OVERLAY DENTURES – CONSTRUCTIONAL AND RESEARCH ASPECTS

Marek JAŁBRZYKOWSKI[*], Joanna MYSTKOWSKA[*]

[*]Faculty of Mechanical Engineering, Bialystok University of Technology, Wiejska 45 C, 15-351 Białystok

m.jalbrzykowski@pb.edu.pl, j.mystkowska@pb.edu.pl

Abstract: The paper presents selected issues relating to movable dentures with their general characteristics of fixings. Reference was made to the most important material-constructional aspects and the problems that arise with this type of solutions. In the work the method of durability and reliability evaluation and selection of materials for the kinematics connections of this type of structure was proposed.

1. INTRODUCTION

Modern dental prosthetics is a very vast area of science that makes it possible to reconstruct the shortcomings of teeth in the form of fixed or movable additions. The group of prosthetic permanent additions includes: crowns, bridges, inlays. In the group of movable dentures are: partial, complete and skeletal. As regards of design, the construction of each of these elements can be distinguished on: skeleton, prosthetic superstructure and fixing elements (Ciaputa, 2009). Fig. 1 shows the modules of the traditional components of a prosthetic bridge. In sense of the operational life and reliability, the key technological process elements include: material, design and technology implementation. The process of securing dentures in the oral cavity and clinical aspects are also important, but these problems are not the subject of work.

Crowns and bridges are permanently embedded, without need to remove it from the mouth. They do not perform well, when the shortcomings are more extensive, covering several cavities. In case of several teeth lost, the denture making is considered. At present, the most popular are acrylic prosthesis in which the artificial teeth are mounted in acrylic plate lying on the palate and gums (Ciaputa, 2009; Hupfauf, 1997). Such a structure is a burden on the bone and soft tissues and does not provide a stable support in the mouth. Much better results provide skeleton denture application. Metal, individually matched frame by braces and prosthetic thorns tightly embeds the patient's own teeth. Such a solution minimizes the chewing forces, transferred to the soft tissues and bone. In order to strengthen the location of the prosthesis in the mouth, a number of precise fixing elements such as latches, slides, telescopes and magnetic fastening is applying. These details allow easy removing off the prosthesis, ensure its stable maintenance and fully comfortable use.

Constantly evolving dental technique makes it impossible to present in this work all types of kinematic connections currently used in the overlay dentures. Thus, only selected types of precise elements are presented, with objective of assessment of their possible approximations immutability and operational reliability. In this context, the author's method of assessment their durability is proposed.

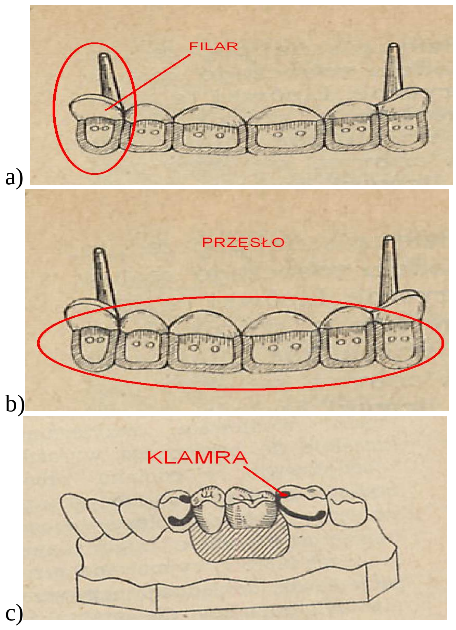

Fig. 1. The construction of prosthetic bridge: a) the pillar of a bridge, b) bridge span, c) buckle (fixing elements)

2. OVERLAY DENTURES JOINTS

It is well known that the precise fastenings are applying to stable or movable prostheses. There are fixed on the prosthetic pillars (natural teeth or implants). They are constructed with two main elements forming the mechanical connection between them. One part is the matrix – seated on the tooth or several teeth, the root of the tooth or at implant, and the second part – quite often is fixed in the mobile denture. In comparison to clasps, precise fasteners have many advantages, for example (Ciaputa, 2009; Hupfauf, 1997; Raszewski, 2009; Sajewicz, 2008):

– they allow to get a good aesthetic effect (avoid metal on the vestibular surface of tooth),
– during the dynamic phase of mastication, precise components ensure impact of only vertical forces on the pillar teeth and preferred stimulation of the toothless segments of prosthetic foundation in a static phase, causing that the prosthesis rely only on the mucous membrane,

- the denture track introduce is always a parallel trajectory to the long axis of resistance tooth,
- in case of the deterioration of prosthesis maintenance, the individual connectors elements can be activated or replaced.

