全像光學元件路標及汽車反光片

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摘 要

全像光學元件反光紙是一種光柵的應用，利用壓印技術來製作。將此反光片貼在汽車的後面，可以反射後方來車照射的燈光。經過計算後的光柵反光紙，白光入射時會反射特定的色光，此種反光紙不需要能量來驅動、且方便製作，可成為一種路況警告標誌。如果將貼紙貼在彎曲的車道上，架駛人可以由反光紙的顏色來判斷車子在路上的位置，這種反光紙是個非常好的路況指標，尤其是在窄路或彎曲的公路上。

關鍵字：反光片、光學元件、光柵

HOE Road Sign and Automobile Reflector

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Abstract

HOE reflector can be a road sign and an automobile reflector. It is made by injection techniques. The reflector, stuck on the backside of a car, will reflect the ray from the backside car lamp. After calculating the grating fringes, white incident light will be reflected as a specific ray color according to the distance of two cars. The reflector strip has no power consumption and is easy to manufacture. It can be a distance warning device as a road sign. If we stuck the reflector strip on the road side wall, observer could measure the distance between car and road mark from its reflected colors. The reflector could be a road guide line, especially on the narrow or curvature road.

Subject terms: reflector, HOE, grating.

I. Introduction

Most of road signs or automobile reflectors can not show the distance to the viewers automatically. We use the grating theorem to design a HOE reflector strip to achieve this purpose. The reflective monochromatic light color depended on the distance between the viewer and the strip. Different distance reflected different color. Short distance reflected red light. Long distance reflected green or blue light. This kind of strips can display color for distance message as a safety warning device. If we select a suitable thickness for the HOE film and coat with a reflective coating, the reflector is doing better, as shown in Fig.1.

II. Theory and Techniques

In our case the far-field grating theory is applied to an array of N slits, as Fig2. For the normally incident plane waves, wave length λ, θ is the angle between y axis and R, which is along the reflected direction, the irradiance I (θ) at distance point p is:

$$I(\theta) = I_0 \operatorname{sinc}^2\beta \left(\frac{\sin N\alpha}{\sin\alpha}\right)^2 \qquad (1)$$

where $\beta = \frac{kb}{2}\sin\theta$

$$\alpha = \frac{ka}{2}\sin\theta$$

$$k = \frac{2\pi}{\lambda}$$

principal Maxina occur whenever

$$\frac{\sin N\alpha}{\sin\alpha} = N$$

That is, whenever $\alpha = 0, \pm\pi, \pm 2\pi, \cdots\cdots$, or equivalent,

since $\alpha = \left(\frac{ka}{2}\right)\sin\theta$

$$a\sin\theta = m\lambda. \qquad (2)$$

$$m = 0, \pm 1, \pm 2, \ldots\ldots$$

From formula (2), set m equal to 1. Assume that the length between car lamp and observer's eyes is 70 cm. After setting grating density and plugging those data into formula (2), we will get two cars' distance according to the reflective light wave length. It shows that if grating having 600 groves per inch, two cars' distances are 44 m, 55 m, and 63 m. Each reflective wave length will be 0.6625

μ m(red), 0.5325 μ m(green), and 0.4675 μ m(blue).

Fig.3 The calculation data is as followings:

a	0.0000423	0.0000423	0.0000423
N	600 groves/in	600 groves/in	600 groves/in
λ	0.4675μm	0.5325μm	0.6625μm
$\sin\theta$	0.0110314	0.0125787	0.0156496
θ	0.6320709 deg	0.7207277 deg	0.8966930 deg
HEIGHT50	45.32010 m	39.746463 m	31.945772 m
HEIGHT70	63.450814 m	55.645049 m	44.724082 m

Where HEIGHT50, HEIGHT70 are the distance between observer's eyes and above his car lamp, the height is 50cm and 70cm each for a small automobile and trunk.

