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Better Bicycle Helmets for Commuters – Evaluation of Ventilation

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ABSTRACT

As a continuation of the work on the development of setting the requirements for ventilation of a bicycle helmet for commuters, 15 full scale helmet mock-ups were created by the students of the Estonian Academy of Arts. In order to encourage creativity for ventilation solutions the students were not restricted to consider the other properties except it was pointed out that the meaning of helmets use is protection.

These 1:1 scaled mock-ups were tested at Thermal Environment Laboratory, Lund University for their heat transfer characteristics (insulation) in a wind tunnel on a thermal head manikin. The helmets were tested at the room temperature with the air velocities of 0.2, 1.6 and 6.0 m/s. The air velocities of 0.2 and 1.6 m/s were tested without a wig and 1.6 and 6.0 m/s were tested with wig to simulate the effect of hair. In addition, 4 reference helmets were tested in some conditions. Three (3) of them were one of the best, one average and one of the less well performing helmets of an earlier study, and one was a helmet commonly bought and used by an ordinary bicyclist.

The helmets in new design were affected by ventilation and covered a wide range of insulation. The reference helmets from the earlier study stayed quite in the middle of the tested range. Thus, the new solutions could work much better or worse than available helmets. However, practically any new helmet was better than the common helmet from the shop. It was also very clear that various air velocities affected heat loss from the helmets. This means that a best solution for a commuter has to be defined by the user's bicycling velocity.

The best ventilation solutions will be chosen and the design work with considering of impact testing will be continued.

Keywords: bicycle helmets, heat loss, 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 the previous step of the project it was assumed that one of the reasons is the thermal aspects that do influence the use [3]. Therefore, an aim was set to improve the thermal properties and ventilation of the helmets, specifically, for various groups of commuters and people who bicycle just for fun.

The work continued with the development of 15 full scale helmet mock-ups by the students of the Estonian Academy of Arts. In order to encourage the creativity for ventilation and allow the comparison of large variety of solutions the students were not restricted to consider the other properties except it was stressed that the meaning of helmets' use is protection. Design aspects should not compromise protective properties, but improve the look, heat dissipation, visibility and issues related to wearing comfort. Thus, the main objective of this task was to create a user friendly bicycle helmet that would not be rejected for perceived heat sensation. By improving the bicycle helmet design we may allow increasing the number of cyclists who regularly use the helmet. Improving traffic safety under bicycling is an important area, especially, considering the possible increase of bicycling as a sustainable mean of transport.

As a summary, the major objective of the exercise was to come out with bicycle helmet solutions at the level of testable mock-ups. The way to solve this was by designing for cooling properties of the helmets through enhanced ventilation. The target groups were the commuters and people who bicycle just for fun. This paper presents the results of dry insulation tests.