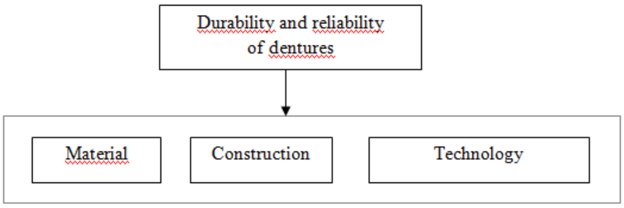

Fig. 2. The denture operational durability using engineering conditions

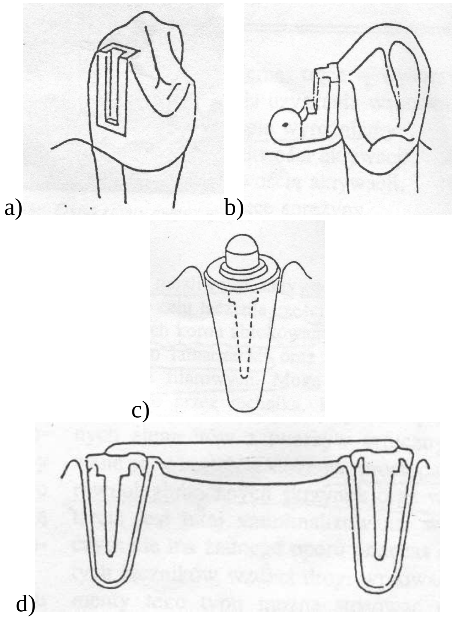

Fig. 3. The examples of precisely constructional joints: a) inside the tooth, b) outside the crown, c) root clasps, d) crosspieces

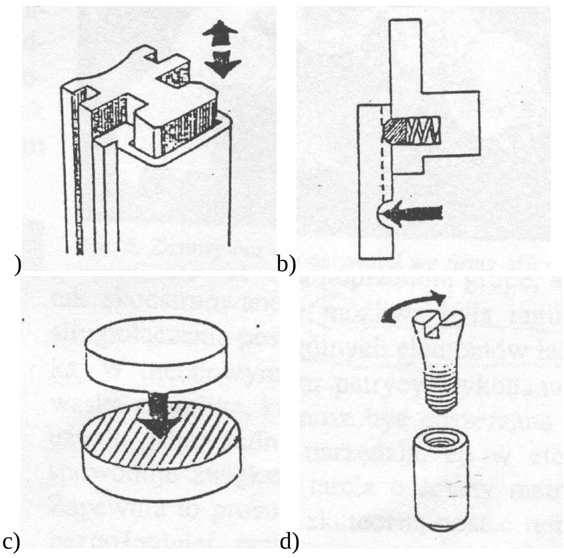

Fig. 4. The overlay dentures fixing methods: a) friction forces, b) mechanical, c) magnetical, d) using screw

In addition, they can be used in many constructions, such as (Ciaputa, 2009; Hupfauf, 1997; Raszewski, 2009):

- skeletal prostheses,
- overdentures,
- partial settling denture,
- stable fastenings.

As mentioned earlier, durability and reliability of teeth prostheses in engineering terms depend primarily on three aspects: construction, material and technology. It is illustrated by the pattern set in Fig. 2.

For the manufacturing process of dentures, noble metals (platinum gold, platinum-iridium gold) and chrome-nickel steels are used. In recent years plastic materials (such as teflon, nylon, silicone) are utilized.

