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## User friendly bicycle helmet for commuters

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### ABSTRACT

The number of adult bicycle helmet users in Sweden has stayed over the years relatively stable around 20 % [1]. In Europe the number of helmet users varies between 1 and 40 % depending on country. Research has shown that the use of helmet considerably diminishes head injuries in the case of traffic accidents [2]. In spite of that it is not fully clear what are the main factors why only a small number of bicyclists use a helmet. In order to raise awareness of helmet use and improve traffic safety COST Action supported a European initiative "Towards safer bicycling through optimization of bicycle helmets and usage".

Why helmet use is not popular? Several reasons could be pointed out: design, destroys the hair style, attitudes against helmet use, nowhere to put, too warm etc. Often the initial complaints are related to heat [3]. In cold additional insulation from the helmet may be a positive factor while compatibility issues may rise.

As the professional bicyclists and most training/competing amateurs do wear the helmets then the aim for traffic safety should be increasing helmet use among commuters and bicyclists who do it just for fun. Therefore a project was initiated where main issue was to reduce initial thermal disturbance from a bicycle helmet while keeping in mind visibility, protection aspects, look, issues related to wearing comfort etc.

Some relevant factors to be considered are:

- The motion speeds of commuters would stay on average around 15 km/h (4.2 m/s) with average high speed not much above 20 km/h.
- Aerodynamics and placement of the vents and air channels.
- The effect of hair should not be underestimated – these may fill air channels with very effective insulation material.

**Keywords:** bicycle helmets, heat stress, ventilation, design.

### 1 INTRODUCTION

The number of adult bicycle helmet users in Sweden has stayed over the years relatively stable around 20 % [1]. In Europe the number of helmet users varies between 1 and 40 % depending on country. Research has shown that the use of helmet considerably diminishes head injuries in the case of traffic accidents [2]. In spite of that it is not fully clear what are the main factors why only a small number of bicyclists use a helmet. In order to raise awareness of helmet use and improve traffic safety COST Action supported a European initiative *Towards safer*

*bicycling through optimization of bicycle helmets and usage* [4]. The project group consists of 4 working groups that deal with following major topics:

1. accident analysis;
2. traffic psychology;
3. helmet construction;
4. thermal aspects of the helmets.

Why helmet use is not popular? Several reasons could be pointed out: design, destroys the hair style, attitudes against helmet use, nowhere to put, too warm etc. Often the initial complaints are related to heat [3]. In cold additional insulation from the helmet may be a positive factor while compatibility issues with other clothing or items may rise.

As the professional bicyclists and most training/competing amateurs do wear the helmets then the aim for traffic safety should be increasing helmet use among commuters and bicyclists who do it just for fun. Therefore a project was initiated where main aim was to reduce initial thermal disturbance from a bicycle helmet while keeping in mind visibility, protection aspects, look, issues related to wearing comfort etc. As the project did start this fall then the paper summarizes the background factors for designing good helmet ventilation for commuters.

## **2 OPENINGS**

Ventilation allows increasing heat loss by convection and evaporation. If convection in hot conditions becomes negligible or even adds to heat gain then the only mean of heat loss will be evaporation. The best ventilation of the head is provided when there is no helmet on the head until you need it. Airbag based, “invisible” helmet [5] allows best ventilation, and certainly avoids issues related to hair style or improves fit with clothing. Simultaneously, it is known that headgear reduces solar load on the head [6], and therefore, covering the head may be an advantage in hot climates. Another aspect is the perceived safety of the helmet uses. Considering this the present project focused on “visible” helmets.

In order to allow ventilation over the head surface there should be openings available that allow air to enter the helmet. However, when the air can't exit then practically nothing can enter either. Outlet openings should be available, and so should the channels that connect inlet and outlet openings. The inlet openings should be designed to allow maximal air flow into the helmet (high air pressure in front). The outlet openings should allow maximal suction effect in the rear (low air pressure). Simultaneously, the protection properties of the helmet should not suffer from too large openings at most common impact surfaces (rear and front). Inlet openings at various distances from front should not be easily connected to each other – the air uses easiest way to leave the helmet if there is any pressure difference, and does not take a long way (= higher resistance) to pass over the head surface to rear. Similar is valid for outlet openings in the rear. Therefore wrongly placed openings may not improve ventilation [7], and bigger openings may not lead to better cooling effect [8, 9].