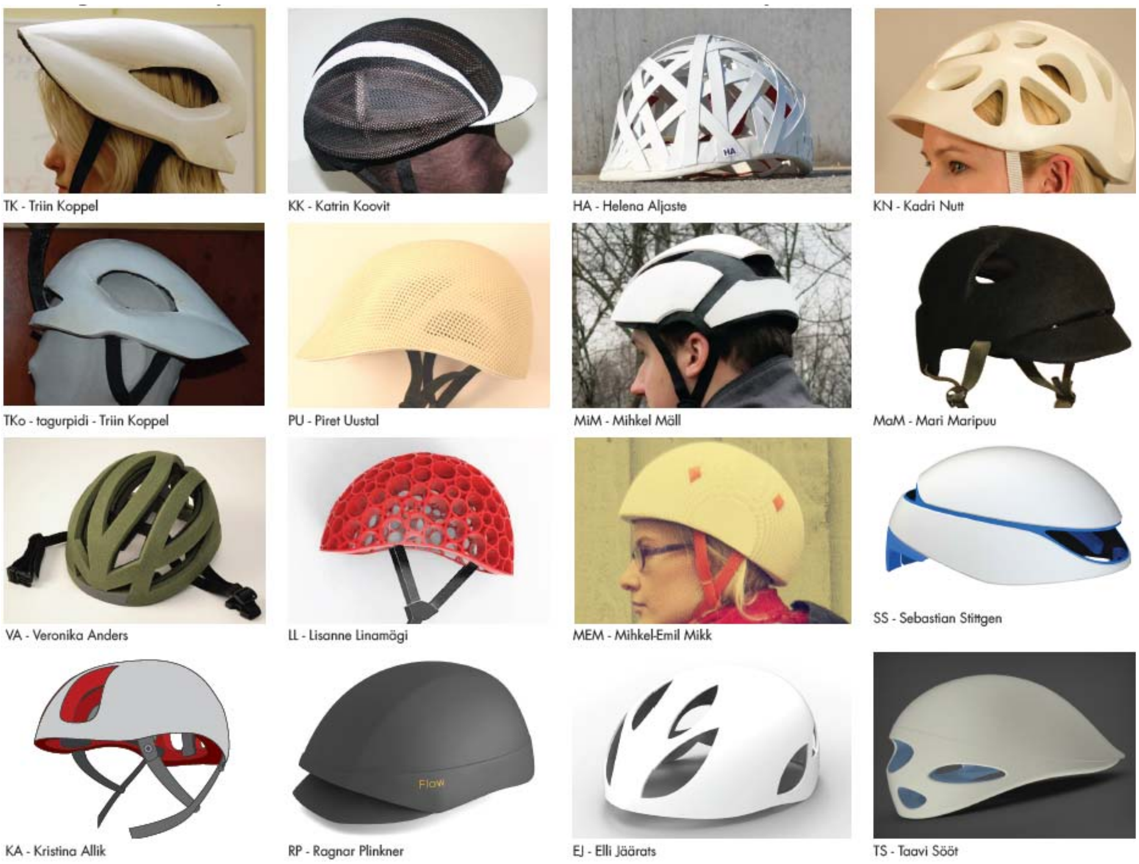

Figure 1. The tested helmets with codes and authors' names.

2 METHODS

A design project was carried out under a course at the Product Design Department of the Estonian Academy of Arts: Bachelor 3rd year, Master 1st and 2nd year. As a result there were developed 15 different solutions of breathable bicycle helmets and 1:1 mock ups were created (Figure 1). TK was prepared as a flexible helmet for racing and ventilation, thus, TKo is TK set on head rear to front. Design solutions could be divided into 2 segments: ones with air tunnels and the others with airy surface.

The 1:1 scaled bicycle helmet mock-ups (Figure 1) were tested at the Thermal Environment Laboratory, Lund University for their heat transfer characteristics (insulation) in a wind tunnel (Figure 2) on a thermal head manikin [4]. In addition, 3 helmets, one of the best, one average and one of the less well performing helmets, tested in a previous study (H5, H17, H20 by Brühwiler et al. [5]), and a common bicycle helmet available on the market (Etto) were tested in some conditions for comparison. As a reference point, a head model without any helmet was tested in the selected conditions.

The head form consisted of six measurements sections: face, forehead, skull, neck, left and right ear. The head form was heated to a constant surface temperature of 34 °C, and placed upright (0° tilt angle) in the wind tunnel at room temperature (Figure 2). Air velocity was set to 3 levels. 0.2 m/s was resembling a standing person; 1.6 m/s as bicycling with pedestrian speed (about 6 km/h) with and without hair (a wig); 6.0 m/s as speedy bicycling (about 22 km/h) with a wig.

Each test lasted for at least 70 minutes. After choosing the air velocity and donning the helmet, the situation was allowed to settle. Stabilization time was about 40 minutes. The last 20 minutes of the stable state were used to record an average heating power to each section, and calculate insulation. More ventilation would lead to lower insulation and better head cooling, and vice versa. Forehead, skull and total insulation were selected for comparison.

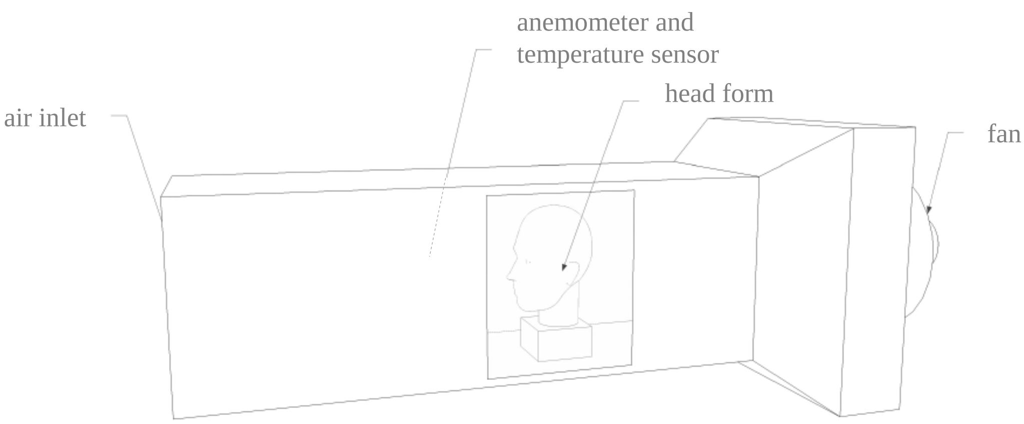

Figure 2. The test setup.

