Computer Design of Illuminating Systems for Ultrasonic Dental Scaler

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Abstract: The possibility to improve the quality of illumination of oral cavity during the removing of calculus from teeth by scaler is investigated. The purpose of the design is to raise the performance of the device illuminating system.

Keywords: illumination distribution design, lighting simulation, light guide plate, LED, micro relief

1. Introduction

Usually dental instruments needs in specially designed illumination systems. For example, removing of calculus from teeth requires proper illumination of the oral cavity. The schematic view of a dental scaler (pin part) is presented in Fig. 1. The illumination is provided with 6 LEDs protected from the side of oral cavity with ring-shaped plate made of some transparent material.

Fig. 1. Scheme of scaler (pin part)

Two points of the design of illuminance distribution in the ring zone (as it is demonstrated in Fig. 2) were considered: (1) the insertion of light guide into the empty space of the covering cup; (2) the shape of clear plate. The dimensions of covering cap are fixed ones.

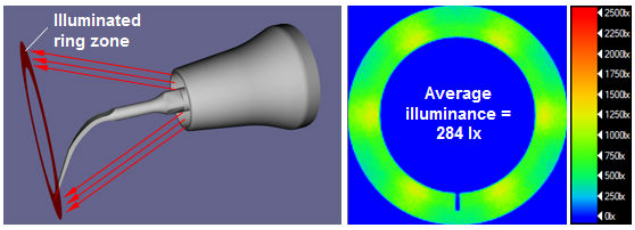

Fig. 2. Illuminance distribution in ring remote zone.

Although the design task looks simple it cannot be solved using traditional lens design toolkits and special software and design technique have to be applied [1, 2].

2. Insertion of light guide into the empty space of the covering cup

Fig. 3 presents the illuminance distribution for light guide restricted with two conical surfaces. All surfaces of light guide including input and output faces have Fresnel properties.

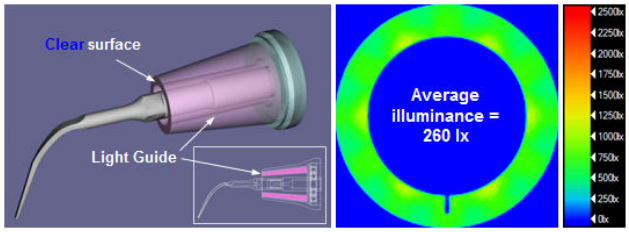

Fig. 3. Illuminance distribution with light guide having Fresnel surfaces

As it is seen the light guide of this shape doesn't improve the quality of the illuminance distribution in the remote zone.

To increase average level of the ring zone illumination the micro relief on output light guide face was introduced. The micro-relief provides both (1) more uniform illuminance distribution, and (2) the higher level of illuminance. Fig. 4 presents the illuminance distribution for remote ring zone when output face of

light guide has micro-roughness.

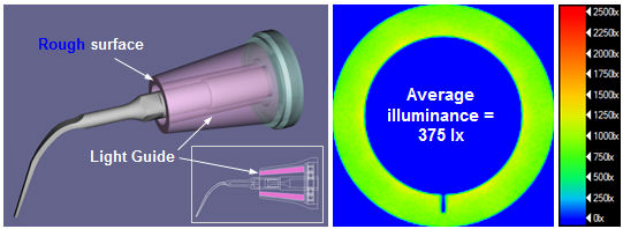

Fig. 4. Illuminance distribution with light guide having rough output face

3. Influence of shape of clear plate on illuminance distribution

Initially the output face of ring-shaped clear plate was a plane one (see cross-section of the plate and corresponding illuminance distribution in Fig. 5a). The output face was designed for the same goals as before: improving of uniformity of illumination and increasing the average illuminance of the ring zone shown in Fig. 2. Two design solutions were applied. The first designed solution was applying the micro-facets on output face of ring-shaped element. Separate facet elements have half-sphere shape and are distributed in chess order. The best achieved design results are presented in Fig. 5b.

