

## Intelligent Assessment for Optical Operator

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### ABSTRACT

The paper is focused to determine the final optical behavior of a lens or a couple of them glued or not by their response in a telecentric beam light. Due to a computer analyze based on determining the spectral curve response by spectrometry and a simulation program, the lens manufacturer can decide either the ensemble is good or not for its purpose or application. The decision to replace the group of lenses and to remanufacture it or not is up to manufacturer but suggested by computer program because the simulation gives a clue of what could be the main cause of damage (the thickness of glue, displacing the lenses or the wrong pairing). Keywords: lens, intelligent control, spectrometry.

### INTRODUCTION

The authors experienced a lot of quality images criteria to say if a lens or group of them is good or not for a certain application. Many of those criteria are imposed by beneficiaries and meet their needs. The authors believe that spectral response can be one key factor which can help manufacturer to figure out how images will be and, at the same time, to have an answer if the decision is not favorable for lens or group of lenses: is that for recycle bin or for garbage. Spectral response of real lens or a pair of them is transferred to computer from a spectrometer via special card. The image of real spectral curve (fig. 1) is compared with the simulated one (fig. 11). Before any response, the manufacturer set up the major differences accepted for individuals, regarding dimensions or glass characteristics. The automatic response displays as many results as the user want to. For interest is focal distance, mainly, because it can be related to any normal or wrong behavior. But there are other criteria too, (such as ghost images or low quality images)

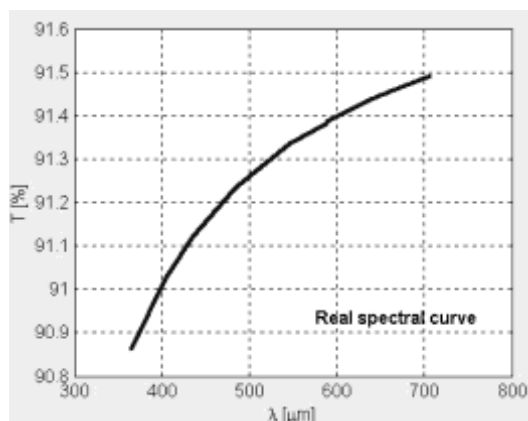


Figure 1: The image of real spectral curve

which can induce a decision. If that two images are matching, the answer is (GOOD) and the lens or group of lenses can proceed; if those two images don't match, the computer changes by simulation, the parameters using the limits imposed, to bring the simulated image as close as it can be to real one. The new parameters are to be displayed for manufacturer which can

decide if lens or group of lenses can be used in other application as a whole, or can be re-manufactured one by one, both of them or only one, or neither nor.

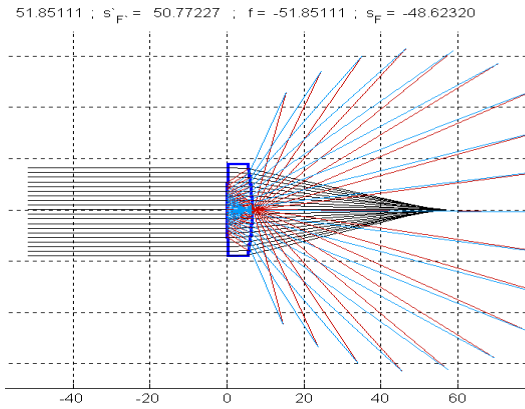


Figure 2: Optical layout of a positive lens

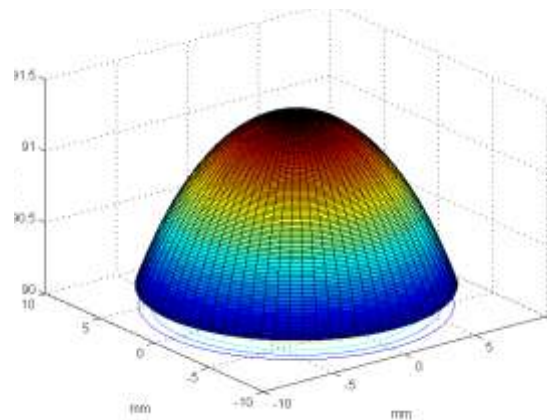


Figure 3: Spatial pattern matrix

The fig. 2 shows the optical layout of a positive lens; it emphasizes the configuration of second order images caused by internal multiple reflections. At the same time, the overall transmission is diminished for all spectral length or only for extreme one. The behavior is showed in the simulation program and the user can “see” the differences. All those differences are compared with the limits and the final answer is based on this comparison. The authors use this method to suggest how is ray tracing appear in the real behavior. A matrix giving a spatial pattern as it is figured in fig. 3 crosses the lens. This pattern allows manufacturer to be very close to real image and to understand if the lens can be good for any application or not.