3 RESULTS AND DISCUSSION

Forehead, skull and total insulation (m²°C/W) are compared in Figures 3-6. The results in the diagrams were sorted by skull insulation in ascending order.

The experimental condition with wind speed of 0.2 m/s represents a worst case scenario for heat dissipation, and is comparable with the situation of cyclists just standing (Figure 3), while in practice under such situation there would be present only minimal heat generation in the body. The helmets were put on the bald head. The best results were acquired from helmets KN, HA and TK, because of their airy structure and less contact area with head. The warmest helmets in this section were Etto and TS. These helmets covered the large part of the head, and the air channels did not work with the low air velocity.

The air velocity of 1.6 m/s (6 km/h) is comparable with the speed of fast walking pedestrian (Figure 4). Helmets were donned on a bald head. The best helmets with this wind speed were SS and TK. The latter was tested in 2 positions - both front and rear side forward. All 3 helmet solutions had the largest vents, therefore the air flow was able to cool the head. Also, there was no hair to fill the vents. SS performed even better than the nude head. This could be related to forcing the air stream into the helmet and over the head surface. Three warmest bicycle helmets were LL, Etto and H20. It should be noted that more than half of the design helmets performed better than one of the best of the earlier study (H17, [5]), although, the differences are not very big within this condition.

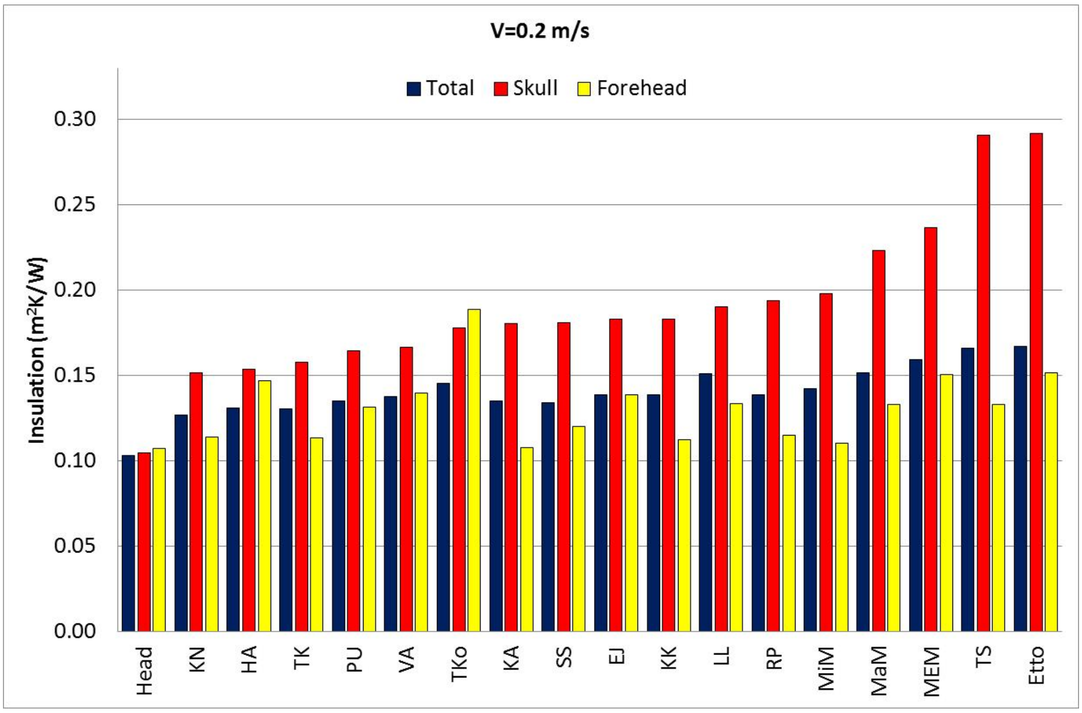

Figure 3. The test results of helmets insulation at air velocity 0.2 m/s.

