to CAD geometry

By scanning and processing the scanned surface, the job is not finished, and just after the scan, there is a complicated work of converting scanned in CAD geometry. The format itself, STL format, represents a large number of data (coordinates of the cloud points) that need to be reduced in order to use the scanned geometry in other applications. Models formed from straight polygons (usually triangular) surfaces are formed, and surface models defined by NURBS of spatial surfaces, which are further transformed into a CAD body record. Models composed of a network of triangular surfaces, where some triangles are defined between the cloud points, still contain too much data to manipulate. Often, the scanner software makes it possible to define a network of triangular surfaces (Fig 11.). Such a network is still too complex and cumbersome to be used in various CADs applications, and it is necessary to simplify its mathematical functions and primitive geometries.

Figure 11: Scanned surface defined through a network of triangular surfaces

Most of the more serious CAD applications, such as CATIA, SolidWorks, Rinocerus, etc., allow you to load cloud points in the STL format and define primitive plots such as levels, spheres, couplings, cylinders, and complex mathematical surfaces such as NURBS. NURBS, whose name comes from the Non-uniform rational basis spline, finds its origins in the shipbuilding industry with applications for defining the ship's lines, and later these mathematical formulations of three-dimensional plots are used extensively in computer graphics for creating curves and plates that allow for great flexibility in defining analytical and free forms. In recent years there has been considerable development of software in the field of computer animation, where NURBS surfaces (Figure 12) are used to describe animated characters, and the characters themselves are created on the basis of a modeling model, which is scanned by 3D scanners such as the NextEngine scanner.

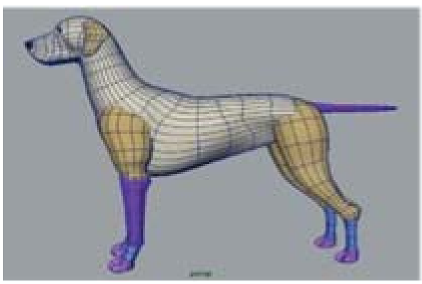

Figure 12: A model of a kernel composed of NURBS surfaces

Rapid Prototyping

Brza izrada prototipa (Rapid Prototyping) je automatizovana izrada tijela temeljena na formiranju slobodnih oblika. S ovim metodama se započelo oko 1989. godine, kada su se na temelju računski zadanih oblika mašina izrađivali modeli i dijelovi prototipa. Danas je brza izrada prototipa uznapredovala do nivoa da se čak koristi u proizvodnji maloserijskih dijelova proizvoda. Iako je cijena jednog izrađenog predmeta znatno veća nego cijena istog tog oblika proizvedenog na klasičan način, npr. brizganjem, uštede pri razvoju su znatne. Cijena uređaja za brzu izradu prototipa (zavisno o tehnologiji) iznosi od 40 000 EUR, do 120 000 EUR (za uređaje koji mogu izraditi objekte manjih dimenzija). Ako se ovo uporedi s gubicima jednog lošeg kalupa za brizganje plastičnih materijala, gdje uzrok greški leži u krivoj interpretaciji crteža od strane alatničara ili čak greški u CAD modelu, tada je dovoljno približno tri do četiri škart kalupa da bi gubici bili jednaki cijeni 3D štampača. Greške u izradi kalupa su vrlo česte u industriji polimernih proizvoda. Princip brze izrade prototipa je građenje dvodimenzionalnih presjeka tijela (xy ravni) u smjeru ose okomite na ravan presjeka (z ravan). Prvi uređaji za brzu izradu prototipa temeljili su se na izrezivanju kartona prema konturi presjeka u xy ravni i slaganje tih izrezanih poprečnih presjeka u smjeru z ravni. Pri tom je korak presjeka koji se izrezuje odgovarao debljini kartona iz kojeg se presjek izrezuje. Većina uređaja za brzu izradu prototipa upravo funkcioniše na ovim temeljima, gradi se sloj po sloj poprečnih presjeka u smjeru z ravni. Na slici 13. je prikazan princip stvaranja oblika koji odgovara polovini cilindra. Ako bi ipak željeli izraditi puni cilindar, tada bi trebalo u donjoj polovini cilindra, ispod cilindra postavljati materijal koji će cilindar držati u svom položaju kako se ne bi prevrnuo. Ovaj dodatni materijal se zove „materijal nosač" (carrier material) i neophodan je pri izradi prototipa. Materijal nosač može biti ili materijal drugačijeg sastava od osnovnog materijala, koji se naknadno odstrani, ili čak ako se izrada prototipa temelji na prašini koja se međusobno povezuje (solidificira), nepovezane čestice prašine stvaraju podršku ovim ukrućenim (solidificiranim) česticama