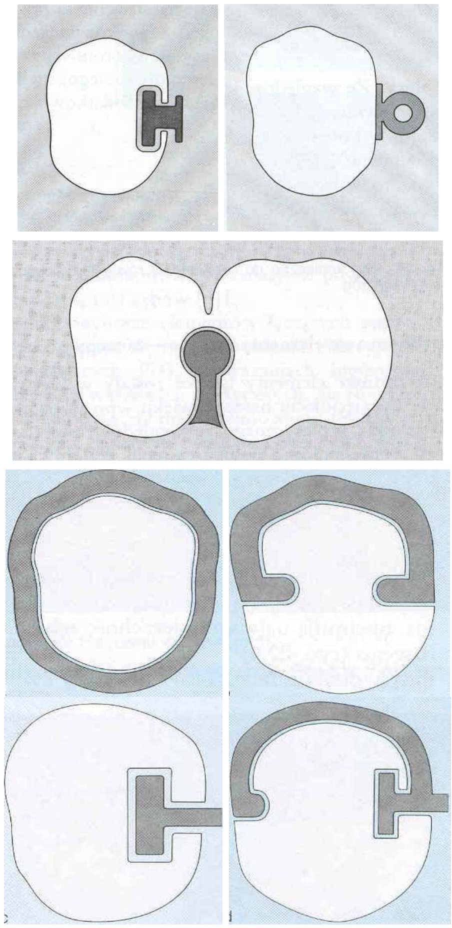

Fig. 5. The examples of the overlay dentures fastening

In case of construction process, the applied connectors are divided into few groups taking into account their physicochemical action (Hupfauf, 1997; Raszewski, 2009; Ciaputa, 2009):

- inside the tooth – stiff joints, screwing, fastening (Fig. 3a),
- outside the crown – screwing joints, hinge and screwing – rotating (Fig. 3b) connectors,
- root clasps – rigid screwing and screwing – rotating (Fig. 3c),
- crosspieces – rigid and resilient (Fig. 3d).

For durability and operational reliability, the fixing type of moving parts of overlay dentures is of high importance.

Those fixing (connections) are obtained by using (Ciaputa, 2009; Hupfauf, 1997; Raszewski, 2009):
- friction forces (Fig. 4a),
- mechanical retention (Fig. 4b),
- the use of magnetic forces (Fig. 4c),
- the use of forces from the screwing (Fig. 4d).

Above (Fig. 5) some fastening construction solutions of overlay dentures are presented. Having in mind research targeted for the purpose of this study these are mainly fixations which use a friction forces. It should be noted that studies of this type of fixations for dentures are now one of the main areas of research of the Department of Materials and Biomedical Engineering at Bialystok Technical University.

3. RESEARCH CAPABILITIES OF ELEMENTS OF DENTURES

For the purpose of assessing the performance of materials for dentures in engineering term, various tribological testers are applied. It should be noted that variations in the use of materials, the scope of external conditions during their real work, or a specific of micro-and macro environment leads to the fact that the overwhelming number of testers are the testers that combine the multiplicity of factors. Often these are testers, in which the construction of a working node is based on the already known schematic friction nodes, such as: pin / disc, ball / disc, pad / roller, roller / disc, etc. As a result, a newer modifications of already known friction testers are constructed, the use of which is addressed primarily to assess the performance of friction elements, not the team of elements, as dental prosthesis. As an example of such a tester is UMT-2 tester presented in Fig. 6 (CETR Tribometers).

Fig. 6. Micro-tribometer model UMT-2 (CETR Tribometers)

Presented in Fig. 6 tribometer is the universal device for evaluation of tribological characteristics and selected mechanical properties of biomaterials, including dentures materials, tools and medical instruments. However, in spite of its versatility and wide range of research opportunities, this device works in the couple of pin/disc or ball/disc. Moreover, studies involving this tester are limited to the evaluation of two co-partners.

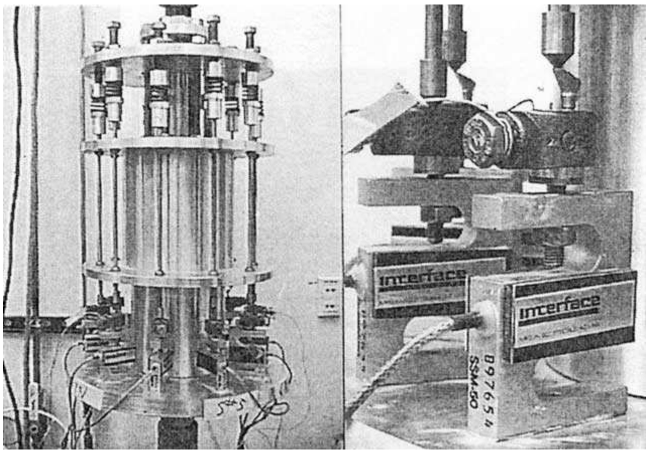

Fig. 7. Cibirka's carousel device (Cibirka, 2001)

