Design of an integrated cooling system by means of thermal variation flows

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Abstract. This project focuses on climate and to be more specific in high temperatures evidenced in some departments of Colombia. At present, the most widely used means of transport are motorcycles which must be supervised under a legal rule, taking into account their safety; therefore, it is necessary to use a certified helmet that fulfils the function of protecting this individual; these helmets in addition to having a definite shape and structure where it surrounds the skull completely in the part of the head also allows the option of having the chin protected or discovered depending on the speed at which the motorcycle is already established factory. Helmets normally have a system that aims not to allow internal heating of this for the convenience of the user, it consists of holes that allow the air flow that occurs when the driver is in motion to be transported throughout the hull and thereby cool it down gradually when driving, however, it does not fully serve its purpose as the distribution is not uniform and there are locations in the hull where this heat is concentrated, thus presenting a high temperature within the hull that makes the driver uncomfortable, taking into account the place and climate in which it is located. This study proposes a portable cooling system for motorcycle helmet that allows whoever is the carrier a state of comfort when driving your vehicle making your helmet stay cool despite the weather and temperatures that have naturally on the site of circulation. All this with the implementation of peltier cells and the use of air flow at the time of driving.

1. Introduction

And with the passage of time has seen the evolution of the same in terms of design, displacement, model and the work to be done; Together with this, resolutions such as the 1080 of 2019 have been issued issuing the technical regulation of protective helmets for the use of motorcycles, four-wheelers, motor cars, tricycles, and the like [1], which means that any person who wishes to become a creditor of any of these vehicles must therefore comply with the rules established for transit and circulation within a given territory.

The hulls must comply with technical regulations as specified in “Norma Técnica Colombiana (NTC)”, NTC 4533 [2], which dictates the minimum parameters that the hull must have to be fit in circulation and not be fined for breaking the established law. In tropical climates where high temperatures have caused a problem for motorcyclists, living in such areas means interacting with heat and excessive sweating, this means that when people put on the helmet to drive motorcycles they feel the suffocation of the thermal sensation inside the helmet, appreciating in greater proportion the
excessive heat present in these types of areas, it is true that on the market we can find many types of helmets among those we find; the full hull that meets the recommended protection characteristics at the time of an accident, because this protects the head, neck and face because they are completely closed and fit better [3]. Speaking of the ventilation of the integral helmets these have air inlets that allow the entrance of this coming from the outside, however, this ventilation does not usually cover 100% of the entire area of the helmet, that is, it does not get to spread well since these air inlets are not large enough to provide thermal comfort to the biker [4].

In the history of man there has always been an endless struggle with temperature, whether with the cold and the way to cover ourselves, to heat the environment, etc. But the part that competes this research is the heat, either in a scorching summer or in tropical areas near the sea (whose case is present in Colombia), this climate can affect the people who inhabit it; it will concentrate on an element that suffers from warming and projects it, taking into account the high temperatures that can occur in motorcycle helmets; in order to give comfort to the user avoiding the high costs [5-7].

In this project a portable cooling system for motorcycle helmet is proposed that allows whoever is the carrier a state of comfort when driving your vehicle making your helmet stay cool despite the weather and temperatures that have naturally in place circulation, all this with the implementation of Peltier cells and the use of air flow at the time of driving.

2. Materials and methods
In order to carry out the manufacturing process of the prototype of the integrated cooling system for a motorcycle helmet, the following methodology is to be followed as set out in Figure 1.

![Development of cooling system](image)

**Figure 1.** Methodology for developing an integrated cooling system for a motorcycle helmet.

The project will be carried out in three steps as shown in the Figure 1. The first step is to investigate about the ventilation system used by motorcycle helmets, all this will be done by determining which helmets are most used by motorcyclists and reviewing the database for new cooling systems to apply, at this point the most relevant information is filtered in order to have a guideline to follow. The second step is to perform an analysis of the system to be applied in the helmet, all this is with the information obtained in the databases that will allow you to make decisions to choose the best cooling system for
the motorcycle helmet, identifying which technology will be used in the prototype, knowing and selecting each of the components indicated for the system; and the third step is to make the prototype design proposal for the helmet of a motorcycle, defining the position where the cooling system for the helmet is to be installed and designing the prototype in computer-aided software. The materials that are adapted to the need of what you want to do and allow the manufacture of the prototype are: Peltier cells, heat sink and battery.