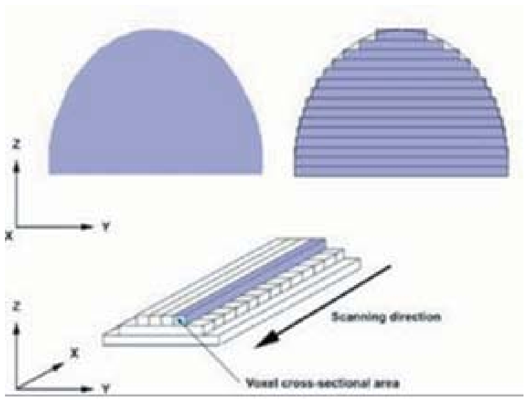

Figure 13: The principle of the construction of a prototype of a half cylinder

He prototype is defined in the computer in such a way that first virtual CAD programs create the virtual body geometry, which is then sent to the peripheral unit where the layer over the layer builds a prototype.

There is a standard format for communicating between CAD packages and software that manages the prototype STL (Stereolitography) format. Rapid prototyping technologies include:

- Laser sintering,
- modeling of liquid discharge,
- stereolithography,
- production of laminated models,
- melting with electronic air,
- 3D printing

3. CAD / CAM TECHNOLOGY IN THE SERVICE ACTIVITIES - IN DENTISTRY

In 1985, using triangular cameras, a multidimensional measurement was performed, enabling the transmission of measurement information to the computer screen. With the help of computer, imaging and CNC milling software, the first restoration of silicate injections at the University of Zurich is obtained. Then there is almost unimaginable technology and practically creating a new concept in dentistry. In Germany, CAD / CAM technology was introduced in dental practice in 1988 (Ritter, AV 2002). Modern software provides such a possibility that the minimum thickness of restoration is less than recommended, warns the dentist of an existing problem. Also, on the virtual model are marked and clearly recognizable critical areas that can be corrected by the offered tools. (www. sirona. com).

The development of technology went from copying the machine to a fully computer-controlled system, with a large tooth-shaped base, which enabled the automatic production of crowns and bridges. Today, there are several of these systems (Cerec, Cercon Celaia, Lava, Everest) and it is believed that in the future they will have much greater use in the production of fixed restoration. Figure 14 shows a fixed restoration produced by a computer of a controlled system.

Figure 14: Production of fixed restoration using a computer system

Thanks to CAD / CAM technology and numerous studies, this has resulted in a formula for extremely fast restorative, which possesses not only outstanding aesthetic characteristics, but also extremely biocompatible. It's non-metallic ceramics. Depending on the defect in the teeth, these materials can be used for making crowns and bridges, dental veneers, but also for special supplements (Figure 15).

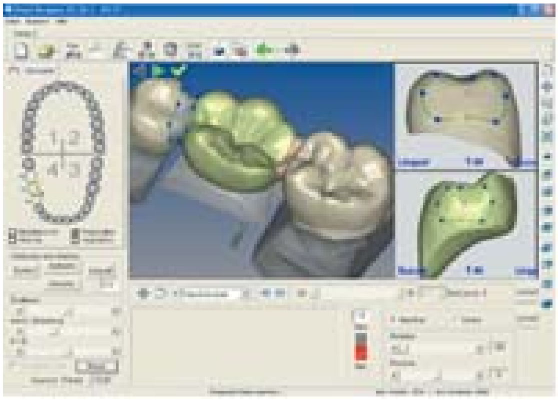

Figure 15: Innovative CAD / CAM technology

All these restorations are produced in dental technology laboratories, equipped with CAD / CAM technology (computer), which guarantees exceptional precision and aesthetics. By forming a 3D image of the teeth and gums on the screen, it allows the dentist to form a precise matching anatomical design of the missing dental substance by the cursor. The obtained 3D models provide the ideal basis for restoration. When designing, the relationship with adjacent teeth, teeth in the opposite jaw, establishing appropriate contacts, as well as the relationship between restoration and soft tissue and gums is taken into account in a very simple way.

CAD / CAM machines through the further milling of finished ceramic blocks produces tooth restoration which is exactly the replica of 3D drawings, i. e. Restoration design performed by the dentist via CAD / CAM software Factory-made ceramic blocks that are processed by the milling process are made in many different shades, so the color responds to the needs of patients as well as the parameters that determine the high level of aesthetics.

