HEADLAMP REPLACEMENTS' COMPARISON METHOD

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Abstract

There are many replacements of headlamps on the market. Offered replacements parts should be "identical" as original and type approved. In fact it means that should have similar to original outside appearance and mounting fixtures and external size allowing for replace original one. From legal point of view to be placed in vehicle replacement headlamp should be type approved. Most important aftermarket criterion is low price. They are often offered for half or even less of original components price. From the other side the replacements can have less performance than original. When final customer want to make comparison between original and aftermarket headlamp it is a problem because there is no standard procedure or information allowing to compare performance. Similar problem have components wholesalers or end sellers. It is also important for traffic safety because many of contemporary headlamps meet some type approval requirements with significant surplus. To try solve this problem was developed method on the base measurements done using "Headlights' analyser". This device allow for measurements of illumination distribution of beam pattern. Appropriate analysis of recalculated illuminance can give important information allowing for comparison beam patterns of different headlamps, especially replacement. This method is based on as much as possible identical aiming of each headlamp using analytical finding of cut-off line than comparing important characteristics of road illumination and glare.

Keywords: *headlighting, road illumination, performance comparison*

1. Introduction

Presently the only officially approved rules used to compare headlamps are type approval requirements. But one of the disadvantages is that assessing rule is "yes" or "no" regarding meeting of the criteria. From official point of view all type approved headlamps are "equal". From the other side it is important to have possibility to compare headlamps, especially when it is needed to make choice between different replacements of original headlamp. There are many replacements on the market which looks very similarly to OEM and are type approved, often offered by manufacturers from different countries. When the original headlamp is broken or worn out there are no formal contradictions to replace it by any but type approved. In such situation the only criterion for service or final customer to choice the replacement is price. From other side could be used reversed criterion that the "best should be the most expensive". In fact there are only substitutes of choice because there is no possibility adequate asses' difference in quality.

To try to come closer to objective quality comparison presently the only imaginable possibility is the laboratory photometrical measurements and comparison of results according type approval requirements. But the comparisons based on type approval requirements and eventually level of exceedance of minimum required values looks not to be good enough method. Another disadvantage of such method of verifying is relatively high cost comparing headlamp price.

The "light analyser" measurements [1] and more advanced results comparisons looks to be more appropriate tool to compare headlamps' features in short time and low costs.

2. Expectations and stakeholders

Analysis of way of design of type approval requirements leads to conclusion that they describe quality of road illumination in simplified manner [2-4]. But for road traffic safety at night-time important are headlamps. Possibility of quality assessment is significant when the choice of replacement is taking into account. After cullet the most often destroyed parts are lamps. Decision regarding choice of headlamp replacement basically are done by vehicle owner. Mostly they relay on vehicle repair shop advice. But the service engineer has no adequate measure or information regarding quality of headlamp replacement. In such situation different factors can influence their suggestions to customer. The most impressing is price. It is the simplest one. The cheapest headlamp is most expected by vehicle user. But the most expensive give higher profits to seller. This could be influencing when the most expensive are original manufacturer parts which often are the greatest trusted. Similar problem concerns distributors and wholesalers. Because they have no other criteria than requirement that headlamp should be type approved awareness of problem is not significant. Quality of headlamps is often equated to the appearance of headlamp which differs between vehicle models. But replacements for given vehicle type are mostly nearly identical regardless of the manufacturer. The quality of cut-off line is the other criterion which eventually could be compared by service. But sharp cut-off line does not guarantee proper road illumination even it is helpful for that.

From the other side there is common feeling that quality of headlights is often not good enough independently on replacement choice dilemma. And drivers are trying to improve lights. Much more of interest are bulbs because they are exchanged more often and their price is significantly lower. On the market there are accessible many replacements advertised as giving "more light" than standard one's. There are also offered "xenon replacements" of halogen bulbs which are illegal but give subjective impression of much better lights. Leading bulbs manufacturers offer bulbs with +(x)% "more light" like +30%, + 90% or even +120%. These bulbs are type approved but they are slightly modified to obtain higher level of final headlamp illumination in comparison to typical bulb. In such complicated automotive lighting environment it is really difficult to make good choice.

3. Headlights' analyser

Headlights analyser is modern computerized diagnostic device design in Motor Transport Institute (Fig. 1 and 2.). It obtained Polish [5] an European patent [6]. The main purpose of using it is to aim headlamps mounted on vehicle according on field requirements. Headlights' analyzer measures illuminance distributions of beam pattern. It corresponds to laboratory measurements but precision of beam pattern is slightly impaired because of using lens projection. But it is still good enough regarding headlamps assessment and comparison. The advantage is the possibility the possibility of fast measurements without dismounting headlamp from vehicle.