2.1. Peltier cells
A Peltier cell (see Figure 2) is a component which together with others forms the so-called thermoelectric cooling and operates through the Peltier effect; the Peltier effect consists in passing a current through a circuit composed of different materials whose joints are at the same temperature, the reverse effect occurs to the thermoelectric effect. In this case, heat is absorbed in one joint and is detached in the other; the cooling part is usually close to 10 °C, while the part that absorbs heat can quickly reach 80 °C. What makes it even more interesting is the fact that, when the feed polarity is reversed, its operation is also reversed; that is: the surface that previously generated cold begins to generate heat, and the one that generated heat begins to generate cold. [8,9]. Thanks to the immense advances in the field of semiconductors, today they are built solidly and in the size of a coin. The semiconductors are manufactured with Teluro and Bismuth to be type P or N (P: good electricity conductors and N: bad heat) and thus facilitate the transfer of heat from the cold side to the hot side by the effect of a direct current. [10]

![Figure 2. Peltier cell.](image)

2.2. Heat sink
Thanks to the immense advances in the field of semiconductors, today they are built solidly and in the size of a coin. The semiconductors are manufactured with Teluro and Bismuth to be type P or N (P: good electricity conductors and N: bad heat) and thus facilitate the transfer of heat from the cold side to the hot side by the effect of a direct current [11,12]

![Figure 3. Heat sink.](image)

2.3. Battery
It is responsible for energizing the system, a battery is an electrochemical device, which allows to have energy in chemical form, once charged when an electrical circuit is connected the chemical energy is transformed into electrical energy, reversing the chemical charging process (See Figure 4). [13]

![Figure 4. Baterry.](image)

The combination of all these elements will make possible the realization of the prototype for an integrated cooling system for the helmet of a motorcycle.
3. Results
The project was carried out with the development of the activities proposed in the methodology, through the search of information, making analyses to the system to be carried out and making the design proposal.

Researching about the ventilation system used by motorcycle helmets and determining which are the most helmet for motorcyclists can be said that more than 90% of helmets have natural cooling, that is to say that the helmet has ducts that at the moment that the driver is handling the air enters through these ducts and distributes the air inside the helmet; almost all motorcycle helmets work as well despite the fact that they all have different designs. Currently in the market we find helmets such as: integral, folding, jet helmet, classic helmet, off-road helmets, trial helmet, trail helmet and dual helmet, although it is true that some helmets have better cooling characteristics than others, it is correct to state that one of them has better safety features and we refer to the integral helmet, based on this in most patents related to the cooling systems for helmets this type of helmet is implemented.

Reviewing the databases in search of new refrigeration systems it was found that some of the patents that have been worked for refrigeration systems of various helmets are: helmet with refrigeration system for beekeeping, helmet with cooling system for motorcycles and cars, and helmet with cooling system for mines. Currently the first helmet in the world with integrated air conditioning (see Figure 5), this system works thanks to a heat pump that is installed inside the helmet and works with the current of the motorcycle battery, this particular helmet was the realization of the patent made by Steve Feher. [14]

![Figure 5. World’s first air-conditioned helmet](image)

On the other hand, we found a company in India called BluArmor, which created a removable air conditioning system as shown in Figure 6, the device is called BluSnap and has a 60-milliliter tank, an electric fan and air filter that is easily turned on and off at the press of a button. [15]

![Figure 6. BlueSnap device](image)

An analysis of the manufacturing system to be applied to the motorcycle helmet is carried out to identify and know the functioning of each component to be used in the prototype. After reviewing all the cooling systems that wear the helmets, it was decided to use a hybrid system that works with the characteristics of natural cooling, using Peltier cells, heat sinks and a power source; the system will be located in the front of the hull with a tilt, in order that the cold part of the Peltier cell is placed inwards and the hot part placed above the heat sink so that the air enters and next to the cold surface make the cooling process and in turn the heat sink extracts the heat from the hot part of the Peltier cell.
SolidWorks computer-aided design (CAD) software was used to build the prototype, because it provides the necessary tools to extrude and assemble the prototype. Figure 7 shows the prototype designed and assembled in SolidWorks, including its location and how it will be used in the helmet, bearing in mind that a portable and easy-to-remove system is being proposed, ergonomic and economic that seeks to mitigate the impact of climate change currently occurring, through thermodynamic tools that allow us to observe the temperature variations in the air flows and generate a state of comfort in the pilot when he is driving.

The design of the cooling system to be implemented in the motorcycle helmet was built, after taking into account bibliographic reports and climate changes was proposed a system in the air inlet of the helmet, in order for there to be an exchange of temperature and to cool the inner area of the hull where the heat which causes an undesirable sensation in the wearer is retained, the air coming from the environment is cooled with a Peltier cells thus achieving that the temperature of the air entering the helmet is lower and generating a state of comfort in the rider. The proposal is ergonomic, lightweight, portable and low cost, making it possible for anyone to access this system and implement it in their helmet, thus improving their experience when riding a motorcycle.

Figure 7. Integrated cooling system prototype design for motorcycle helmet.

4. Conclusions
The design of an integrated cooling system for motorcycle was obtained that allows with its use to feel a thermal comfort when driving your motorcycle, thus benefiting motorcyclists living in tropical areas because of their function and low manufacturing price, and being eligible for any type of population wishing to acquire this system and integrate it into their hull, having the possibility to be foldable and to operate with the current supplied by the same motorcycle. The Peltier effect was the system used for the development of the cooling system for motorcycle helmets, providing great utility for its low cost and market availability for mass production. It is expected that the design can materialize and commercialize, being of benefit to a lot of people who owns motorcycles and live in areas where high temperatures do not allow them to have an excellent experience when driving.

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