We provide a CIM(comuter integrated manufacturing) technique, as shown in Fig.4, to produce surface relief type hologram as the reflected strip. We have developed a new method to analyze the performance of the reflector. Injection method has been used here to replicate large number of plastic articles. The injection mold contains a fine structure of blazed surface of holographic optical element (HOE) for transferring to an outside surface of the molded article. The structure on the relief surface is very fine for about 0.1 μ m space between every fringe. Any roughly action may induce worse effects during experiment. It is important to obtain the uniform distribution and lower value of residual stress in the plastic HOE to avoid the deformation and warping of the shape.

The diffraction efficiency of the embossing master (with holographic fringes in photoresist) can be analyzed by defining our new method1.2 for the fabricating process and grating profile characteristics. In order to reasonably resolve the problems of the diffraction efficiency, we combine the optical and AI (artificial intelligence) sciences to find the key of HOE'S fabricating process1. The flow chart is shown as Fig.4. Many uncertainties are unavoidable because we judge the process parameters using our experience. In an ordinary HOE fabrication process, decision-making is made by the human mind. Here, the ability to manipulate fuzzy sets is used. We define the input process parameters set of injection holographic optical element as A {the degree of the temperature of injection tube Tt, the degree of the injection pressure Pe, the degree of the packing time t1, the degree of injection velocity vi, the degree of the injection time t2, the degree of the cooling time t3, the degree of cycling time t4, the degree of the time of the material in the injection tube t5, the drying time of the material t6, the temperature of the mold Tm, the temperature of the runner Tr, the force of mold locking Fl} , the output results set B is {the degree of the flow line Fl, the degree of the edge function Fe, the degree of the image prints which are cloudy Fc, the degree of the burning spots Fb, the degree of the breakage in the product Fb, the degree of the shrinkage in the product F3} . The output results set B change in the different processes and unstable environments, so we must change the input process parameters set A for different processes.

Let X= {the function of leakage of the product χ_1, the function of defect of the edge χ_2, the function of shrindage χ_3, the function of brightness of the image prints χ_4, the function of burning spots of in image prints χ_5, the function of the flow line χ_6 and the function of bubble of the product $\chi_7\}$. Then we can see the support of a fuzzy set B in the universal set X is the crisp set that contains all the elements of X that have a nonzero membership grade in A. Assume that χ_i is an element of the support of fuzzy set A and μ i is its grade of membership in B. Then B is written as

$$B=\mu_1/\chi_1+\mu_2/\chi_2+\mu_3/\chi_3+\cdots\cdots\mu_n/\chi_n \tag{3}$$

where the slash is employed to link the elements of the support with their grades of membership in B and the plus sign indicators.

An α-cut of a fuzzy set B is a crisp set Bα that contains all the elements of the universal set X that have a membership grade in B greater than or equal to the specified value of α. This definition can be written as

$$B\alpha=\{\chi\in X/\mu\beta(\chi)\geqq\alpha\} \tag{4}$$

The value α can be chosen arbitrarily but is often designed at B the value of the membership grades appearing in the fuzzy set under consideration. Here we use the α-cut method to obtain the value of B. These measurements of B are made under a fuzzy model, not an exact model. This estimation is fuzzy statistical analysis. For many purpusses, a very approximate characterization of a collection of data is sufficient because most of the basic tasks performed by humans do not require a high degree of precision in their execution.

We create the following rules to resolve the common problems in the manufacture process:

rule 1. If the leakage of the product is apparently great, then increase the injection pressure, the temperature of the mold, the velocity of injection, and the temperature of the injection tube; in the meantime decrease the friction of the nozzle.

rule 2. If the edge of the product is not good, then increase the force of mold locking and decrease the packing time, the injection pressure, the temperature of the injection tube, the injection velocity, and injection time.

rule 3. If the warping condition is serious, then increase the power of injection machine, the supplement of method, and the velocity of injection, the cooling time, and decrease the temperature of injection, and the cooling time and decrease the temperature of injection tube and the cycling time.

rule 4. If there are breakage result, then decrease the injection pressure and the packing time; and increase the temperature of the injection tube.

