Aspects Concerning Impact Tests on Composites for Rigid Implants

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***Abstract*—In order to obtain a suitable rigid implant, we need to be certain that its properties are very close to the structure it is supposed to replace or support. For this reason, the materials to be used for manufacturing should be carefully selected, so that their mechanical and biomechanical properties correspond to the intended purpose. The present paper is dealing with some impact tests developed for these types of structures and the required testing methodology.**

***Index Terms*—composites, impact, rigid implants, tests.**

I. Introduction

It is a very well known fact that a wide range of afflictions due to various accidents, certain diseases or old age can lead to the damage of some bone or dental structures, having more or less serious implications upon the person's life quality. The implant comes as a foreign body in the human body, having the mission of taking over the tasks of the afflicted structure or to support the body in the recovery process if this is still possible.

In order to be sure that the implant meets its purpose, the properties it offers should be as close as possible to the ones of the replaced or supported structure and also it should not affect the human body in a negative way. For this reason, the materials we are using for implants manufacturing will be very carefully selected, so that they are biocompatible, preserve the required mechanical and biomechanical properties along the entire use cycle or at least as long as possible and let us not forget the fact they should require reasonable expenses, considering the fact that they need to be individualized according to the psycho-somatic characteristics of each beneficiary.

This way they can be made available to a larger target of individuals who require them, contributing to a substantial improvement of their life quality and many times to the smooth readjusting of a person to a normal productive life.

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II. Fundaments and Methodology

One of the main requirements to meet for a rigid implant is the impact resistance, especially as far as the dental implants or prosthesis are concerned. They are constantly subjected to dynamical shock stress and impacts during the mastication process but also due to some accidental phenomena during their entire life-cycle.

Also, most of the used materials are obtained by successive layers applied over a basic material in order to be able to benefit of all useful properties of the materials involved. The impact tests also offer us an idea about the adherence degree of the material layers on the basis.

For this purpose we used an equipment provided by INSTRON, model 8200 (fig. 1), ideal for testing thin cross-sections of composite and ceramic materials, thin films and also metals. Using this equipment we are able to obtain the changing values for impact velocities and impact energies. The maximum impact velocity is about 4,4 m/s, while the range of impact energies is somewhere between 1,356J and 132,8J.

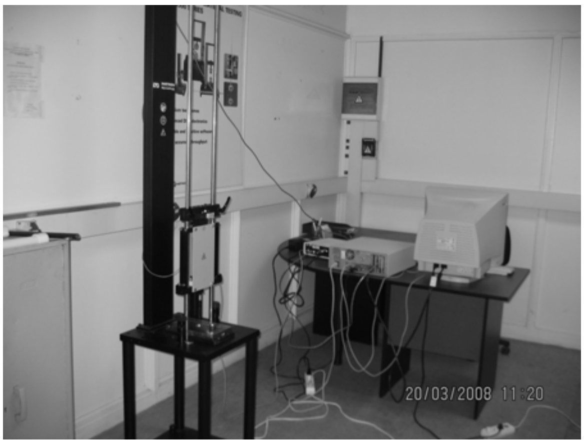

Fig.1 Impact testing equipment with data acquiring system

The results are acquired by a computer system with dedicated software, which provides graphical data concerning the impact velocities and energies.

The method used by the testing equipment is based on dropping a certain weight on a vertical direction inside a guiding tube. Knowing the weight dropping height and the value of the weight, the software allows the instantaneous determination of the impact energy, impact velocity, peak load and also other parameters characterizing the studied impact.

The use of this method offers several benefits, the most important for our purpose being:

- it is one – directional with no preferential giving in directions. The material gives in through the weakest point of the sample and starts propagating from that point out.
- samples must not be destroyed to be considered failures. Material damage may be defined by deformation, rupture initiation or even complete rupture according to the beneficiary's requirements.

All these factors make this method to represent a better simulation of exposure to functional impact, much closer to the real conditions.

The samples used for testing are usually plate shaped manufactured from the basic material and improved with successive layers, as shown in fig.2.