4. THE PROCESS OF PRODUCING CERAMIC RESTORATIONS BY CAD/CAM TECHNOLOGY

The process of producing ceramic restorations by CAD/CAM technology is more precise than the conventional process of producing metal-ceramic crowns and bridges. Figure 16. provides an overview of the CAD/CAM system in the process of producing crown bridges.

By applying modern machines type MC XL for grinding of finished ceramic and zirconia blocks, fixed prosthetic restoration can be today made for only 2-3 hours in the office. The advantages of this machine are multiple. Precision of milling is moving in the range of +/- 25 microns, while the time required for grinding circular bridge does not exceed 6 minutes. Thanks to a grinding resolution of 7.5 microns, prosthetic restoration surfaces that are produced this way are certainly adhere better, compared to conventionally made works (www. kalmar. hr/usluge/cadcam).

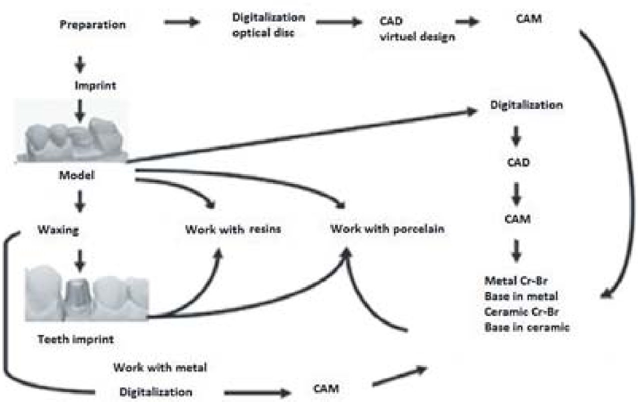

Figure 16.: Display of dental CAD/CAM system in the process of producing crown-bridges (M. Takashi, H. Yasuhiro, K. Jun, K. Soichi, T. Yukimichi, 2009).

Prosthetic restoration are made in several phases, which take place erwhich are allocated by the following order (Joda, T. Buser, D.2016) : a). *Overview and history* Based on the indications and the status of the tooth, the dentist diagnoses and recommends several options, explaining the pros and cons, depending on the indication. b). *Preparation of teeth for placing prosthetic restorations*. Process begins by grinding of teeth and its suppression, which is carried out by dentist depending on the type of the ceramics to be used for the certain clinical case, ie. to create prosthetic restoration. c). *Taking the tooth imprint*. The dentist performs the tooth imprint (one or more, depending on which prosthetic restorations works), on which it will carry out further construction and casting of prosthetic restoration. d). *Casting of the model*. Based on the tooth imprint plaster model is casted, on which is carried out further work, on the basis of tooth imprint. e) *3D scan of the model*.3D oral camera captures teeth, after which the image is transferred to a computer and processed using the software. These cameras allow a high degree of accuracy and efficiency, and is particularly suitable for the restoration of individual crown. f) *Modeling*. CAD/CAM software modeling the teeth based on the entered requirements. g) *3D teeth printing*. Before you start teeth printing, you need to install ceramic blocks in the milling. The ceramic block is fixed on the wheel that allows block to be inserted. Bridge is produced by milling process on the basis of the 3D model from the block set in the CAD/CAM device. Milling machine develops the desired shape in accordance with the instructions of a computer. The ceramic block is processed by turning on its axis, a diamond disk rotates, moves up and down around the ceramic block and processes it. The movement of the diamond disc is enabled via electric rail. h) *Cementation*. Prosthetic restorations are cemented with special aesthetic cement for metal-free ceramics. There are two types of cementing - temporarily and definitively. Temporary cementing of restoration is done in the period of adaptation of prosthetic restoration to the jaw, while definitive cementing is done after ensuring that the prosthetic restorations is accepted.

The advantages of metal-free ceramic compared to metal-ceramic works: Complete biocompatibility of materials; The absence of allergy to this material (a large number of patients with metal-bridges suffer from allergic reactions because of the large amount of nickel in the metal alloy); Absence of bimetallism at metal-free works (creating low-voltage levels between the two metals, eg. between metal-ceramic crowns); Firmness of works is 4 times higher than the metal used for metal-ceramic works; Persistence and not changing its physical and chemical properties even after long years spent in the mouth; The aesthetic superiority compared to metal-ceramic works; Beneficial effects on the gums, ie. „gingiva" with which it comes into contact; The absence of dark discoloration of the „gingiva" at the junction of crown and gums.