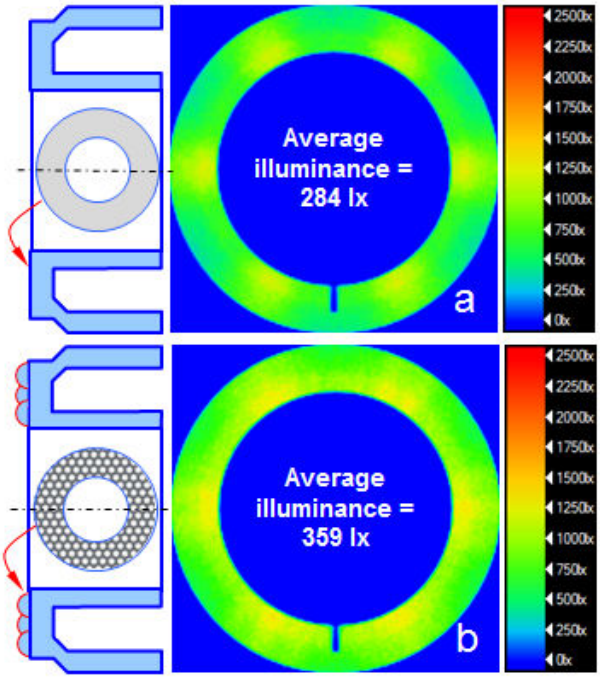

Fig. 5. Illuminance distribution for different shape of output face of ring-shaped element: a) plane surface; b) surface with micro-facets.

The second designed solution tried to achieve the design goal curving the plane surface of the output face of ring-shaped element as it is demonstrated in Fig. 6b. Really the plane face was transformed to the toric one with the designed radius of cross-section. The best achieved design results is presented in Fig. 6b.

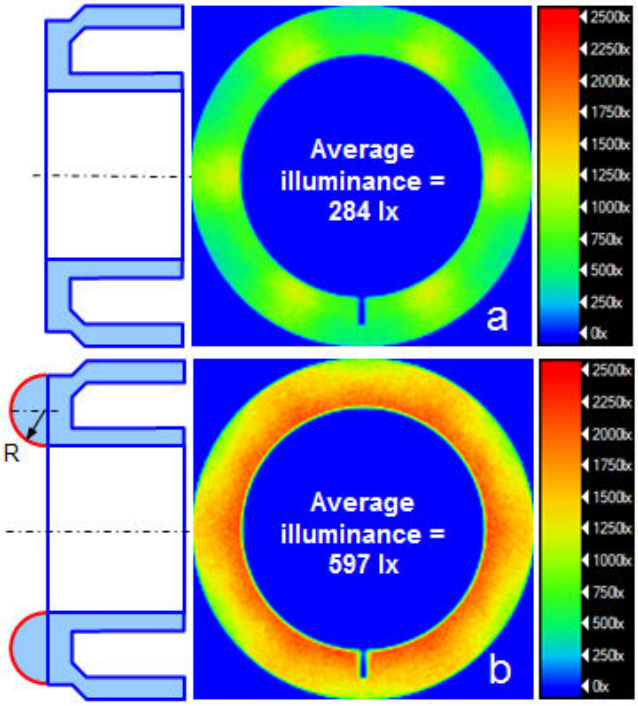

Fig. 6. Illuminance distribution for different shape of output face of ring-shaped element: a) plane surface; b) toric surface.

Note the distributions presented in Fig. 5 and 6 were obtained without light guide.

5. Conclusions

The current design showed that (1) an application of the addition light guide plate to transport light from LED to the remote ring zone cannot help to achieve maximal efficiency of illuminating system, and (2) the simple toric shape of the output face of the ring-shaped element is better solution for uniformity and efficiency of the ring zone illumination.

Presented examples also demonstrate that given class of optical devices can be effectively simulated and designed using SPECTER software [3].

6. References

1) Sergey Ershov, Dmitry Zhdanov: 15-th Int. Conf. GraphiCon-2005 Proc., Novosibirsk, 2005, p. 284-288.

2) Thomas L. R. Davenport, Thomas A. Hougha, William J. Cassarly. Optimization for Illumination Systems: The Next Level of Design // Proc. SPIE 5456, 81 (2004); doi:10.1117/12.548683

3) SPECTER – Integra Inc. http://www.integra.jp/en/specter/index.html