

Thermoplastic Reflector Design for Robust Optical Performance

Triloka Tankala, Poovanna TK and Arunachala p
GE India Technology Center Pvt Ltd

Russell Bloomfield and James Wilson
SABIC Innovative Plastics

ABSTRACT

A headlamp reflector has many performance requirements. Principal among these is the need to deliver a compliant beam pattern while withstanding a severe heat environment. In serving this requirement, the reflector must reliably secure the light source (bulb filament) relative to the optical prescription (facets) of the reflector.

Traditionally, achieving this performance requirement has been challenging since the reflector elements which are designed to deliver stable and reliable optical performance, are the same elements which must also withstand thermal stresses and adjustment-related static stresses within the reflector. The integrity of these optical elements may also be limited by surface sink, especially in the bulb fastening and attachment locations.

The current work describes the design of a reflector bracket through which these forces can be minimized and accommodated while delivering robust optical performance. Improved Optical performance of the reflector is presented by comparing with a traditional reflector mounting approach.

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INTRODUCTION

A typical headlamp assembly consists of a reflector, lens, bulb, shield, bezel and housing. Many of these components are being replaced with plastics, for better performance, system integration and weight reduction. All the parts inside the headlamp get heated up, due to the thermal loads from the bulbs, the primary source of heat and light. Various methodologies are available for quick prediction of temperature of the reflector [1]. However it is important to predict the temperature profile of the reflector in order to see the thermal and thermo mechanical behavior of the reflector subjected to thermal and structural loads. This is mainly due to the fact the deformation of the reflector will have significant influence on the beam pattern and its stability [2]. Deformation of the reflector due to thermal expansion, stress relaxation, and creep have become more critical than with conventional lenses because changes in reflector shape shifts the optics, causing the whole beam pattern to deform. The international ECE Regulations for filament headlamps [3] and for high-intensity discharge headlamps specify a beam with a sharp, asymmetric cutoff preventing significant

amounts of light from being cast into the eyes of drivers of preceding or oncoming cars.

High beam headlamps provide a bright, centre-weighted distribution of light with no particular control of light directed towards other road users' eyes. As such, they are only suitable for use when alone on the road, as the glare they produce will dazzle other drivers. International ECE Regulations permit higher-intensity high-beam headlamps than are allowed under North American regulations [4].

Beam pattern homogeneity, gradients and intensity are significant parameters when it comes to the optical performance of the automotive headlamp reflector. The primary optical performance requirement for forward lighting is that the headlamp must conform to one of the established SAE or ECE luminous intensity standards. To meet these regulations, the headlamp beam pattern requires a sharp "cutoff" line. Above the cutoff line resides the glare-control zone in which luminous intensity values are minimized for the safety of oncoming drivers. Below the cutoff line resides the illuminated zone in which luminous intensity values must observe appropriate values in order to ensure roadway visibility for the driver. To help achieve this stringent beam