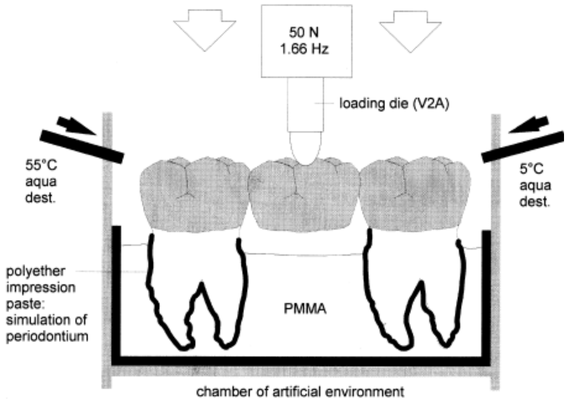

Fig. 8. The example of machine for denture's operational reliability test (Behr, 1999)

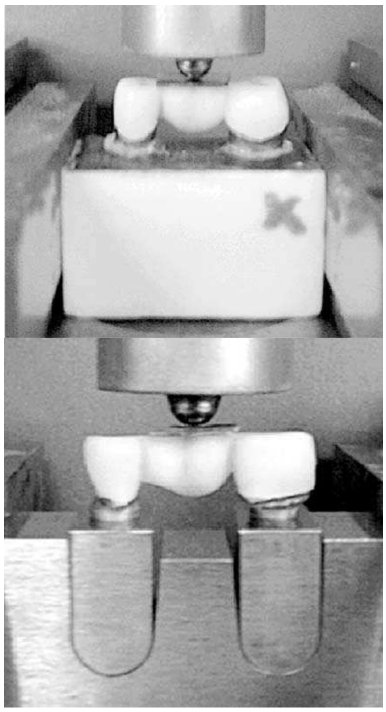

Fig. 9. An example of model for prosthetic bridges tests (Fischer, 2004): a) stable part of bone, b) movable part of bone

In view of the fact that the dental prosthesis is a team of various interconnected components, there is a need to study under the same conditions the external extortions and kinematics of the load of team elements simultaneously. In Fig. 7 the tester used by the Cibirka (Cibirka, 2001) in which 10 elements were analyzed simultaneously (dental implants) is shown. The studies were conducted in a fatigue cycle to determine the operational durability of the analyzed elements. However, this research was orientated only for a rapid review of implant materials, thus in effect only the implant was tested. Aspects of more elaborate construction dentures were omitted.

Further research focused on the operational reliability of dentures resulted in the appearance of works, which used a simple linear bridge restorations.

An example of a more advanced device is shown in Fig. 8. This machine reflects in a greater degree the working conditions of dentures in the mouth. However, the modeled load takes into account only the movement in the vertical plane, which greatly simplifies the real conditions of the prosthesis work.

Some modification of the device shown in Fig. 8 is an apparatus model whose view is given in Fig. 9 (Fischer, 2004). The advantage of this solution is the ability of a deviation from the equilibrium position (vertical) of the bearing screws mounted in tooth socket.

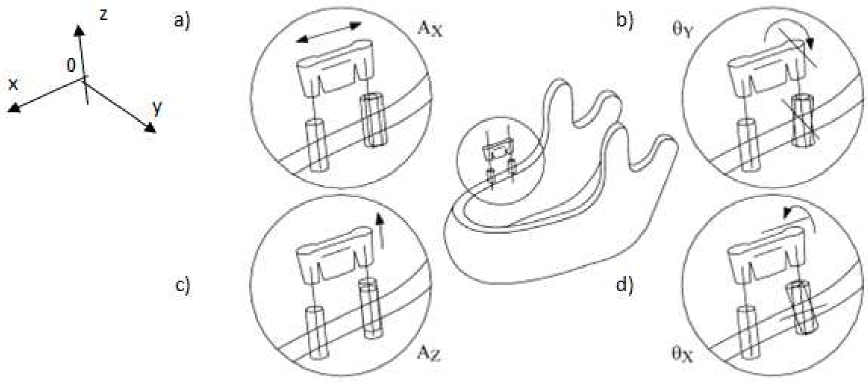

Fig. 10. The examples of errors resulting from load-bearing pillars in teeth sockets (Pietrabissa, 2000): a) an error of the implant's fastening distance, b) bend to OY axis, c) an error of implant fastening depth, d) screwing to OX axis

