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IMAGE PROCESSING USED TO ANALYZE THE LAYERED LENS STRUCTURE

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Abstract: *The lens is an optical element mounted in a frame of metal, plastic or other materials for the purpose of correcting and / or protecting the visual system. These medical devices (orthotics) are made of optic, polycarbonate, or plastic with refractive indices standardized (1.523 ophthalmic refractive index) or not ("strong glass" with refractive indices above 1.6). Glasses for correction or protection, general use or for professional activities, for private use or sports, cultural or dedicated to different fields require special materials and technologies. The first part of the paper presents some considerations regarding the construction of glasses and the use of specific materials. In the second part of the paper, the stages of analysis of some variants of glasses used for different sports and the image processing of some lens and accessories material features are presented. In the final part of the paper are presented the results and the conclusions obtained.*
Keywords: *lens, composite materials, spectacles, image processing*

1. INTRODUCTION

Spectacle lenses, whether for correction or protection, should provide the subject/patient with a viewing quality unaffected by the optical and chromatic aberrations of the optically transparent media, unimpaired as the intensity of the light radiation used, and also without any effects due to harmful substances or radiation environment.
Of all the categories of glasses that a human subject can use, the guards are of particular interest in their construction, which must adapt to the facial shape they are protecting and the level of protection they have to provide. [1]
Through a series of European and international standards, important aspects have been regulated for sports goggles or other areas of activity, for the protection of the visual function (**BS EN 172:1995, BS 7930-1:1998.** Eye protectors for racket sports, Squash Oculars., **BS EN 174:2001.** Ski goggles for downhill skiing, **BS EN 166:2002.** Personal eye protection, **BS EN 167:2002.** Personal eye protection: Optical test methods, **BS EN 170:2002.** Personal eye protection: Ultraviolet filters: Transmittance requirements and recommended use, **BS EN 171:2002.** Personal eye protection: Infrared filters: Transmittance requirements and recommended use, **BS EN 14458:2004.** Personal eye equipment Face shields and visors for use with firefighters' and high performance industrial safety helmets used by firefighters, ambulance and emergency services, **BS EN ISO 8980-3:2013** Ophthalmic optics - Uncut finished spectacle lenses Part 3: Transmittance specifications and test methods, **BS EN ISO 12312-1:2013** Eye and face protection - Sunglasses and related eyewear - Part 1: Sunglasses for general use, **BS EN ISO 12311-1:2013** Personal protective equipment - test methods for sunglasses and related eyewear), these standards being important in construction and use. [2]
According to the findings of eye protection research, eye injuries can occur for two reasons: 1. Do not wear safety glasses and 2. The protective eyewear is not adapted to the activity.
Eyeglasses used in the ocular area are often supplemented with protective systems for the entire facial area, taking into account protective structures for all human sensory systems (auditory, odor, tactile) to avoid injuries or dysfunctions. In addition, it has been found that many of the injuries can be avoided by the human subject if he is trained, prevented and informed to use such equipment. These aspects are also important in the sport field to prevent injury to the visual system in the conduct of that activity.
In different synthetic documents [3], almost 2/3 of the population is expected to practice sports, and 60% of them need visual correction. It is therefore necessary for a sports eyewear to meet the aesthetic requirements of the customers without compromising their optical quality.
The leading sports eyewear makers have optimized the optical properties of the lens to minimize aberration and enhance the wearer's comfort by developing corrective lenses for spectacles for different sports.
Eye / facial protection systems that can be used in various activities can be categorized as follows: Safety spectacles, Eye shields & Over-specs, goggles, face shields, combined protection, sport (fig.1).

Figure 1: Different variants of ocular protection systems [1]

A protection / correction lens requires a wide range of technological processes, but the most important aspect is the realization of layers that provide multiple optical, mechanical and chemical qualities of these lenses, making the glasses a stratified structure with antireflection properties, hardness and wear resistance, oleophobic and hygrophobic protection. (fig.2)

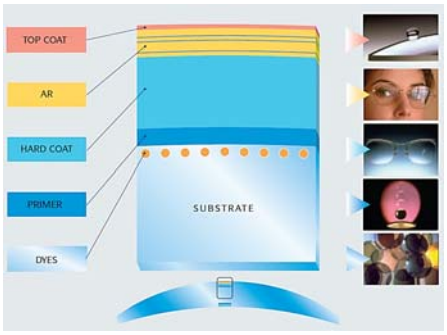

Figure 2: A coated plastic lens is a complex system [4]

From the point of view of the shape and dimensions of the adaptation of the safety spectacle frames it can be seen that an important characteristic of the sports eyeglasses is the large curvature of the frame (fig. 3), which produces some prismatic optical effects, oblique astigmatism or refractive errors, but has the advantage of increasing the field of view by approx. 30%.

Figure 3: Different variants of sportive spectacles [5]

Also, for these glasses, some frame sizes can be individually adapted, such as pantograph, vertex distance, interpupillary distance, even frame curvature when anthropometric dimensions or range of use of the eyeglass requires this.

2. EXPERIMENTAL SETUP

The experimental system, designed for the analysis of the lens protection glass structure in the sport field consists of a set of equipment for compression testing, surface defects visualization and a simulated temperature variation system to which lenses and frames of glasses have been subjected for different sporting disciplines (ski and swimming). For this experiment, sports-ski and swimming glasses were used, with a service life of between 3 and 15 years, to exemplify the importance in the process of protecting the visual system of the use of properly adapted and well-functioning systems.

Figure 4: Different variants of ski spectacles used in experiments

Figure 5: Different variants of swimming spectacles used in experiments

The compression test of the ski and swimwear variants highlighted a number of aspects related to lens behavior in the frame, that is, the lenses cracked, deformed and left the frame resulting in the complete destruction of the lens being made of polycarbonate material, none of them (ski or swimming spectacles) did not break, but they were deformed.