After measurement data are converted to beam pattern characteristics with help of sophisticated algorithms. One of them is utilised to finding "cut-off line" and calculating aiming. It is also calculated if cut-off is in agreement with required shape (Fig. 2). This type of measurements offers much higher precision than visual aiming and cut-off estimating. There are also measured most important photometric values according of ECE type approval requirements.

In fact photometrical measurements done by Headlights' analyser allows for much more complex analysis of light emitted from headlamp also for advanced and "experts" methods of assessment. Important is that analysis of measurements can be done "outside" of Headlights' analyser.

To adequately compare different headlamp replacements it was needed to find appropriate method for it. Because there are some different "unofficial" methods of headlights assessment important is that chosen method should be sensitive for headlamp replacement in terms of road safety. As an example could be author method utilizing Headlight's analyser to compare different automotive filament bulbs signed by manufacturers as emitting "more light".

Bulb manufacturers to advertise "improvement" of type approved bulbs use their own comparisons rule based on light emitted by headlamp:

$$E_{\%} = 2E_{75\mathrm{R}} + E_{50\mathrm{R}} + E_{50\mathrm{V}}, \tag{1}$$

Fig. 1. View of the Headlight's analyser

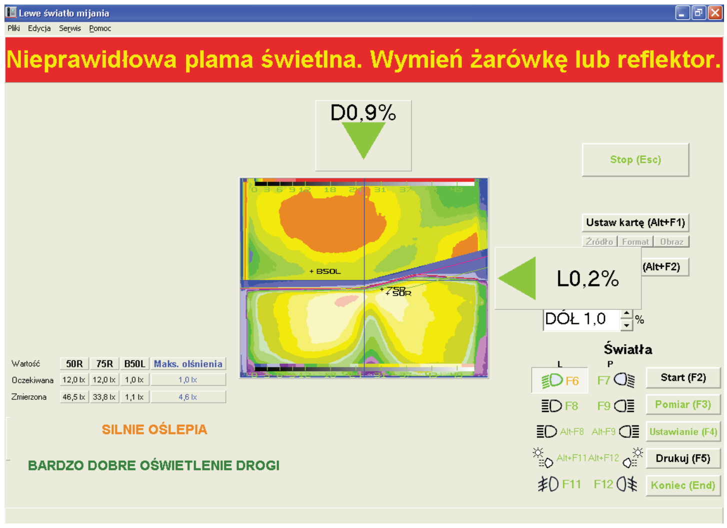

Fig. 2. Example of measuring results of incorrect beam pattern

where:

$E_{\%}$ – means value for final comparisons,

E_{75R} – means value for type approval measuring point 75R,

E_{50R} – means value for type approval measuring point 50R,

E_{50V} – means value for type approval measuring point 50V.

These values are referenced to "average" typical bulb. There is no description regarding headlamp in which such measurements are performed. Design of reflector and its size, way of directing light rays have significant influence for final comparison results. Aware of it bulbs manufacturers inform that such values are described as "up to" given value e.g. +90%. It is obvious that final value is approximately 4 time higher than average illumination increase because of using doubled value for 75R point where typically light is focused and added point 50V where typically value is much smaller and finally not significantly influencing result.

Example of beam pattern change for "worse" and "better" bulb is presented in Fig.3.

To compare influence of bulb change for beam pattern of the same headlamp author developed method much more appropriate to illuminating features of bulbs inserted to real headlamp. There were chosen maximum value of illumination in whole beam pattern and luminous flux emitted from headlamp [7] as more adequate to possibility of better focussing "improved bulbs" filament and, eventually increased total luminous flux emitted from such bulb.

a) b) c)

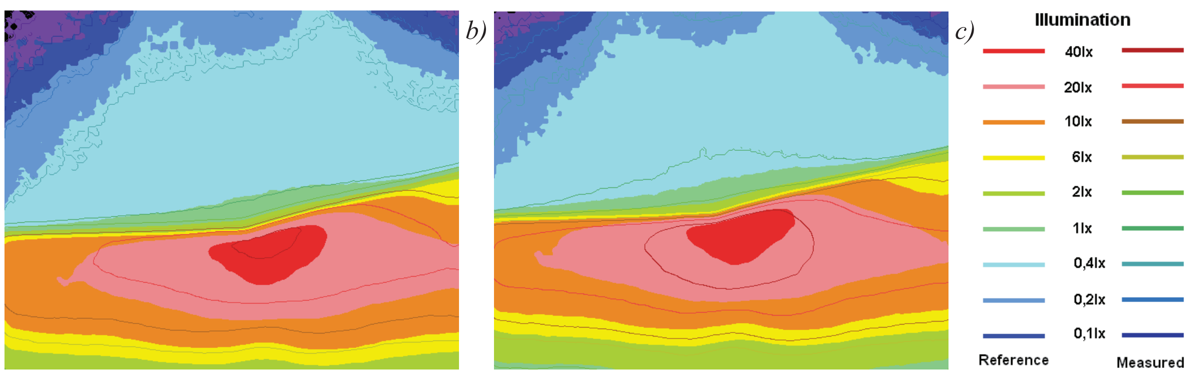

Fig. 3. Example of measuring results: bulb "worse" than reference (a), bulb "better" than reference (b), legend (c)

