A SIMPLE NON-DESTRUCTIVE METHOD FOR THE DETERMINATION OF THE REFRACTIVE INDICES OF FINISHED LENSES

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ABSTRACT

A simple and rapid method for the determination of the refractive indices of finished lenses has been described which depends upon immersion refractometry. Observations taken on some lenses of known material to establish the validity of the method have also been reported.

Introduction

In optical design and computation as well as in the inspection of optical components a need frequently arises to determine the refractive indices of the material of lenses without destroying them. This is particularly essential in understanding functional characteristics of various lenses used in some unusual designs in optical instruments adopted for use by the Services and for evaluating the optical data for imported instruments for which the relevant information is not readily available but for which optical components for maintenance and replacement have yet to be manufactured locally.

Various methods have been suggested from time to time[1,2]. Most of these methods require fairly costly apparatus and protracted investigations. For the specific purpose, it was felt desirable to develop a simple and rapid method which can give data definitely correct to the second decimal place with reasonable accuracy in the third decimal place. The following method was found to meet the requirements.

Method

The method basically depends on immersion refractometry. If a convex lens of a material of refractive index n_l is placed in a medium of refractive index n_m, the following results occur under the conditions specified :—

(a) $n_l > n_m$ lens acts as a convex lens,
(b) $n_l < n_m$ lens acts as a concave lens,
(c) $n_l = n_m$ lens loses all its power and acts like a simple glass plate.

In the case of a concave lens, the behaviour is reversed and the loss of power occurs when $n_l = n_m$.

The following experimental set up will help in noting this transition

Monochromatic radiation is made parallel by the collimator and is made to illuminate a reference mark drawn on a glass plate. The lens in a suitable holder is held in a hollow glass cube containing the immersion liquid. The arrow mark is seen through the lens and the liquid in the hollow cube. The refractive index of the immersion liquid is varied by the addition of another

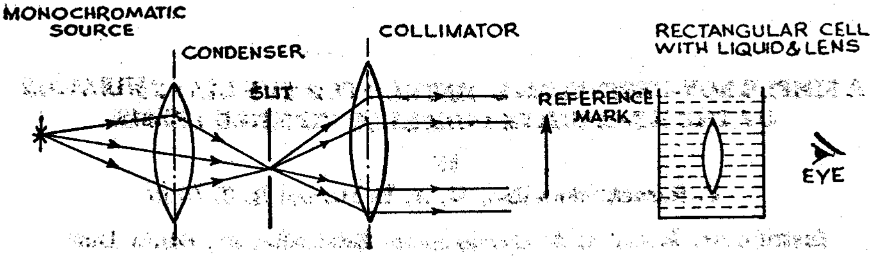

FIG 1.

liquid miscible with the existing one. These two liquids are chosen so that their refractive indices are greater and smaller than the expected value of the material of the lens.

The lens action is judged by the fact that the arrow mark through the lens casts a real and inverted image on a screen if the lens is acting like a convex lens. As a concave lens, it gives a diminished, erect image on the same side as the object itself. The transition could be judged in terms of the relative movement of the image.

The refractive index (R.I.) of the immersion liquid, as stated above, is varied by mixing well the miscible liquid of different R.I. The lens under test (immersed in the liquid) is then moved laterally and the behaviour of the image of the reference mark observed through the lens. If any movement of the image is observed, the R.I. of the liquid is further varied till this movemnet completely disappears and the image appears to be of the same size as that of the reference mark, *i.e.* till the lens starts behaving like a parallel plate. This will occur when the R.I. of the liquid is equal to that of the immersion liquid. The R.I. of the liquid is then immediately measured with an Abbe Refractometer which is capable of reading accurately upto third decimal place, with an estimated value in the fourth.

Three lenses of known material were tested to establish the validity of the method. A few lenses of a special American design telescope were also tested by this method and the type of glass used for their manufacture determined from a commercial catalogue.

Results

The results of measurements made on the lenses are given below:—

Measured R.I.	Specified R.I.	Remark
$1{\cdot}51_{49}$	1·5170	
$1{\cdot}51_{50}$	1·5106	Known from the melt.
$1{\cdot}51_{30}$	1·5180	
$1{\cdot}51_{07}$, $1{\cdot}50_{84}$, $1{\cdot}50_{99}$, $1{\cdot}51_{09}$	1·5117 (Hard Crown)	Determined from commercial catalogue
$1{\cdot}61_{43}$, $1{\cdot}61_{46}$	1·6170 (Dense Barium Crown).	Do.

The data are accurate definitely to the second decimal place and vary only 3 to 5 units in the third decimal place. Individual values of different readings for the same lens have a deviation of 0·0005 showing good internal consistency.

The present method has the advantage that it requires no elaborate equipment. The hollow glass cube is easily available in the market or can be made by cementing together strain free plane glass plates with sodium silicate. A couple of old lenses will serve the purpose of the collimator lens, the slit for which can be made with two old safety razor blades. The method is particularly recommended as a routine procedure in the inspection of optical components and determining the type of glass used in the manufacture of normally encountered lenses for which no data are available.

Acknowledgement

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