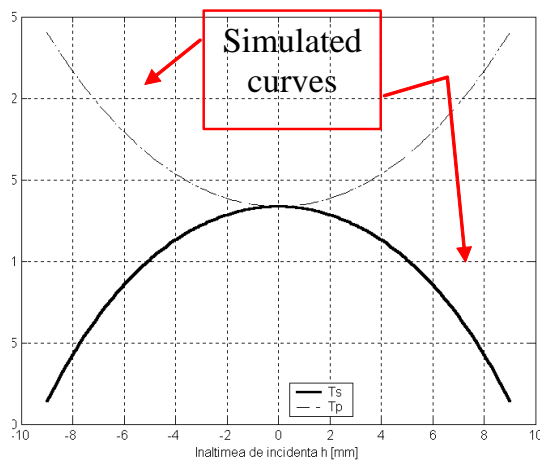


Figure 4: Simulated curves

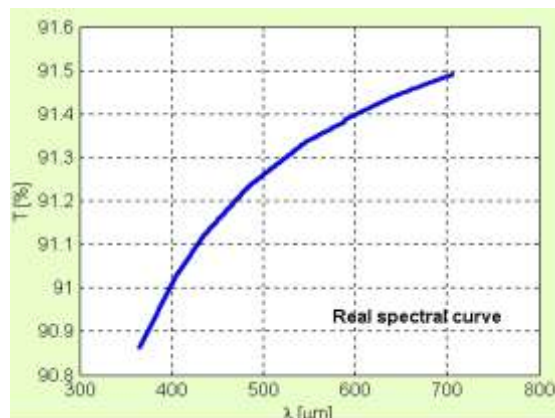


Figure 5: Spectral characteristic of the positive lens in the visible spectrum

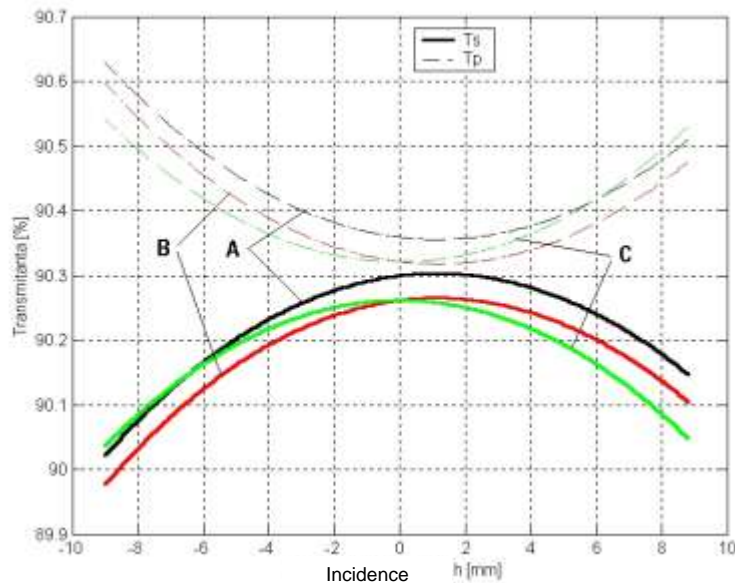
The transmittance curves are computed and compared automatically. The answer GOOD or WRONG is just a clue for manufacturer. He is thinking about what can be the cause of wrong behavior makes the final decision. If the lenses work as a group (glued or not) the manufacturer can have the simulated behavior of each one and the decision can be more accurate. Fig. 4 shows simulated curves and figure 5 presents the spectral curve, captured via computer card.