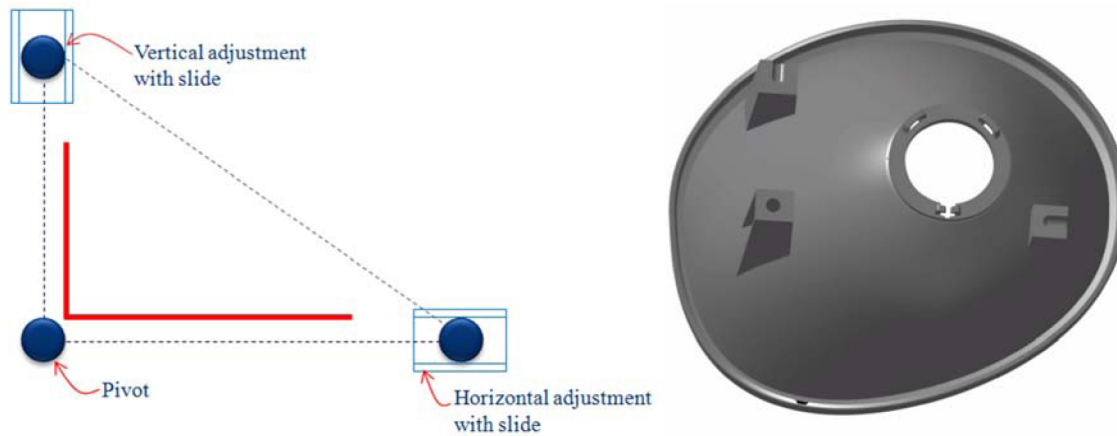


Figure 1. Typical aiming system of a headlamp reflector

pattern cutoff line, the headlamp design calls for precise alignment and dynamic adjustments for the headlamp reflector mechanism which is achieved through an aiming system.

The modern day aiming system typically consists of a reflector which is mounted at 3 points as shown in [Figure 1](#). The reflector mounting scheme is generally L-shaped in configuration and provides a three-point suspension for the reflector in which two of the points are adjustable for each horizontal and vertical aiming purposes. The mounting features at these two points also allow for translational motion between the reflector and the adjustment screw. The two adjustment points are located on opposed legs of the “L”. The third point is fixed in position and is located at the intersection of the two legs. Traditionally, these mounting provisions are made on the backside of the reflector through ribs and bosses.

Increasingly, traditional materials for reflectors such as metals and thermosets (e.g. Bulk Molding Component (BMC)) are being replaced with lightweight, high temperature, thermoplastics like polyetherimide (PEI). Thermoplastic materials enable dramatic elimination of secondary operations, more elegant design features and thinner wall-sections. Combined with their inherently lower specific gravity, this further enables significant weight savings (up to 50% vs. BMC) and faster cycle times with reduced process scrap. Also from a sustainability perspective, it is important to note that some high temperature thermoplastics, like PEI, can enable complete recycling of reflector scrap, even metallized scrap, back into the reflector without loss of aesthetic, structural or optical properties.

The trend towards large, clear polycarbonate headlamp lenses has further increased the surface requirements on the visible elements in a headlamp, such as the reflector and bezel. Packaging requirements have become more compressed as well and today's reflectors (together with the materials from which they are made) must satisfy considerably stricter requirements regarding manufacturing tolerances, versatility of processing to different designs, heat

deflection temperature, mechanical strength and, in particular, surface quality of the parts.

This calls for a sink mark free reflector surface, which can be achieved more easily if we can remove the mounting features and ribs from the back side of the reflector. A neat reflector without B-side features such as a pivot attachment housing, a horizontal adjustment housing, and a vertical adjustment housing would also reduce the residual stresses in the part. In addition to this, the headlamp is subject to extremely high temperatures and the reflector should be able to deliver reliable performance even after prolonged exposure to temperatures reaching 200° C or higher.

A design which reduces the thermal stresses in the reflector is desired in order to assure minimal beam pattern distortion. In this paper, we will discuss designs which enable free expansion of the reflector in order to reduce beam pattern distortion while eliminating the need for much of the B-side geometry traditionally employed for mounting and aiming the reflector.

DEVELOPMENT OF A HEADLAMP REFLECTOR WITH BRACKET

The design and functional requirements of an automotive headlamp reflector is studied with the aim of developing a new design concept which helps ensure robust performance while maintaining ease of manufacturability. Typically, a headlamp reflector consists of common features that enable or incorporate horizontal (H) adjustment, vertical (V) adjustment, pivot, bulb shield attachment and bulb attachment. The aiming or adjustment features like H, V and pivot, which can be major contributors for high stress in the reflector, are removed from the back side of the reflector and incorporated in a separate reflector bracket, thereby making the headlamp reflector free of features on the rear surface. The new bracket with all the functional features for its aiming mechanism is shown in [Figure 2](#).