rule 5. If there is burning spot, then decrease the injection pressure, the temperature of injection tube, the velocity of injection flow, and the time of the material in the injection tube.

rule 6. If the brightness of the image is not good, then decrease the temperature of the injection tube and increase the temperature of the mold and the drying time of the material.

rule 7. If the flow line is apparently great, then increase the temperature of the injection tube, the pressure of injection, the injection pressure, the temperature of injection mold, the packing time, and the temperature of the runner head.

rule 8. If there is many bubble in the product, then decrease the injection pressure, the temperature of injection tube and increase the velocity of injection flow and the cycling time of the material.

This model takes advantage of this tolerance for imprecision into fuzzy sets which bear an approximate relation to primary data. One can make an addition in these rules if he thinks its necessary. The correction value depends on the summation of the whole correction effect from rule 1 to rule 8.

From the transfer function of injection we correct the values of the injection temperature and packing time or holding time by our CAE plastic injection analysis software3. From our analysis, we improve the product quality and reduce waste. Some problems such as wrinkling, curling, and breakage in the plastic plate or the short life in the embossing master can be eliminated under the proper operation parameters. We believe this system will be valid in manufacturing the prototype of the holographic products [4].

III. Experiments

We stuck the reflective strip on a wall. The observer sit in the driver seat and car light incidents to the front car reflector. We tested the different distance at 44m, 55m, and 63m, the reflective light is red, green, and blue each. The reflective strips are proved to have the function of distance discrimination.

We designed a color sensor device to detect the monochromatic color of the reflector as Fig.5. This device installed on the front side of window shield. When color sensor got the specific monochromatic light, the warning device sounded beep. We used color sensor PD151 to detect the monochromatic light. The characterization of PD151 is two photodiodes within a package to detect the different visible light hand. For any specific monochromatic light, this device will generate a small specific voltage signal. A Comparator Circuit will judge the voltage level and decide the sound bepp or not.

IV. Conclusion

1. The diffraction efficiency must be carefully designed for good reflection rate. We use fuzzy concepts to get the best parameters of HOE.
2. If we use specific monochromatic narrow field sensor with color filter to detect the reflective light, this device will become the automation distance warning system for driving security.

This paper has been patenting.

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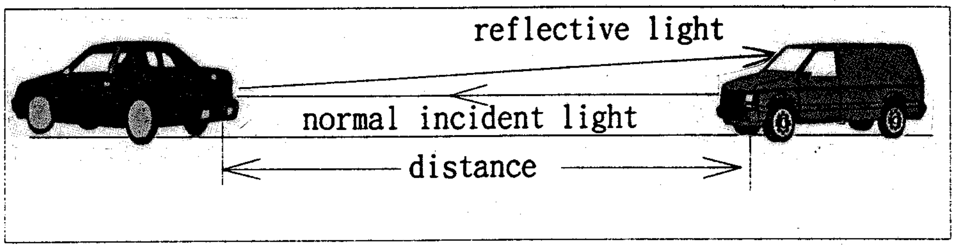