The disadvantages of metal-free ceramic compared to metal-ceramic works: *Price*. Due to the expensive and long-term development of this technology, expensive CAD/CAM machines and expensive process for manufacturing, metal free crowns are more expensive than metal-ceramic works. However, taking into account the relationship between price and quality, it can be said that the ratio is on the side of metal-free ceramics.

5. OPTICAL METHODS OF SPATIAL DIGITALISATION

Optical methods of spatial digitalisation, like mechanical, based on the criteria of space where the scan is performed, are divided as: a) intraoral and, b) extraoral methods.

In relation to the size of the scanning area, they are classified on the dotted and striped (surfaced). Intraoral scanning means work in a dental office, while the extraoral methods, mainly related to laboratory work. Both methods have been developed side by side, but today in the practical application is present only a single intraoral (two are in announcement) and the great number of extraoral systems. The requirements set for them are different. For ergonomic reasons, intraoral scanner should not be fixed to the remaining teeth. This affects the request of its shape, size, weight and ability to maintain hygiene, but above all the speed of scanning. Empirically it is proven that trained user can keep the scanner head immovable and still versus the scanned tooth, mostly for 0.5 seconds. The data on the speed of data measurements acquisition, in addition to the resolution, is one of the most important in the choice of the system and its broad applicability. Size of the scanning field is minimally 14x14mm, and optimally 25x14mm. The range of scanning depth should be at least 10 mm, but should not be greater than 14 mm. Scanner resolution should be at least ± 25µm (Pfeiffer J Dental 1998). The most famous representative of intraoral optical method is Cerec system (Sirona Dental Systems GmbH, www. Sirona. de) shown in the picture 17. (Schneider, W.2000).

Figure 17.: Sirona, 3M Dental CAD/CAM System

This technique is using more light rays, in the form of lines, projected on the preparation (line hatched area). The rays in rapid oscillations move across the object, so that in a short period of time is obtained three-dimensional shape of preparation. Similarly to conventional photography, the camera at the time of recording should be kept as still as possible. Fixing the camera opposite to the object at this system is not necessary because the time required for data processing from all the 340, 000 pixels is less than 0.5 sec (Fig.18). During the year 2005 are shown two more intraoral scanners Evolution 4D and HintEls.

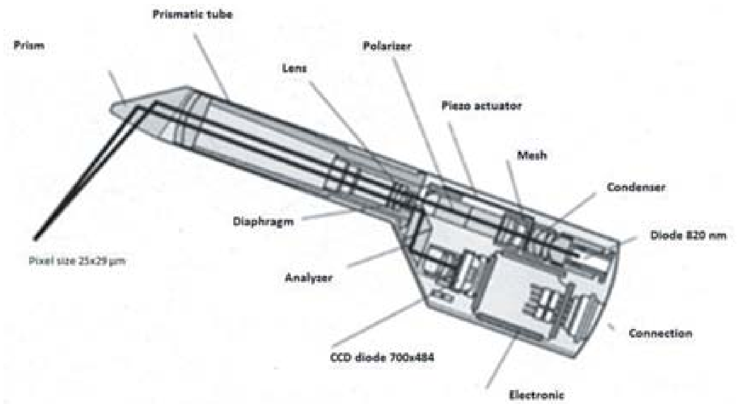

Figure 18.: Scheme of Cerec 2 scanner head section

Extraoral systems scan is carried out on the model, and for this reason there is a need for dental technical laboratory. In these systems it is not critical high speed data collection, because the head of the scanner and the object that is scanned are immovable, but the width of the scanning and precision measurements.

A different solution, to achieve the third dimension by using the CCD chips, gives the laser triangu procedure, after Lelandais and Clainchard-in (1984). If you focus laser dot air with oscillating mirror for CCD camera there will be a clear limited laser line. The great advantage of this system is the possibility of scaning undermined surfaces. This mode is for now only possible as extraoral methods.

Representative of extraoral dot scanner is Cerec Scan (Fig.19) and Cerec inLab (Fig 20). The scanner is fixed to one of the motors of the milling machine and object of scanning is movable. Scanner resolution is similar to the intraoraoral scanner, but the scan time of one tooth is much longer. For the „four-member" bridge it takes 2-3 minutes. This year, the factory has developed a new high-resolution scanner, in which this time is reduced to about 40 seconds (Cerec INEOS) (Monkmeyer, U. R. et al.2005).