The measurements were done as relation for tested bulb in reference to “standard” bulb – selected from good quality bulbs but in basic realisation. Values chosen for alternative comparison are sensitive to geometrical differences of filament regarding reference one like length, diameter, 3D displacement, inclination to axis etc. [8].

In addition in this method it is also possible an useful to compare “movement” of position of point of maximum illuminance. In addition the luminous flux was measured [7] because expressed effectiveness of utilization of filament luminous flux by headlamp reflector.

3. Headlamp comparison method

To compare headlamps replacement above methods looks not to be appropriate enough. The light distribution of vehicle headlamp is significantly influenced by design generally in unpredicted manner. For instance it is possible that maximum value of illumination is not very high but will cover relatively large solid angle. Differences can concern as well horizontal as vertical position and size of similar “spot” of light. Besides are many other possibilities which are difficult to predict and describe. Also total luminous flux emitted by headlamp is not good representative of headlamp quality because it is much more important is where the light is directed. Because of this reasons comparisons of different (or similar) headlamps should represent real road illumination (and glare) performance. Especially simple comparing using standard type approval requirements looks not to be adequate, especially because of doubts which point or area should be preferred and what weight should be assigned.

Beam pattern measurements using Headlights’ analyser looks attractive for such task because of above described advantages: short time of measurements, illumination distribution measurements and possible more advanced analysis.

Finally for this task was chosen method describing road illumination at horizontal plane when vertical illumination at the road surface is taken into account. As a basis there are used measurements of illumination distribution on vertical screen obtained by Headlights’ analyser (Fig. 4, 6 and 8). Then are done recalculation of vertical illumination to the road surface. The same values of mounting height were used (75 cm). In calculation there are used superposition of beam patterns of two headlamps displaced at the same distance for each tested headlamps. In real vehicles different values of mounting position are used. But for this comparisons to avoid differences not connected with headlamp design were used the same mounting values. Isolux lines for road surface for examples of different headlamps are presented in Fig. 5, 7 and 9.

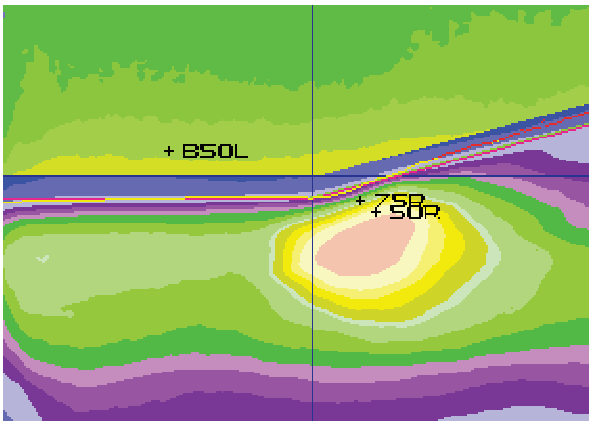

Fig. 4. Example of Headlights’ analyser isolux diagram at screen for headlamp No. 1 (lux values not assigned)

As quite obvious and intuitionally understand criteria it is proposed to compare geometrical characteristics of isolux lines. Maximum range and width in given distance are chosen. It looks to be also important deviation of light beam from vehicle longitudinal axis. This could be result of

Fig. 5. Isolux lines of vertical illumination at the road surface for headlamp No. 1

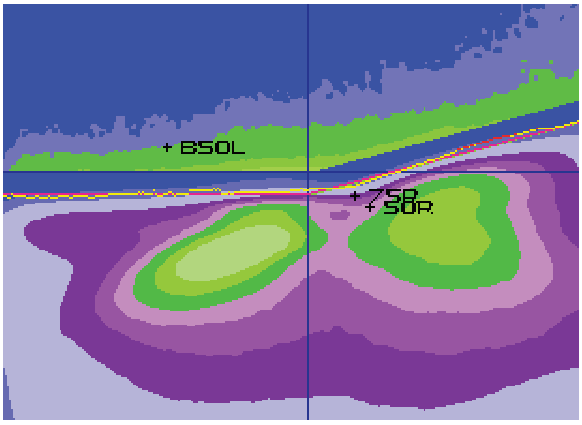

Fig. 6. Example of Headlights' analyser isolux diagram at screen for headlamp No. 2