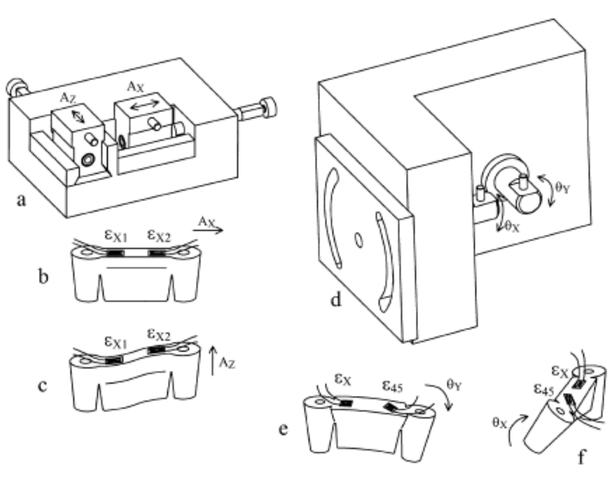

Fig. 11. The example of test machines and types of modeled external extortions (Pietrabissa, 2000): a) the simulation of error of the implant's fastening distance, b) straighting the implants, c) bending, d) screwing, e) the element to incorrect modeling of implants in X and Y axis determine, f) an element for double-axis screwing

Other interesting proposal was submitted by the authors of work (Pietrabissa, 2000). They established that the most common form of errors in the functioning of prosthetic bridges are errors resulting from different axis fixation of load-bearing pillars in relation to the geometry of the prosthetic bridge. Fig. 10 shows the analyzed errors.

The analysis of cases presented in Fig. 10, allowed authors of work (Pietrabissa, 2000) to build a model test which integral part is shown in Fig. 11 (11e and 11f). This figure illustrates the diagrams of machines enable to get analyzed earlier states of deformations. The test stand prepared in this way provides much more research combinations and gives better opportunities to assess the real state of a prosthesis, taking into account the possible, future implantologist's errors. However, it lacks a constant reference to the quality of service of the dental prosthesis.

Another example of the dentures diagnostic test stand is an instrument shown in Fig. 12 (Kuchta, 2006). The advantage of this instrument is that it allows richer kinematics of the motion and putted loads, but the simulation of the conditions of micro-and macrosurroundings corresponding to the mouth environment is missing. It is mostly long-term effects of various types of liquids and gases, such as saliva, alcohol, juice, coffee, tobacco smoke, etc. In this solution there is also no reference to co-partner, which is the opposite jaw. However it is worth to remember that the instrument is intended to prosthetics diagnosis and not to assess their operational strength.

On the above examples of different instruments for the dentures evaluation, the best seems to be a device presented in Fig. 13 (Studium Famulaturen&Auslandsaufenthalte). The main advantage of this model is the using in its construction the classical testing machine. There is no need to build a separate, specialized facilities and it provides an easy way to rebuild the test stand for other kind of tests. In addition, it is possible to assess both the whole – complete dentures, as well as smaller sets, which in a sense indicates the test stand universality.