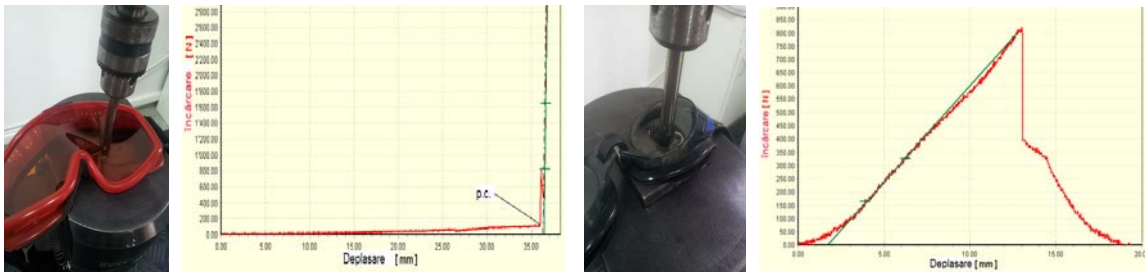

Figure 6: Compresion test of ski (left) and swimming (right) spectacles

Taking into account that the result is influenced by a series of errors and factors such as material quality and weariness, it can be noticed that once the period of use increases, the force of the glasses decreases. Older glasses pose dangers to the visual system and it is recommended that they be replaced after the manufacturer's intended period of time to be used safely.
For a deeper analysis of the lenses and spectacle lenses characteristics, the lenses and frames in the facial contact area were analyzed microscopically. For each case (ski, swimming), mechanical or thermal aggression elements were used and analyzed using a digital microscope with magnifications between 20x and 50x, through specific image processing procedures, shape and size of the traces produced on lenses or frames.

3. RESULTS

The results of the recordings on the digital microscope allows analysis of glasses' use defects and controlled aggression by materials such as wood, metal, stone (fig.7).

Figure 7: Attempted mechanical aggression controlled by wood (left), metal (middle), stone (right) of the ski goggle lens (digital microscop images with 20x magnification)

From the analysis of the dimensions and forms of the scratches made on the surface of the lenses (with a constant pressing force in all 75 N cases) it is found that the wood left a wide, uniform trace, composed of several fine scratches, the metal leaves a precise trace the stone crushed the lens into abrasive particles (fig. 7).
In the case of swimming lenses and glasses, the process of controlled thermal and chemical aggression was achieved by using a system where glasses were subjected to variable temperatures from -18° C to 100° C and the attack of corrosive substances such as hard water, saline and chlorine water (for 168 hours).
As a result of these tests, the surface of the lenses, as well as the surface of the frames made by silicone material, foam, natural rubber or hard plastic material for the glasses were analyzed with the 50x magnification digital microscope (fig.8).

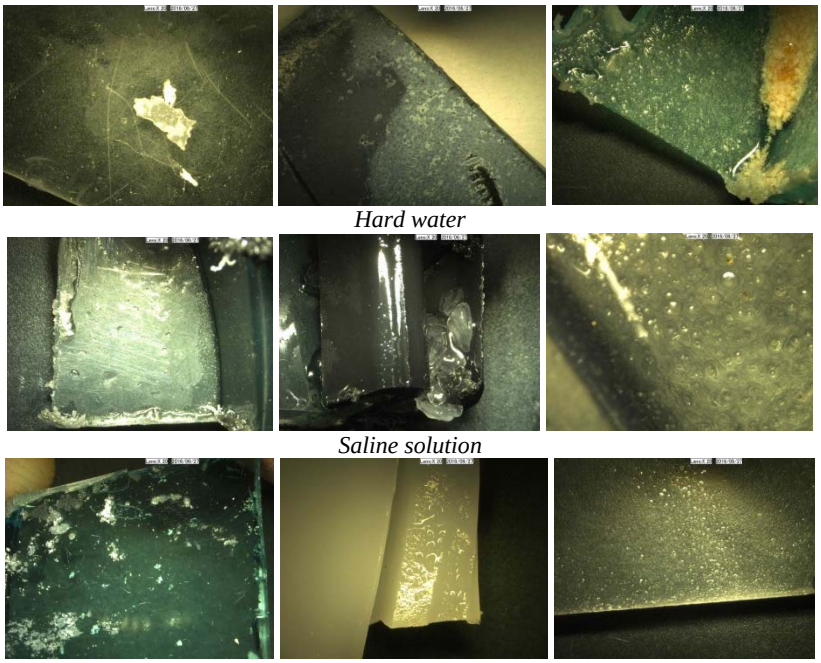

Figure 8: Recordings by digital microscope (50x magnification) of lens and frames surface

From the microscopic analysis of lenses and frames immersed in chemically aggressive solutions it is found that they behave differently depending on the age of use, the old ones have more deposits), such as the deposition of salt or residues from the hard water it adheres more to the frame and less to the lens, the saline solution mattered the surface of the lens and modified the roughness of the frame material that came into contact with the facial area, and the chlorine solution altered the gloss of the lens and frame surfaces. To measure the magnitude of these damages, the Keyence digital microscope software application and the *ICMeasure* application have been used to get the exact values of these structural changes together.

4. CONCLUSION

In this research, following the various stages of experimentation, it has been found that the lenses for sports goggles are the necessary and practical equipment for carrying out specific activities, and they have to respect the duration of use in order to have safety in use. From microscopic analysis and image processing measurements, we have noticed the modes of deterioration of the active optical surfaces but also of the frames so as to realize that the long exposure to these mechanical, chemical, thermal sources can shorten the life of a pair of goggles and to no longer fulfill their role for which they were achieved.

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