Fig.1 The car reflector diagram

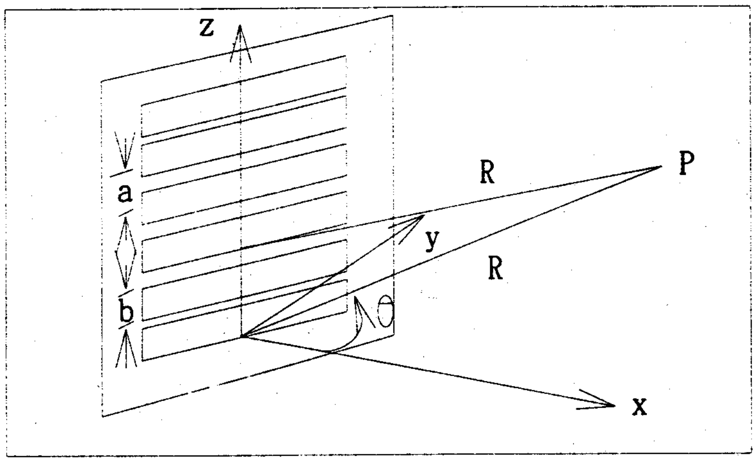

Fig.2 N slits grating

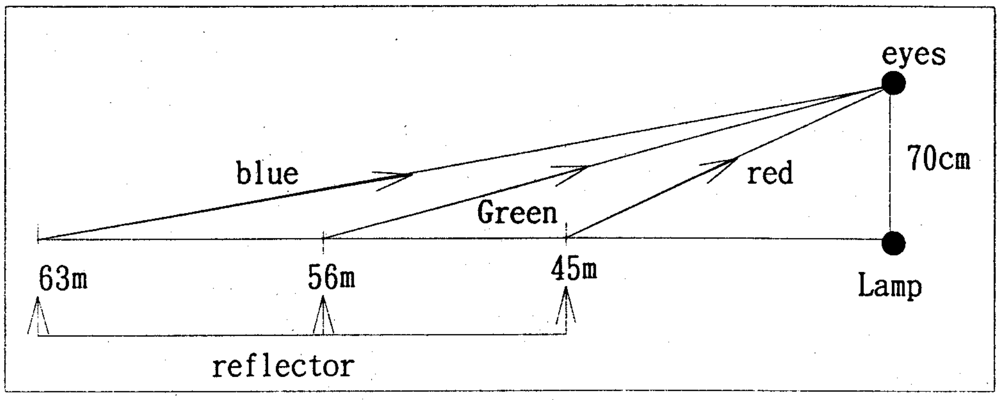

Fig.3 The results of calculation

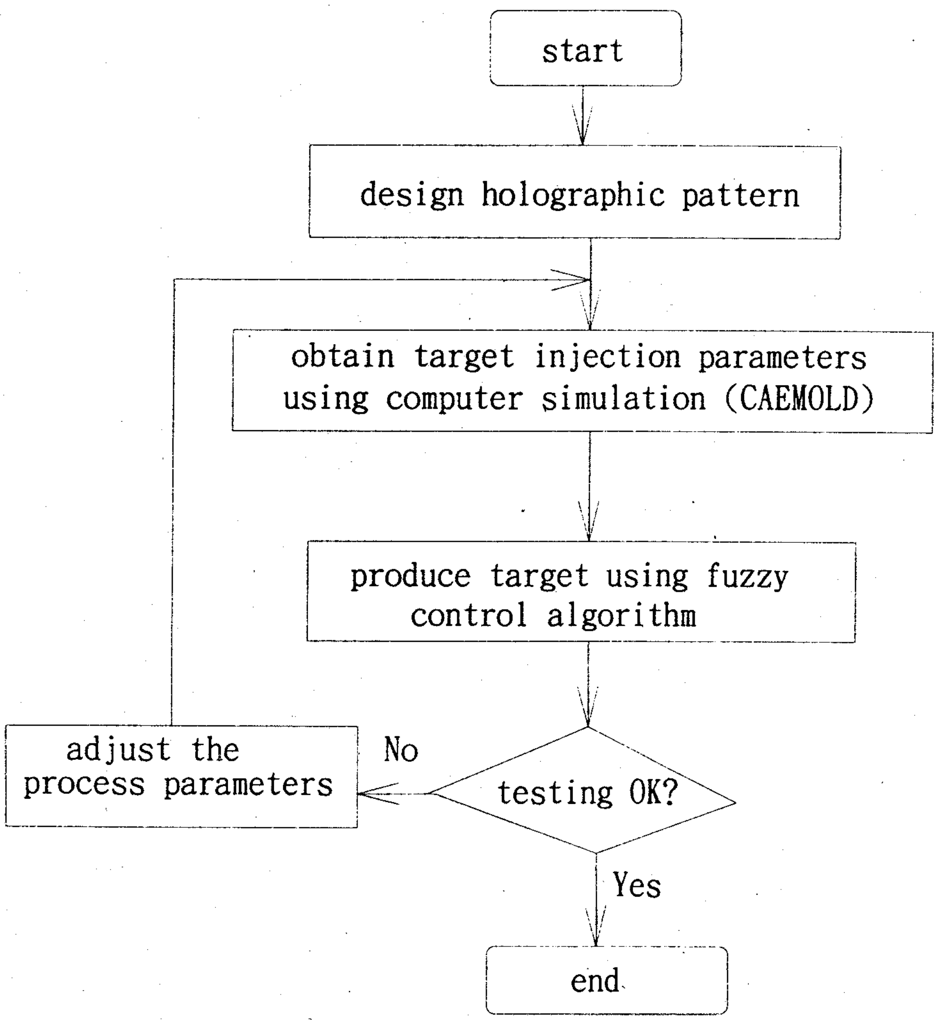