Figure 19.: Cerec Scan – integrated laser scannerr, dot scanner in the left engine

20.: Cerec inLab system – from left to right: in Eos ekstraoral Cerec in Lab with inbuilt dot scanner, PC computer with 3D softver

6. RESEARCH ON PATIENTS SATISFACTION IN USE OF CAD/CAM TECHNOLOGY IN BOSNIA AND HERZEGOVINA

Generally speaking, given that they are essential for the provision of dental services, patients are essential, because if there are no patients for the service, there is no need, and it is crucial to continuously conduct research and analysis of feedback from patients. When analyzing the opinions, feelings and experiences of patients, it is necessary to take into account all factors that in any way touch the patient. These are above all: the speed of service delivery, the pain that is (not) felt when providing services, the aesthetic effects and the price of services as one of the most important elements, given the economic crisis and turbulent market trends in our country and in the regional one.

Accordingly, it is formulated ten questions, formed into the questionnaire for assessing the level of satisfaction of patients after making dental implants using CAD/CAM technology. After treating the patient, while still in the dentist's chair, ask the patient to set aside a few minutes to fill out the questionnaire, expressing their opinions and feelings about the experience with dental restorations.

In order to examine the level of patient satisfaction, 200 patients were screened and 10 questions were asked per patient, with the possibility of giving five responses to the question in the last 6 months (Table 1).

Also, in addition to the above questions, to which the patient responds, indicating the level of agreement with the above findings, the patient has the ability to verbally and in writing to state its suggestions that would contribute to the further improvement and advancement of providing these services.

Table 1: *Structure of questions for patients with five suggested answers on the issue (Author 2018)*

Questions	Disagree	Partially agree	Agree	Mostly agree	Strongly agree	Total:
1. The process of preparations for the prosthetic restoration is pleasant and does not last long.	0	20	26	56	98	200
2. It is not necessary repeatedly to come to the dentist, in order to complete the preparation process.	0	0	76	84	40	200
3. Producing restorations takes surprisingly short.	0	0	10	45	145	200
4. During producing restoration, it is involved surprisingly professional staff	25	30	25	36	84	200
5. Installing restoration is completely painless.	0	25	65	48	62	200
6. Restorations do not differ entiate from natural teeth, look completely natural.	0	0	25	40	135	200
7. Once the restoration is set up, it is needed a certain period of adaptation.	0	8	60	45	87	200
8. Dental restorations give completely natural feelings, no need for restrictions of certain foods.	0	0	0	0	200	200
9. Recommend the proces tom its frineds.	0	5	95	50	50	200
10. Price is afrodable.	0	0	22	25	153	200
Total:	**25**	**88**	**404**	**429**	**1054**	**2000**
Participations in %.	1, 25	4, 40	20, 20	21, 45	52, 70	100

The results showed that patients exceptionally satisfied with making dentures by CAD/CAM technology. Since the questions are formulated mainly that the first column (I disagree) reflects the lowest level of satisfaction of the patient (1, 25%), while the last two columns (I Mostly agree and I agree) reflect the highest level of patient satisfaction (74, 15%).

Results the research and the answers in dependence to patient satisfaction are shown in the following figure 21. (chart):

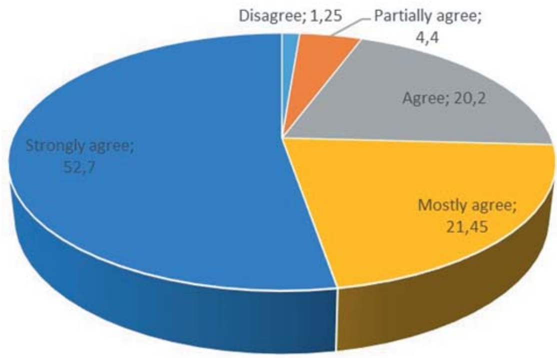

Figure 21.: Structure of the responses to the questionnaire on patient satisfaction (Author 2018.)

From Figure 21. can be noted that the most significant participation in the structure of responses take final answers to the set of 10 questions: most agree and strongly agree, that is the highest level of patient satisfaction in the amount of 74.15%. A minimum participation to the set of 10 questions take answers: do not agree, that is the lowest level of patient satisfaction of 1, 25%. The introduction of new technologies in Bosnia and Herzegovina leads to the improvement of services in the field of dental medicine, as confirmed by patient satisfaction (94, 35%). Accessibility prices to patients is very satisfactory (89%). On the issue of „Product restorations takes surprisingly short", patient satisfaction is 95%. Asked whether dental restorations giving a natural feeling?, patient satisfaction is 100%.