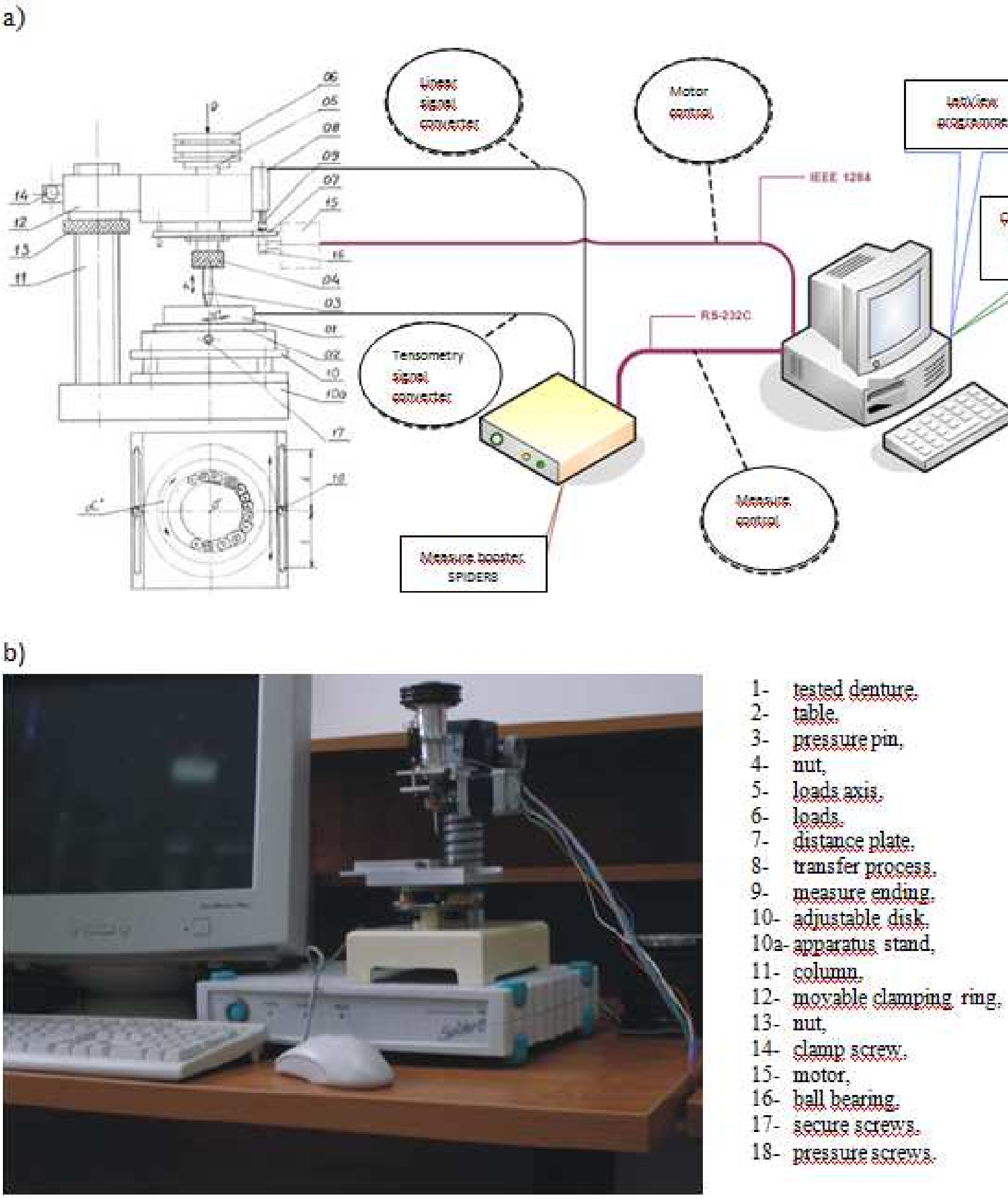

Fig. 12. The laboratory stand for dentures diagnostic (Kuchta, 2006): a) the stand's diagram, b) view of apparatus and system register

Fig.13. The stand for denture tests – artificial mouth (Studium Famulaturen&Auslandsaufenthalte)

It is also worth mentioning that the operating system is locked in a casing, which also makes it possible to use liquid and gaseous media. As a drawback of this test stand (shown in Fig. 8) can be considered very small movement kinematics of the analyzed elements. Indeed, it is confined to put loads in the vertical plane and turnover in the axis of the prosthesis.

Given by the examples presented above and the literature analysis of utilized methods and apparatus for testing dentures a device of own design was proposed.

4. THE PROPOSITION OF OWN DEVICE FOR ASSESSMENT THE OPERATIONAL RELIABILITY OF THE DENTAL PROSTHETICS ELEMENTS

Due to the patent process started, this paper shows only a simplified working area of the device with the possibilities of movement and load (Fig. 14). Designed device is intended to serve both the individual components like crown or permanent fillings, through simple and diagonal bridges to full dentures. Fig. 14a illustrates view of the working node of the device in lateral position. This projection shows the load pins movement (up-down) in the vertical plane. Because of the possibility of three or more (optional) pins, Fig. 14b and 14c presented the placement and the full range of designed moving elements. Working pins are driven by a special mechanism, which makes their movement is shifted in phase. This gives the so-called 'wave' effect. Thus, in Fig. 14b is indicated the swinging movement of the lower table in relation to horizontal surface. At the same time the lower table has the ability to perform lateral movement (right-left) and rising and sinking to the bottom (Fig. 14c shows the example of fitting the prosthesis to match its location on one of the tables). Normal operation of the device intersects with each other all these movements, thereby making the complex movements of the test pieces - both sinusoidal in longitudinal and transverse table axis.