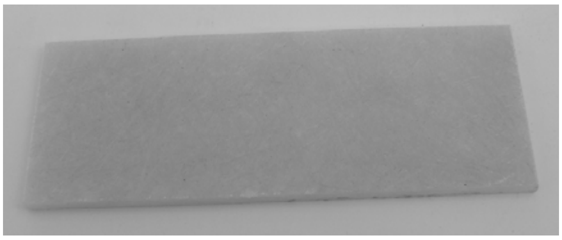

Fig.2 Sample used for impact tests

The sample is placed in a special groove, designed to allow the central part of the material (subjected to impact) to deflect according to the testing parameters, shown in fig.3.

Fig.3 Place for sample positioning

After fixing the sample between the two guiding sleeves, exactly over the groove, we performed tests for different loads between 1 and 5 kg, for impact heights in the range of 25 and 150 mm.

Usually the structure resistant element is made of titanium, covered then with different type of acrylates or even with polytetrafluor – ethylene (PTFE) for some dental prosthesis that require low friction joints in order to be attached to the natural remaining structure. But the expenses are too high for average people so we decided to use instead of the titanium core, a fibre reinforced composite material and see if it meets the requirements.

The present paper deals with the impact tests we performed for the composite material that would be more accessible as far as the expenses are concerned.

III. Experimental Results

The results obtained during the measurements are primarily stored in a table form, where we introduce the known parameters such as: type of material, thickness, width, also weight, falling height and the diameter of the falling body chosen for that specific test (e.g. see Table I).

The table also will contain the measured parameters, such as: maximum load, maximum energy, impact velocity, time and some observations concerning the type of test upon the sample (e.g. frontal testing F or both frontal and rear testing B).

Table I Measured parameters during tests

No	Thickness (mm)	Width (mm)	Weight (Kg.)	Height (mm)	Φ (mm)	Impact measured parameters				Obs
						Max. load (kN)	Max. energy (kg m)	V (m/s)	Time (msec.)	
1	7,75	60,5	3,06	25	20	2,818	0,1600	0,855	2,7374	F
2						2,574	0,1582	0,858	2,8961	F
3						2,768	0,1616	0,857	2,7710	F
4						2,800	0,1814	0,924	2,8564	B
5	7,75	60,5	3,06	35	20	3,519	0,6283	2,610	2,5848	F
6						3,075	0,7585	2,870	2,9633	F
7						3,428	0,794	3,024	2,7496	F
8						3,519	0,8343	3,189	2,7069	B
9	7,75	60,5	3,06	40	20	4,064	0,1608	0,809	2,9877	F
10						4,235	0,1622	0,811	2,5238	F
11						4,106	1,1567	0,812	2,7161	F
12						4,143	0,1647	0,818	2,6520	B
13	7,75	60,5	3,06	50	20	5,063	0,2000	0,935	2,4139	F
14						4,869	0,2016	0,930	2,8839	F
15						4,610	0,1997	0,926	2,6367	F
16						4,600	0,1999	0,929	2,8076	B

For each type of impact test, 5 samples were used in order to obtain a result which is as accurate as possible and each sample was tested 3 times, once in the central part and twice towards the lateral sides.

We changed the dropping mass value from 1 to 6kg and the height from 100 to 580mm and used samples with thickness between 5 and approx.8mm.

The results were obtained as diagrams time versus load and time versus impact energy, with the results table attached providing accurate values for the peak load, deflection at peak load, energy impact at peak load, impact velocity, like shown in fig.4-7.

The diagram in fig.4 reveals a 5,07kN peak load, 0,61kg.m impact energy corresponding to the peak load and a 1,36m/s impact velocity, over 4,8s period of time.

The diagram in fig.5 shows an 8,53kN peak load, 2,07kg.m impact energy during peak load and 2,8m/s impact velocity over 5,2s period of time.