Ts12 min = 90.140067077317312 [%] - h = -9.00 [mm]	Tp12 min = 91.336293400554723 [%] - h = -0.05 [mm]
Ts12 max = 91.336243150943304 [%] - h = -0.05 [mm]	Tp12 max = 92.404718690019820 [%] - h = -9.00 [mm]
Rs1 min = 4.429990916839964 [%] - h = -0.05 [mm]	Rp1 min = 4.390216739052248 [%] - h = -9.00 [mm]
Rs1 max = 4.469925747874993 [%] - h = -9.00 [mm]	Rp1 max = 4.429988913882058 [%] - h = -0.05 [mm]
Ts12r min = 0.179250865969625 [%] - h = -0.05 [mm]	Tp12r min = 0.000043835276314 [%] - h = -9.00 [mm]
Ts12r max = 0.581166665511729 [%] - h = -9.00 [mm]	Tp12r max = 0.179240528193590 [%] - h = -0.05 [mm]
Ts12rr min = 0.000351800585962 [%] - h = -0.05 [mm]	Tp12rr min = 0.000000000003606 [%] - h = -7.82 [mm]
Ts12rr max = 0.081062928296140 [%] - h = -9.00 [mm]	Tp12rr max = 0.000351731989672 [%] - h = -0.05 [mm]
Ts21r min = 4.046205899250785 [%] - h = -0.05 [mm]	Tp21r min = 3.205018551950302 [%] - h = -9.00 [mm]
Ts21r max = 4.545961203642034 [%] - h = -8.55 [mm]	Tp21r max = 4.046169048072136 [%] - h = -0.05 [mm]
Ts21rr min = 0.007941059018151 [%] - h = -0.05 [mm]	Tp21rr min = 0.000000437087692 [%] - h = -7.82 [mm]
Ts21rr max = 0.193209608714513 [%] - h = -9.00 [mm]	Tp21rr max = 0.007940073609867 [%] - h = -0.05 [mm]

Figure 6: Numerical results of the spectra-energetic characteristics

Numerical result makes the decision easier and accurate as it is shown in fig. 6.

## VALIDATION OF THE METHOD



- A – identical curve for both lenses on the glueing surface
- B – the radius  $R_2 > R_3$ , causing an interlaced at the center
- C – the radius  $R_2 < R_3$ , causing an interlaced at the margins

Figure 7 Curves for transmittance

The authors faced a lot of questions regarding the influence of the optical and dimensional