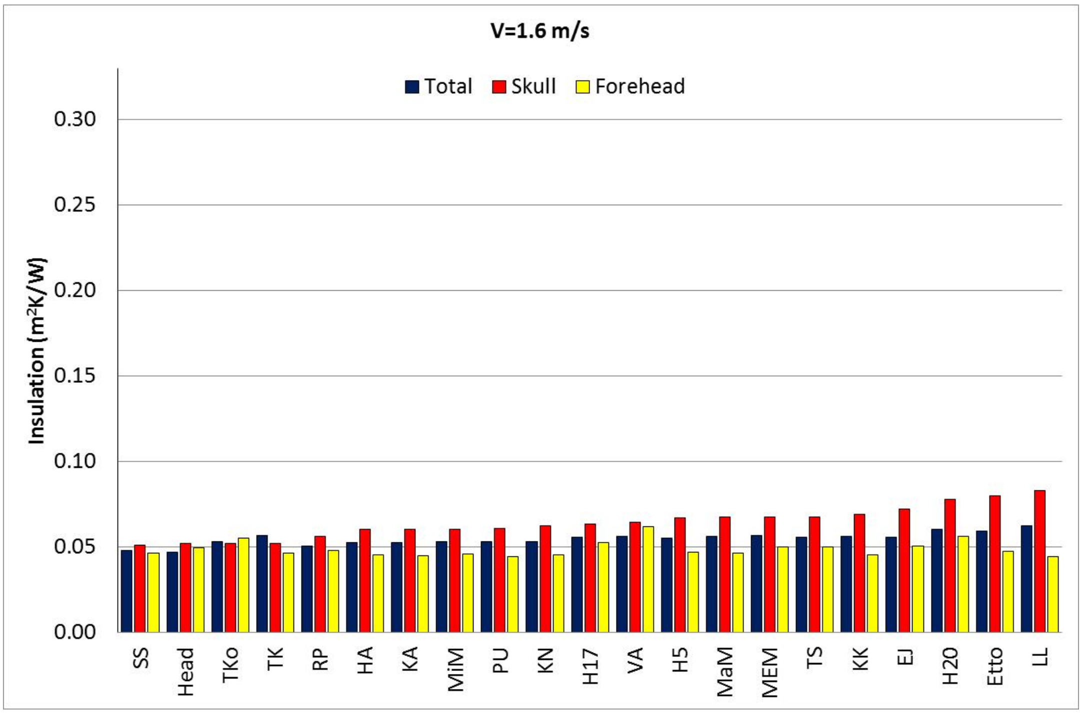

Figure 4. The test results of helmets insulation at air velocity 1.6 m/s.

Figure 5 depicts also the results with air velocity of 1.6 m/s. This time a wig was donned on the head model in order to study the effect of hair. As expected the wig increased insulation. This time the best ventilation results were observed in TK and RP. TK was most probably showing a good performance because it's zigzag structure and open front which, however, became problematic with stronger wind. The RP helmet inner structure was designed to compress the hair down so the upper air channels stayed open. The poorest performance was observed in Etto and MaM.