Fig.4 Scheme of Hologram fabricating process

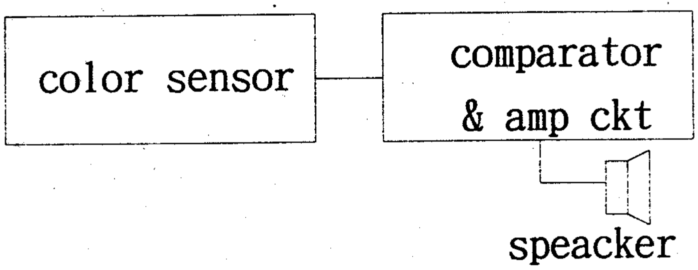

Fig.5 Automatic distance detector diagram

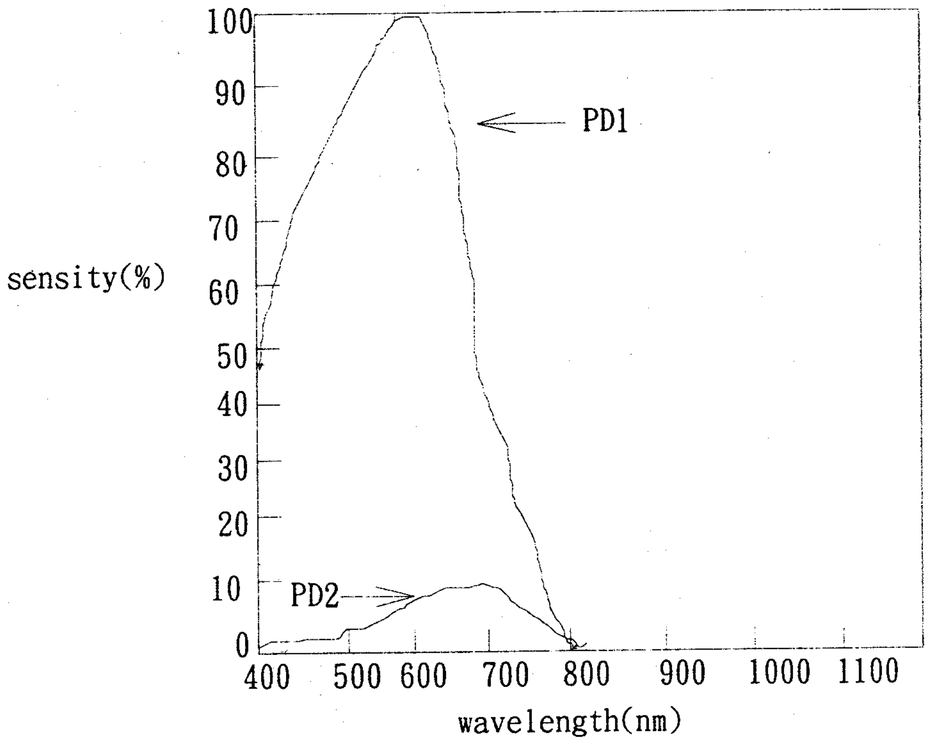

Fig.6 The characterization of PD-151