$f' = -91.45408$  ;  $s'_F = -94.84157$  ;  $f = 91.45408$  ;  $s_F = 90.26568$

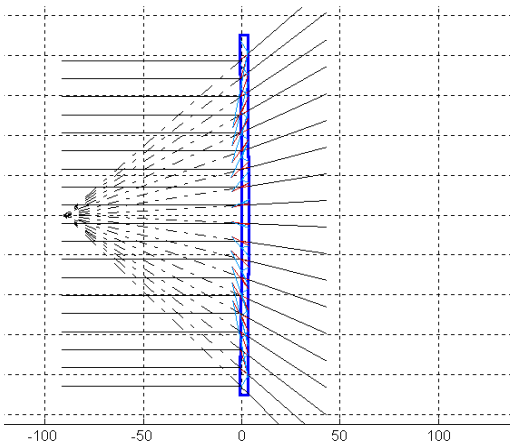


Figure 8: Optical layout for negative lens

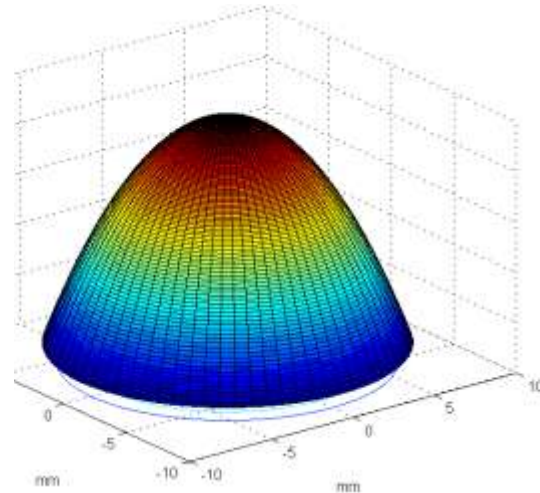


Figure 9: Inspection matrix

parameters on the transmittance curve. That's why, the next step was to display these influences. As it is shown in fig. 7 the curves for transmittance have different shapes linked with the deviations suffered of some basic parameters for interest in this application. The curves A, B, C show the transmittance for different values of radius  $R_1, R_2, R_3, R_4$  of a group of glued lenses. The condition of gluing is to have the same nominal values for gluing radius (in our case  $R_2$  and  $R_3$ ). In reality, the limits admitted for nominal values and randomly paired cause a third lens (very thin one, made from glue) but with significant influence in total transmission. The percentage of losing transmitted light varies up to 0.1%. So, the spectrometer has to be of the first class to have such accurate measures.

The behavior for negative lenses is pretty similar. The major difference between those two types of lenses is the ghost images which, in most cases is virtual one. Due to this position, the image can cause a chain of ghost images, if negative lens is coupled with a positive one.

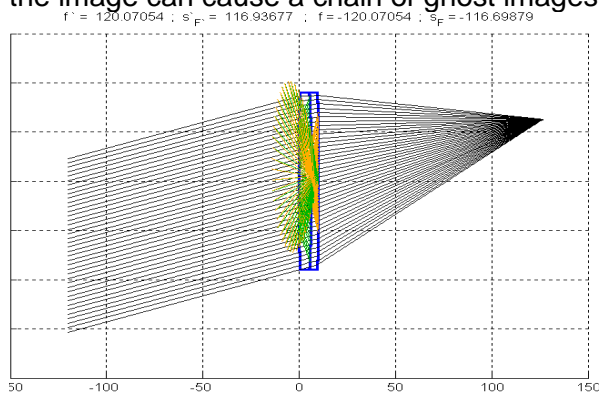


Figure 10: Behavior of coupled lenses

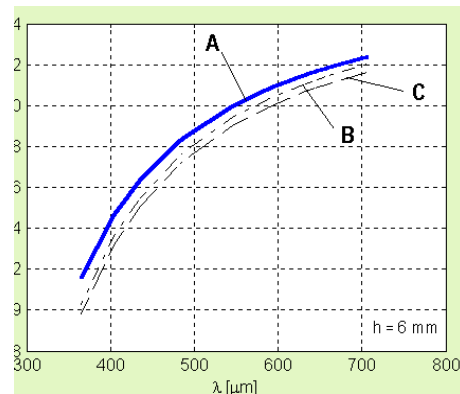


Figure 11: Influence of ghost images



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The behavior for coupled lenses (usually glued) is shown in the fig. 10. The ghost images are neglected in this picture due to overloading it. The influence of those ghost images is figured out in fig. 11. The differences between behavior of one component and the couple as a whole can be seen comparing the fig. 11 with fig. 5. The transmission of coupled is lower ( $T$  90% at 500 nm.) then of each component. The major influence, except the thickness of lenses is due to ghost images. Fig. 12 represents transmission of coupled lenses for a normal distribution in the entrance pupil.

## CONCLUSION

Intelligent inspection based on comparing spectral curves (simulated and acquainted) can give an answer about what would be the behavior of coupled lenses as a whole in the future ensemble.

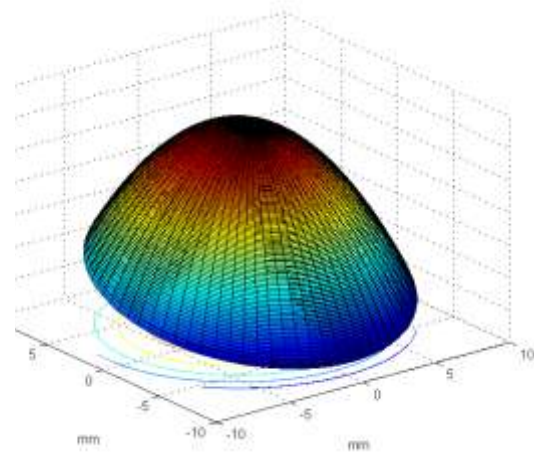


Figure 12: Transmission of coupled lenses

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