Optionally, the removal of the lower table is expected in case of evaluating of the individual components like crown or materials on permanent dental fillings. In such cases, the test sample is fixed onto the table top in front of the loading pin.

Another important element of the designed tester is the possibility to choose the number of pins. Minimally it may be one, with maximum of 5 pins, as illustrated in Fig. 14c. Starting situation involves the use of three pins, but there is the possibility to use also five pins. There is also an option of changing the position of pins, depending on the size of the prosthesis.

With respect to the external forcing parameters it should be mentioned that the load on test samples will be regulated by appropriate setting of the upper table, the number of working pins cycles, electric motor's speed, therefore time of device work may be set in any way.

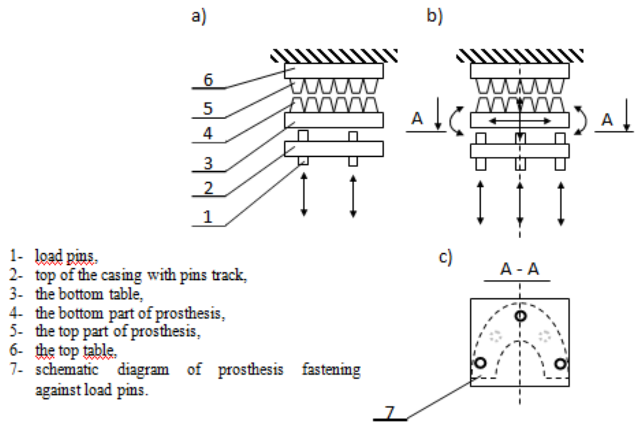

Fig. 14. The working couple of the device for exploitation stability assessment of the dentures elements: a) view of the side, b) view of the back, c) section A-A

It is assumed that the tester's work will enable the measurement of maximum force. In addition to the loading force measurement the possibility of the measurement of friction force between the cooperating elements is anticipated. During analysis the generalized friction force will be taken under account - as the resultant of the all partial friction forces. Tests can be conducted either within a specified time or until the first of any damages of assessed elements. It is envisaged that the quality of prostheses will be decided by reliability coefficients or tribological factors. It should be noted that the entire work space will be closed in a transparent chamber with the corresponding connecting pieces, which can be pressed distorting medium, such as: tobacco smoke. By the droplet method or aerosol will be added liquids such as alcohol, tea, coffee, artificial saliva, etc. In addition there is the possibility of heating the system to the temperature of 37 ° C.

The designing tester in such a way gives a good approximation (with respect to the kinematics of motion of working elements and micro- and macrosurroundings) of dental prosthetics elements work in the real conditions of mastication in mouth. At the same time the usage of various media will enable to assess their impact on the reliability of tested items, but above all it is necessary to model a real "microclimate" of the mouth.

5. SUMMARY AND CONCLUSIONS

In the work the closer construction problems of overlay dentures fixings was elaborated. The sustainability and reliability of this type of construction in terms of research opportunities was discussed. A few types of testers for assessing the performance of biomaterials used in dentistry and the durability and reliability of prosthetic dentistry elements was presented. The existence of numerous test stands, which kinematics of motion is based on the well-known for a long time tribological testers, such as: stem / disc, ball / disc, etc was indicated. The presented test equipments are helpful in evaluating of the materials and components of dental prosthetics, but in their construction it is not possible to simulate the complex movements of the stomatognathic system, or simulate the microclimate of the mouth.

According to above testers analysis, the own construction solution of tester which asses the reliability of dental prosthetics elements was proposed. Due to the patent procedure taken, this paper presents only the simulated conditions of external forcing in the form of a simplified kinematic scheme. It should be noted that the tester is designed to allow simulation of complex movements of the tested components, and additionally it is envisioned to maintain artificial -model climate corresponding to the microenvironment of the mouth.

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This work was financed by Polish Ministry of Science and Higher Education as a research project in 2010-2013 years (Grant No N N507 592938).