Placement of openings should consider helmet tilt [10]. This does depend not only on head position but also on bicyclist position on the bicycle. Latter will be affected by bicycle design, e.g. racing bikes, mountain bike and city bike. Mountain bikes are relatively popular in cities, and especially in young, active population. Both racing and mountain bikes do assume stronger tilt due to low position of handlebars. Large number of cyclist use classical or city bikes where posture is more upright. In city, where it is important to have a good overview of traffic and not only the track in front, the head position can expected to be more upright.

## **3 BICYCLING VELOCITY**

Tilt will also be affected by bicycling velocity. Higher speed leads to stronger tilt and lower one to more upright position of the body and the head. The bicycling velocities, and thus, air speed around a bicyclist can be estimated [11, 12]:

1. 0.15 m/s – windstill condition, standing bicyclist with natural convection;
2. 1 m/s (3.5 km/h) – common air velocity under a calm day and quiet walking velocity;
3. 2.8 m/s (10 km/h) – relatively slow speed in the city;
4. 4.2-5.6 m/s (15-20 km/h) – average speed in the city;
5. 6.9 m/s (25 km/h) – quick city bicycling and average speed under long distance competitions (~1000 km);
6. 11.6 m/s (42 km/h) – average speed under shorter distance competitions (~120 km)

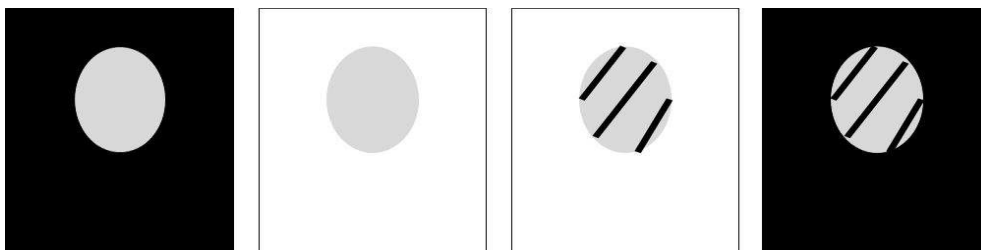
Bicycling velocity will be strongly affected by traffic situation and availability of bicycle routes. Even if maximum velocity may reach over 25 km/h the average can seldom be much above. Considering rush hours 15-20 km/h is more realistic. Bicycling at lower average velocity than that does not increase the heat generation by exercising body much more than walking. At such low speed it may be difficult to force air into the helmet anyway. If professional bicyclists often have short hair then average commuting population does not need to share that hair style, and the effect of hair needs to be considered when designing a helmet for them. Thus, a helmet for commuters needs to ventilate best in a speed interval of 15-20 km/h at the presence of hair.

The design of commuters' helmet does not need to depend on possible effects of additional air resistance from the openings and their design. It is not meant to be a competition helmet where hundredth of a second may decide a winner. Providing thermal comfort at common commuting velocities is of much higher priority.

#### 4 OTHER FACTORS TO BE CONSIDERED

Impact protection is the main reason for using helmets. Any ventilation solution should not affect the protective performance of the helmet. Hygienic needs, e.g. cleaning, could be kept in mind, while at this stage these are of lower importance.

Visibility in the traffic is an important parameter to avoid collisions. The lights on the bicycle should be functional in the dusk and darkness. However, in all times the helmet could be used to make the bicyclist visible. In the tight traffic the head may be an only body part that could be seen by drivers. The choice of colours and patterns should consider the contrast with the background (Figure 1) [13].



**Figure 1.** Object discrimination on different backgrounds.

Traditional, natural [14] and modern [15] materials or their combinations could be used to make a helmet prototype. No manufacturing constraints should be considered. The major requirement at the present stage is good ventilation performance (final prototypes will be tested on thermal head model). Also, there should not be present obvious decrease in protective performance, however, in the next stage the best design solutions for ventilation should be checked and improved for impact protection, and tested.

#### 5 CONCLUSIONS

Defining a user group for helmets is an important step that allows defining design requirements. Background on the possible ventilation outcome depending on specification of open-

ings in the helmet and air velocity around the users is essential start points for designing a thermally comfortable bicycle helmet for commuters.

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