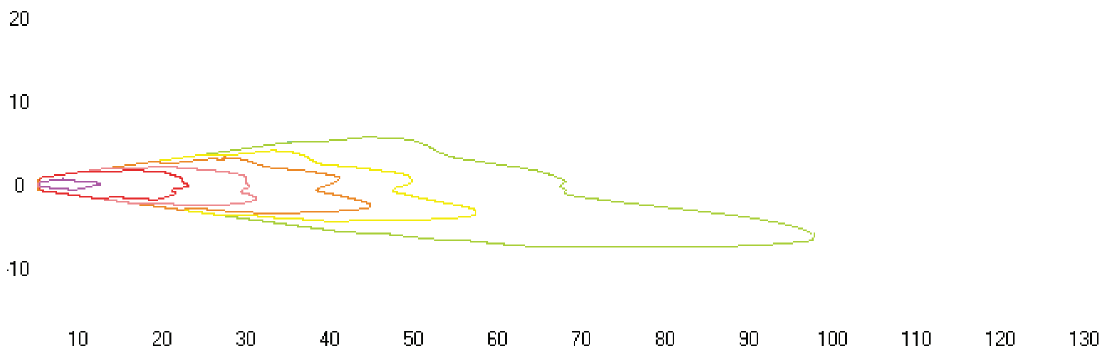

Fig. 7. Isolux lines of vertical illumination at the road surface for headlamp No. 2

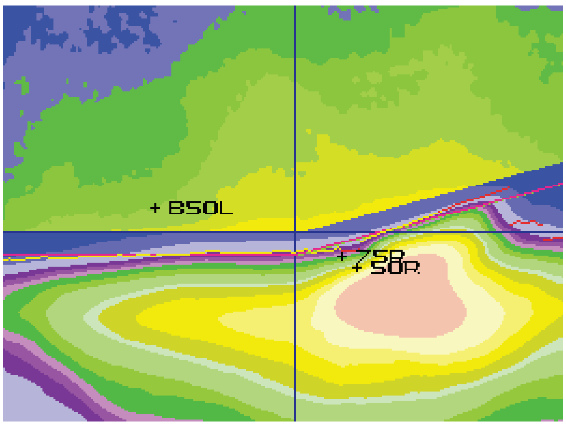

Fig. 8. Example of Headlights' analyser isolux diagram at screen for headlamp No. 3

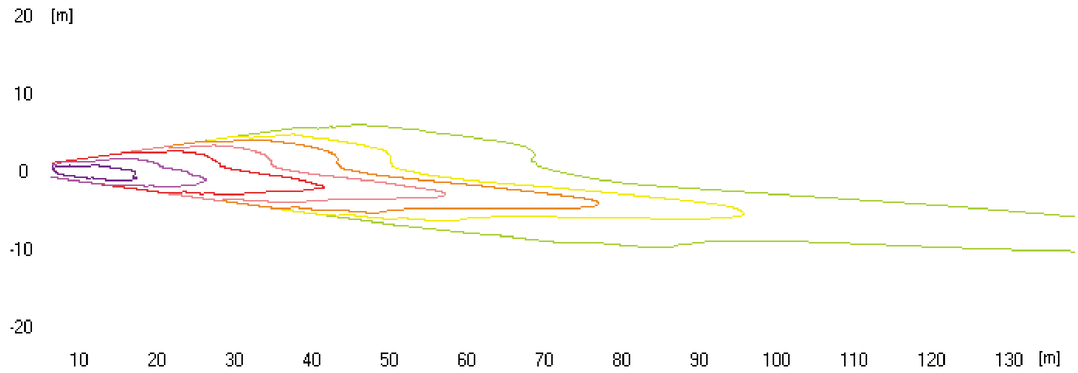

Fig. 9. Isolux lines of vertical illumination at the road surface for headlamp No. 3

differences in relative position between cut-of line and maximum of luminous intensity. Proposed value of isolux line is 1 lx as it is commonly treated as minimum illuminating threshold. But cold be used also 3 lx line or other.

Presented examples show that it is clear relationship between differences observed in illumination distribution and road illumination range and width. It can be observed that shape and sharpness of cut-off line can significantly different an finally influence for comparisons results. Because in Headlights' analyzer it is used mathematic procedure for cut-off determination and evaluation it simplified human decision.

7. Conclusions

Headlights' analyser is good an comprehensive device which allow for different advantage measurements and comparisons of headlamps and their components. There are preliminary attempts to use it in this application. But results are very promising. For glare assessment could be used recalculation of vertical illumination to the surface of presence of eyes of oncoming drivers. It is needed to make more comparisons and tests especially to improve details of criteria as well as try to find some quantitative measures more advanced than "range" and "width" or adjusting distances for comparison. But also in presented form measurements give significant information can be successfully used in practice.

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