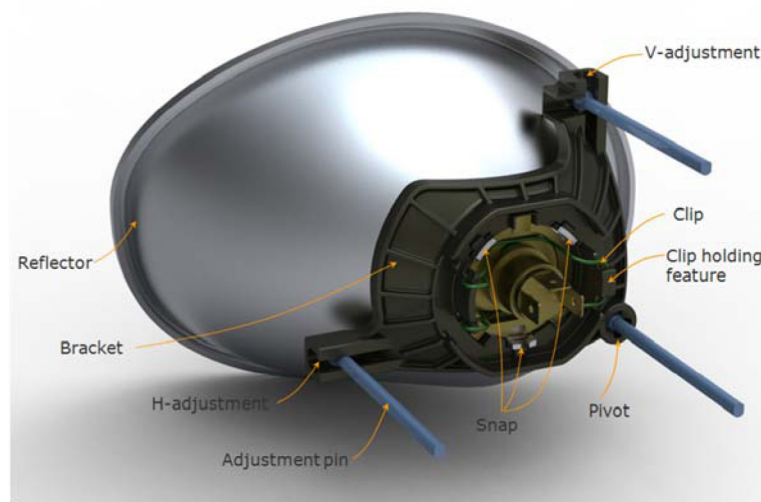


Figure 2. Assembled view of headlamp reflector and bracket

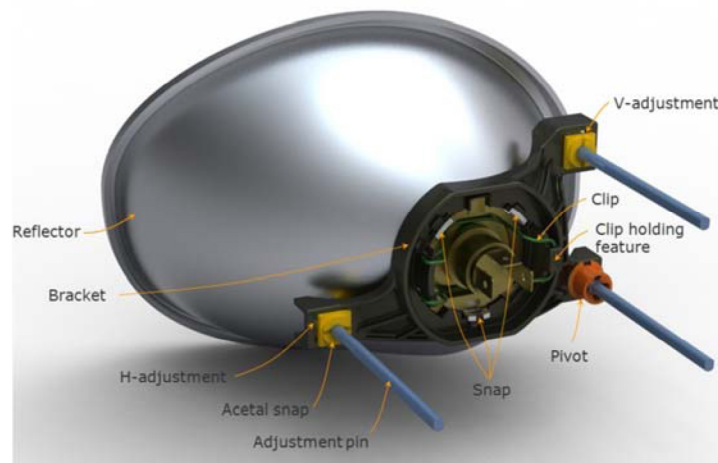


Figure 3. Assembled view of headlamp reflector, bracket and plug-in snaps

The manufacturability can be further simplified by introducing plug-in snaps which can eliminate the side cores in the tool as shown in [Figure 3](#).

In continuation of the overall reflector bracket design concept, the section below discusses the different methods of assembling the reflector with the bracket & bulb shield.

The mounting bracket is assembled to the reflector with the help of push snaps. The snap feature is comprised of center opening snaps located on the bulb holding area of the reflector and an engagement feature on the bracket which is shown in the [Figure 4](#).

Alternatively, the reflector and bracket can be interlocked using turn and lock concept. The turn and lock snap design is comprised of a hook on the reflector and locking feature on the bracket. The hook snaps onto the lock by turning the

bracket relative to the reflector and thereby, locking the parts together as shown in the [Figure 5](#).

In a conventional headlamp reflector, the bulb shield is often fixed to the reflector using a screw. In this design, we can secure the bulb shield onto the bracket by providing integrated snaps on the bracket thereby eliminating the threaded fastener. This also helps in reducing the assembly time and, more importantly it will help in reducing the thermal stress in the reflector.

The bulb holding clip is directly integrated on to the bracket. The function of the clip is to secure the bulb against the reflector in a way that aligns the arc or filament of the bulb to the focal point of the reflector. In this new bracket design, the clip holding feature is integrated on the bracket itself thereby reducing the number of parts which are required in the conventional reflector as shown in [Figure 7](#). These