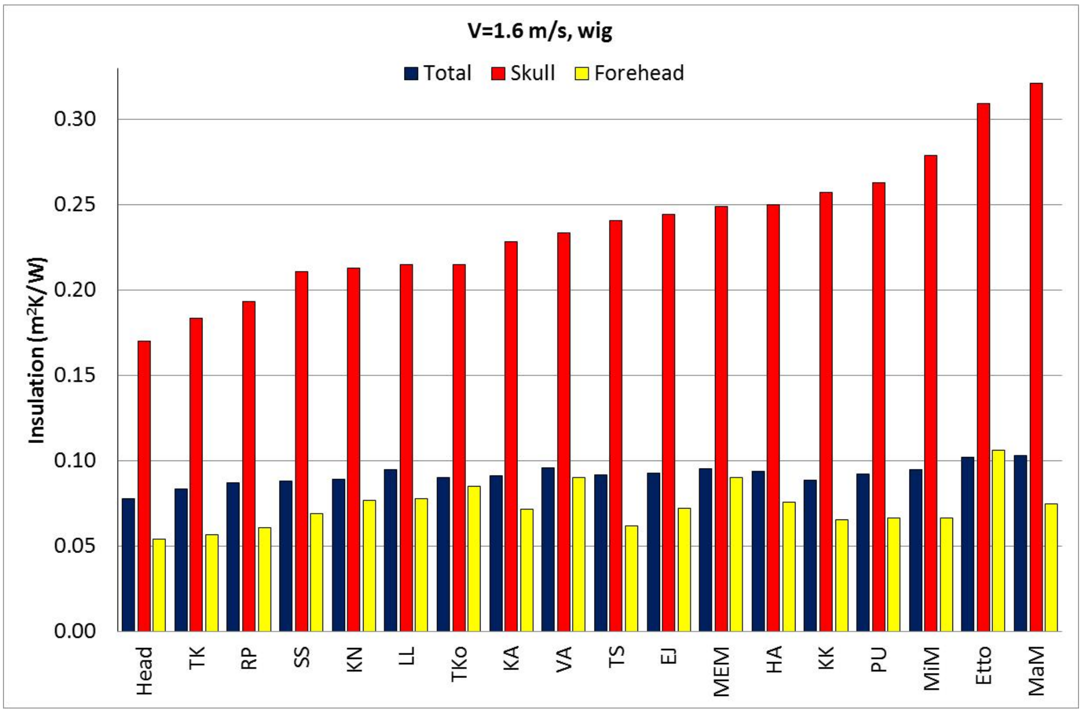

Figure 5. The test results of helmets insulation with a wig at air velocity 1.6 m/s.

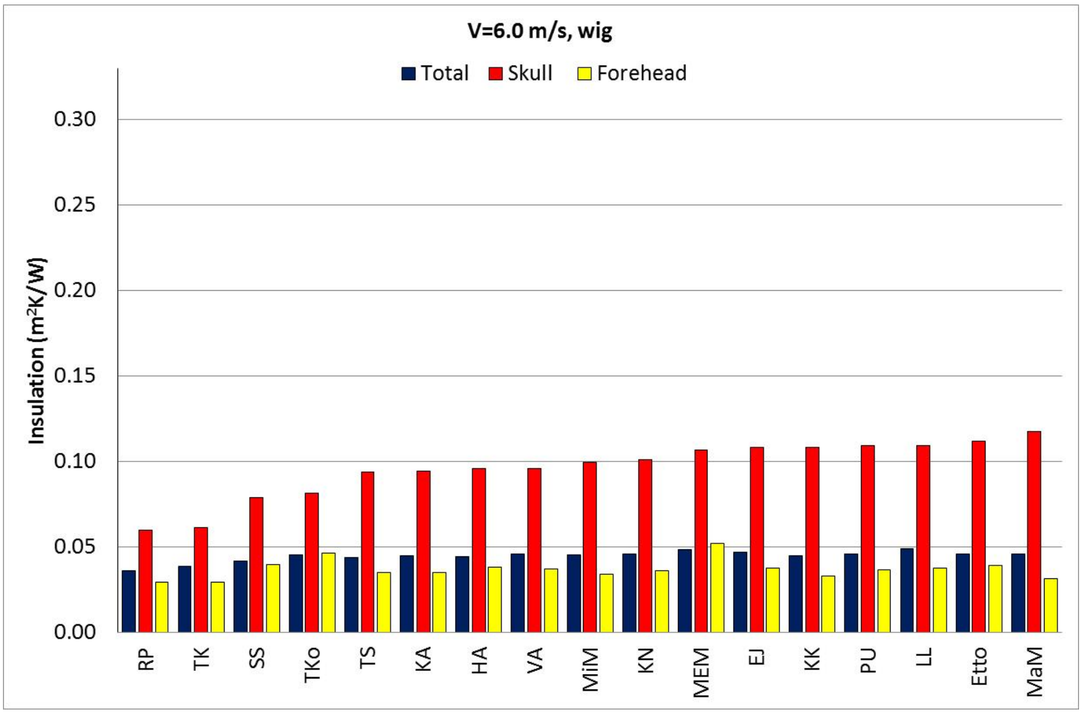

Figure 6. The test results of helmets insulations with a wig at air velocity 6.0 m/s.