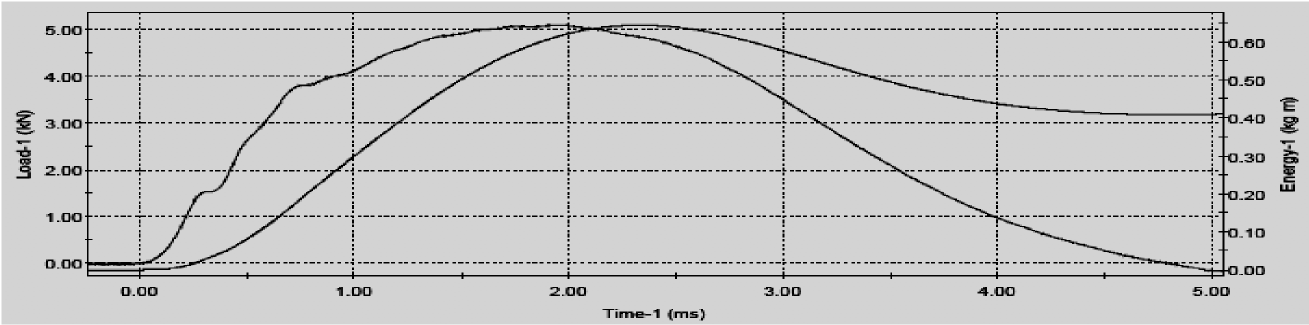

Fig.4 Load and energy diagram versus time for a 6,06kg weight mass and 100mm dropping height

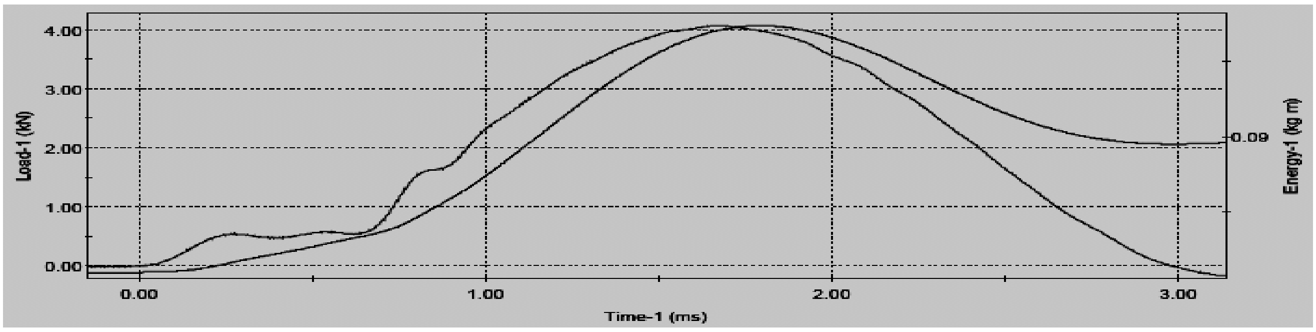

Fig.5 Load and energy diagram versus time for a 6,06kg weight mass and 430mm dropping height