Responding individually to each question asked from the questionnaire for the given structure, the answers are as follows: (Figure 22):

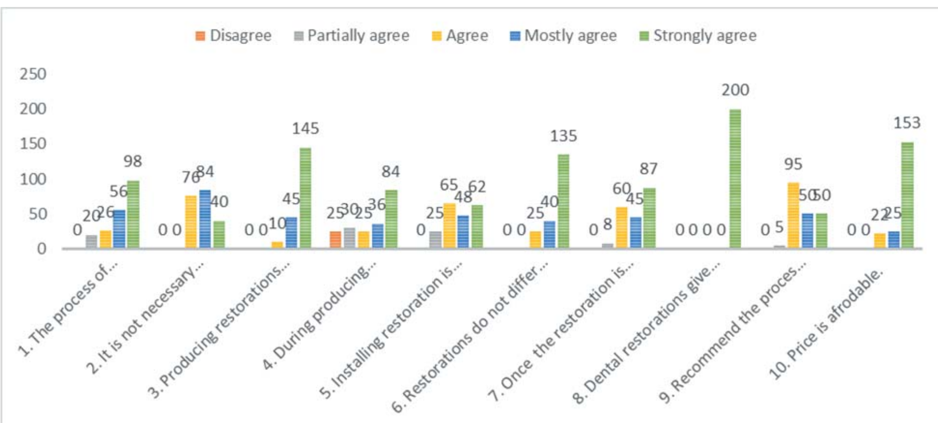

Figure 22.: The structure of the questionnaire responses on the issues of patient satisfaction (Author 2018)

CONCLUSIONS

Computer-supported production is what CAM represents and is used for programming CNC machines. CAM software has the ability to simplify the machining process, enabling users to set the Job Tree job - so they can organize their workflow, set Toolpaths, and run simulations of their parts that are interrupted for diagnostics. CAM will also create a g-code for its CNC machine that will be monitored during operations. In general, CAM begins with a Roughing cycle to remove material from the material. As the cycle approaches finishing, semi-finishing and finishing, Toolpaths refines the part into something that is ready for handling or distribution.

Computing production (CAM) is the use of software for controlling machine tools and related products. CAM can also refer to the use of computers to assist in all operations of the production plant, including planning, management, transport and storage. Its main purpose is to create a faster production process and components and tools with more precise dimensions and consistency of materials, which in some cases only uses the required amount of raw materials (thereby minimizing waste), while reducing energy consumption.

CAM is a subsequent computerized process with a computer design (CAD) and sometimes with the help of computer engineering (CAE), because the CAD model generated in CAE can be entered into the CAM software, which then manages the machine tool. CAM is used in many schools with the help of computer design (CAD) to create objects.

CAD / CAM technology in service activities - aesthetic fixed restoration is used in the development of inlays, onlays, crowns and bridges. The use of this technology provides high quality, professionalism, profit, as well as the constant growth of „new" and satisfied patients.

The application of new technologies (software technology) has a significant impact on industrial development, the development of service activities, the quality of products and services, the employment of new educated workers, higher consumption and quality of life in general.

Any progress in the field of information and communication technologies is simultaneously applied in all areas of activity including industry, medicine, dentistry, and other activities. This paper presents additional evidence of the necessity of applying new (information) technologies in industrial production and service activities. In the future, the expansion of information and communication technologies will contribute to an even greater influence in the industry in designing and designing new products, prototyping, creating new products, and in service activities on timely diagnosis, timely and adequate treatment, monitoring therapeutic effects, and achieving a high level of aesthetics in the field of medicine-dentistry.

„The ideal CAD / CAM system" has been the dream of many researchers for many years. Since CAD / CAM precision is in the function of all individual errors in procedures and equipment, and this scaning is the initial source of possible inaccuracies, the higher resolution scanner will most likely contribute to the quality of the entire system.

The research has shown that the new technologies in the field of medicine-dental services in Bosnia and Herzegovina have led to improvement of services, which confirms the satisfaction of patients (94, 35%). Accessibility rates for patients are very satisfactory

(89%). When asked if the restoration was short, the satisfaction of patients was 95%. When asked if dental restorations give a natural feeling? The patient's satisfaction is 100%. The use of CAD / CAM technology significantly reduces the time it takes to create prosthetic work, and CAD / CAM systems are easier to use. The above research leads to the conclusion that the possibility of employment in this branch of service activities for young educated personnel is constantly increasing.

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