Wind speed of 6.0 m/s is the condition of cyclist riding at about 22 km/h speed (Figure 6). The head form had a wig. With this air velocity it was shown that less but strategic openings and systems with clear air channels were superior to the other solutions. The best bicycle helmet in this test was RP. This fully covering shell type helmet forced air to enter from the visor area in the front to cool the head. Good results were shown also by TK, but it may be related to weak positioning on the head, and should be improved with a proper system to fix it on the head. It fell backwards a couple of times during the experiment. The same helmets as with 1.6 m/s and wig condition had the lowest performance even with 6 m/s wind.

TS, which was the warmest with low wind, worked better with substantial wind. This could be related to that the air channels start working. On the other hand, PU helmet was much warmer with a wig and even stronger winds did not improve the results. The warmest in this experiment was MaM. MaM has vents that should guide air to enter, but the tight fit of the helmet did not leave any room for air flow.

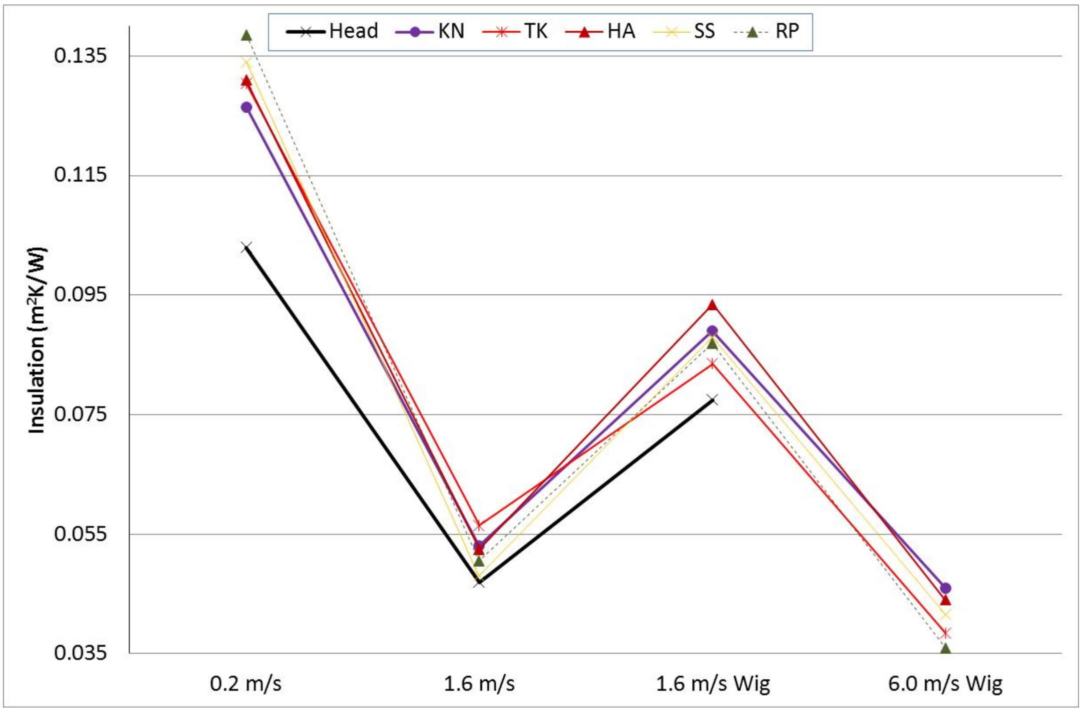

Figure 7. The changes of insulation in under specific conditions best ventilating helmets.

Figure 7 summarizes the main findings of the study by comparing the best helmets of various conditions and reference condition of the bald head. It is clear that different helmets perform best in specific conditions. It means that selection of proper helmet needs to consider bicycling velocity and haircut. The reported tests did not include any sweating simulation. The variation of performance may widen when this aspect is tested.

4 CONCLUSIONS

From the scientific viewpoint the study was successful – the task was set to find the most different ventilation solutions to be tested, and this was managed well. Various design helmets focused on specific solutions and/or their combinations, and these were used to study possible effects. The testing gave information on solutions that would fit best with low speed, high velocity and hair style. This would allow customisation to specific user needs. The designed helmets' cooling capacity was commonly better in practically any condition than a very common average user helmet, and on above half cases the solutions did function better than the best helmet that was tested earlier [5].

The work will be continued by modification of some mock-ups according to new ideas, in order to see if any change would improve or lower the performance. As sweating is a natural way of human temperature regulation then evaporation tests are needed. Further, the best solutions will be chosen, and the design work with considering of impact testing will be continued.

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