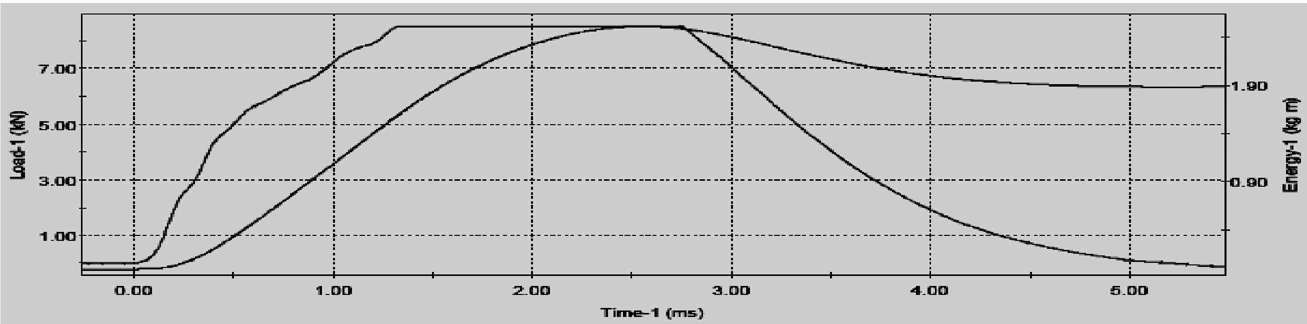

Fig.6 Load and energy diagram for a 3,06kg weight mass and 40mm dropping height

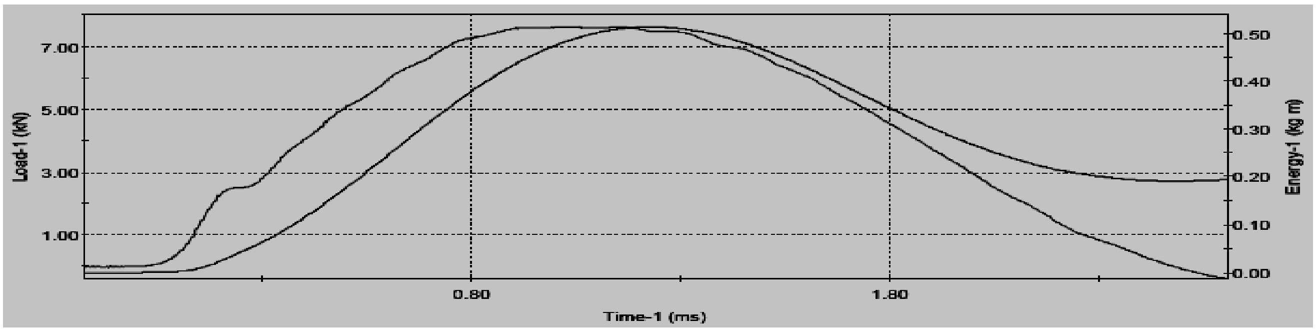

Fig.7 Load and energy diagram for a 3,06kg weight mass and 140mm dropping height

The diagram in fig.6 reveals the following: 4,06kN peak load, 0,16kg. m impact energy for the peak load and 0,8m/s impact velocity over 2,98s period of time.

The above diagrams represent just a few examples of the results obtained during the impact tests.

Analyzing the diagrams and the tables provided by the equipment software, considering also the initial conditions concerning weight and height, we can conclude that the peak load increases as expected with the weight mass and also with the dropping height. Also the impact velocity is higher with the increase of height and weight.

The values obtained for the material deflection is little over 1mm in almost every situation, which is insignificant considering the magnitude of shock. At this rate, the implant is able to resist even at greater loads, provided they are within normal occurring phenomena.

Another issue that interested us was the layers adherence after the impacts and we were able to establish that even the great impacts did not produce any damage upon the material layers, just a small deflection, as in fig 8.

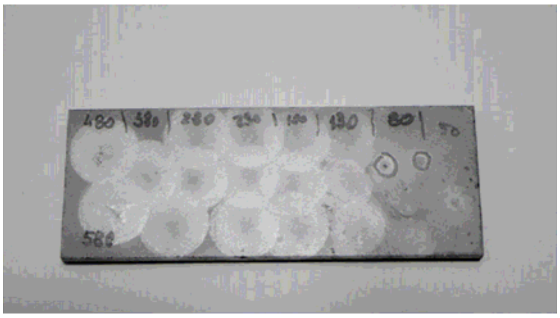

Fig.8 Rear part of a sample after testing for various dropping heights

Only for a height of 580mm and a maximum weight mass of 6,06kg, the material shows a bigger deflection, but we also need to consider the small thickness of the sample, around 7mm.

IV. CONCLUSION

After analyzing the testing results we might conclude that a fiber reinforced composite material is suitable from the point of view of impact resistance and also can be a good basis for the improving layers to be applied.

Other mechanical tests were also conducted by the team within various research projects proving that at least from mechanical point of view, the composite materials may be used as a cheaper but also suitable possibility in manufacturing rigid implants.

Future researches are going to be directed, in association with biochemists and medical staff, to establish the biocompatibility of these materials in order to offer an alternative for the people affected by various diseases or accidents.

Another issue for our future projects concerns the individualization of orthesis and prosthesis using rapid prototyping and software simulation in order to ease the patient adjustment to the foreign intervention, both from psychological and physical point of view.

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