Heat transfer simulation of motorcycle fins under varying velocity using CFD method

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Abstract. Motorcycle engine releases heat to the atmosphere through the mode of force convection. To solve this, fins are provided on the outer of the cylinder. The heat transfer rate is defined depending on the velocity of vehicle, fin geometry and the ambient temperature. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Many experimental methods are available in literature to analyze the effect of these factors on the heat transfer rate. However, CFD analysis will be used to simulate the heat transfer of the engine block. ANSYS software is selected to run the simulation.

1. Introduction
This project focuses on studying the simulation of heat transfer of motorcycle fin under varying climatic condition. Fin act as the important part that help to reduce the distribution of overheat by the motorcycle engine block. The study includes modelling the motorcycle fin using solid model as the references used for CATIA software. Furthermore, the scope of the study had two model engine block of motorcycle will to simulated, where is Kriss 110 and Lagenda 110.

Heat transfer simulation will be conducted using ANSYS software. This simulation is used to determine the relationship between velocity, temperature and heat transfer coefficient of motorcycle fin. The purpose of the selection two model engine block is to make the comparison which is more effective to help the engine block maintain the heat is needed.

The rate of heat transfer that will distribute depends upon the engine block model, number of fin, fin pitch and wind velocity. There is an optimal cooling rate of an engine for its efficient operation. If the cooling rate decreases, it results in overheating leading to seizure of the engine. At the same time, an increase in cooling rate affects the starting of the engine and reduces efficiency.

The objective of this project is to study relationship between velocity and heat transfer coefficient (h). Others objective are to compare motorcycle fin modeling with different type of motorcycle engine block that have different design and to analyze relationship between velocity and varying temperature. The existing of motorcycle engine block was used in this study.

The problem of this part is it contribution of heat transfer coefficient (h), Temperature (T), Velocity, Fin Geometry (thickness, gap), material and surface roughness, as shown in Figure 1. Heat transfer rate that contribute while running the engine depends upon the velocity of vehicle, fin geometry and the ambient temperature. If the cooling rate decreases, it results in overheating leading to seizure of the engine. At the same time, an increase in cooling rate affects the starting of the engine.
and reduces efficiency. It is means that the efficiency of heat transfer rate will be improved with the result of this study.

Figure 1. Gap between Pitches.

This study consist two type of motorcycle engine block, which is Modenas Kriss 110 and Yamaha Lagenda 110z, as shown in Figure 2. This selection is necessitated caused to get the differences of fin performance based on different brand. Engine block was designed with different geometry based on brand of motorcycle. Besides that, shape and material of engine block are considered.

Figure 2. Modenas Kriss 110 and Yamaha Lagenda 110z engine blocks.

In study of heat transfer, a fin is a surface that it is extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection or radiation of an object determines the amount of heat transfer. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems.

Motorcycle fin is designed with several type of it. It is constant area straight fin, variable area straight fin, pin fin and annular fin. The reason of designing is commonly to analysis the effect of the heat transfer wherein the type of design is one of the factors that gave effect. The purpose of designing fin is to obtain the effectiveness of the fin. Although the fins significantly increase heat transfer from the cylinder, considerable improvement could still be obtained by increasing the number of fins.

Besides that, the thickness of fin, gap between fins are important in order the designing. Based on the type of fin (Figure 3), motorcycle engine block is normally design with the constant area straight fin. But, it also has certain motorcycle fin have been designed with variable area straight fin.
A fine mesh has been created near the fins to resolve the thermal boundary layer which is surrounded by a coarse external mesh for better results and fast solution. A face mesh has been done by quad element and pave scheme with size function as shown in Fig.5. The volume was then meshed by hex element and cooper scheme in GAMBIT to obtain the 3D mesh. The metallic fins have also been meshed using the same principles for obtaining accurate temperature distribution.

2. Design and Modeling
The engine block was designed based on existing engine block which is engine block Modenas Kriss 110 and Yamaha Lagenda 110z. The design was created in CATIA software as shown in Figure 4 and Figure 5.

The engine block was modeled as aluminum and was created in ANSYS software. Meshing has been done before run the simulation, as shown in Figure 6.
3. Result and Discussion

The engine block of motorcycle for Modenas Kriss 110 and Yamaha Lagenda 110z were simulated by using ANSYS software. In order to study relationship between velocity and heat coefficient (h), a various value of air velocity of wind were determined. The air velocity of wind is selected from 60km/h, 80km/h and 100km/h. The results of air velocity of wind against heat transfer coefficient (h) are shown in table 1.

\[ h = 5.108 \ u^{0.643} \]  

(1)

Where:-

h: Average fin surface heat transfer coefficient.
u: wind velocity in km/hr.

With the heat transfer coefficient being independent of the ambient temperature, Eq. (1) relates the heat transfer coefficient with the wind velocity.

| Wind velocity (m/s) | Total heat transfer coefficient (h) |
|---------------------|-----------------------------------|
| 16.67 (60km/h)      | 15.802                             |
| 22.22 (80km/h)      | 16.532                             |
| 27.28 (100km/h)     | 17.520                             |

The result shows that the total heat transfer coefficient (h) increased when air velocity of wind increased. Value of heat transfer coefficient increased upon on a several reason, one of the reason is, high velocity. Table 2 shows the result of wind velocity against heat transfer coefficient for Yamaha Lagenda 110z. The values of heat transfer coefficient for Yamaha Lagenda was same with Modenas Kriss 110, which is the values of heat transfer coefficient increased when the air velocity of wind increased.

Figure 6. Meshing at engine block (Modenas Kriss).
Table 2. Result of wind velocity against heat transfer coefficient for Yamaha Lagenda 110z.

| Wind velocity (m/s) | Total heat transfer coefficient (h) |
|---------------------|-------------------------------------|
| 16.67 (60km/h)      | 16.013                              |
| 22.22 (80km/h)      | 17.368                              |
| 27.28 (100km/h)     | 18.002                              |

Figure 8. Wind Velocity against Heat Transfer Coefficient (Modenas Kriss 110 and Yamaha Lagenda 110z).

Comparison between Kriss and Lagenda shown in Figure 8. Yamaha Lagenda performance better than Modenas Kriss. Even though, the difference of total heat transfer between two models are not large. The values of wind velocity were determined to gain the value of heat transfer coefficient. The values of heat transfer coefficient increased when the wind velocity increased.

4. Conclusion
As the conclusion, the simulation of two type of engine block which is Modenas Kriss 110 and Yamaha Lagenda 110z has been done accordingly to the requirement. The values of wind velocity have been determined to gain the heat transfer coefficients. This simulation is proving that the wind velocity is one important part that can affected the total of heat transfer and the value of heat transfer coefficient. Besides that, the design of motorcycle fins need to considered in order to measure total heat transfer, because fins are work to trap the air to maintain the heat of engine block, if the fins design are not too appropriate with the requirement, it can cause to overheating.

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