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HEAT TRANSFER ANALYSIS OF IN-WHEEL ELECTRIC MOTOR HOUSING WITH DIFFERENT COOLING FIN ARRANGEMENT USING ANSYS

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Abstract:- In wheel motor is a new advance technology which the electric motor is integrated within the wheels. The in-wheel electric motor is fitted right into the wheel rim of the vehicle. Locating the Electric motor in or behind the wheel offers many advantages. It eliminates the need for the Conventional engine, transmission differential and the other power train components.

In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy. In this thesis, An analysis was conducted to study the heat transfer of in-wheel electric motor cooling fin for light electric vehicle application. This study focuses on motor housing design and heat transfer analysis of different cooling fins arrangement for motor housing. The design of the cooling fin on the motor housing is important to ensure an efficient thermal management, an optimum output power, reliable and safe operation to the user. Three types of cooling fin arrangement on the motor housing has been selected and modelled in PRO-ENGINEER software. There were straight fin, slanting fin and transverse fin. Then, all models were exported to ANSYS for heat transfer analysis purpose.

A replicate of wind tunnel test was used to simulate the analysis. All the variables are kept constant during the analysis such as materials thermal properties, air temperature and air velocity. Results of the analysis are presented in the figure and graph of temperature distribution, velocity vector, total heat transfer and maximum temperature. It has been found that the straight fin arrangement has highest efficiency of temperature distribution with the lowest total heat transfer rate of 2056.91 W.

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I INTRODUCTION

1. 1 INTRODUCTON OF MOTORS

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator.

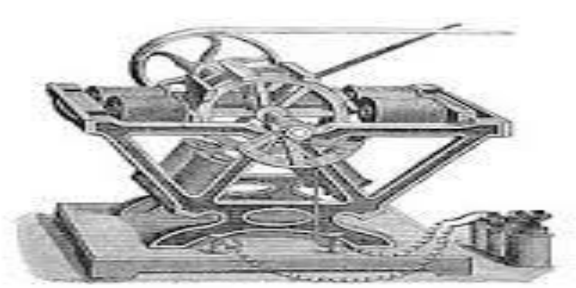

FIG1:ELECTRICAL MOTOR

In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy.

1.2 SELF-COMMUTATED MOTOR

1.2.1 DC MOTOR

All self-commutated DC motors are by definition run on DC electric power. Most DC motors are small PM types. They contain a brushed internal mechanical commutation to reverse motor windings' current in synchronism with rotation.

FIG2:DC MOTOR

1.3 ELECTRICALLY EXCITED DC MOTOR

Workings of a brushed electric motor with a two-pole rotor and PM stator. ("N" and "S" designate polarities on the inside faces of the magnets; the outside faces have opposite polarities.)

A commutated DC motor has a set of rotating windings wound on an armature mounted on a rotating shaft. The shaft also carries the commutator, a long-lasting rotary electrical switch that periodically reverses the flow of current in the rotor windings as the shaft rotates. Thus, every brushed DC motor has AC flowing through its rotating windings. Current flows through one or more pairs of brushes that bear on the commutator; the brushes connect an external source of electric power to the rotating armature.The rotating armature consists of one or more coils of wire wound around a laminated, magnetically "soft" ferromagnetic core. Current from the brushes flows through the commutator and one winding of the armature, making it a temporary magnet (an electromagnet). The magnetic field produced by the armature interacts with a stationary magnetic field produced by either PMs or another winding (a field coil), as part of the motor frame. The force between the two magnetic fields tends to rotate the motor shaft. The commutator switches power to the coils as the rotor turns, keeping the magnetic poles of the rotor from ever fully aligning with the magnetic poles of the stator field, so that the rotor never stops (like a compass needle does), but rather keeps rotating as long as power is applied.

1.4PERMANENT MAGNET DC MOTOR

A PM motor does not have a field winding on the stator frame, instead relying on PMs to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. PM fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Most larger DC motors are of the "dynamo" type, which have stator windings. Historically, PMs could not be made to retain high flux if they were disassembled; field windings were more practical to obtain the needed amount of flux. However, large PMs are costly, as well as dangerous and difficult to assemble; this favors wound fields for large machines.

FIG3:PERMANANT MAGNET DC MOTOR

1.5 ADVANTAGES / DISADVANTAGES

The primary purpose of saving energy is to lower consumption by only allowing the load to use as much power as needed to get the job done, high speed, and low speed or somewhere in the middle without the sharp surges associated with an on/off motor. Even though at face value they use less energy, as someone else posted there are other associated costs. As far as power is concerned, it’s a catch 22 same as CFL lighting. CFL uses less power but is the most polluting of all lighting technologies when it comes to adding harmonics to an environment. It all comes down to the application and cost / benefit scenario.

In a number of HVAC retrofits we have equipped existing standard rated motors with AC drives. While it is true that inverter-duty motors are better suited, I don't believe they need to be required as part of the upgrade. I believe the customer should use the motor to the end of it's life and when a replacement is needed, then upgrade to the inverter-duty motor. The life-span of the existing motor may be slightly shortened; however, the realized savings would be more immediate while maximizing the life-span of existing equipment.

II LITERATURE REVIEW

The renewable energy is vital for today's world as the nonrenewable sources that we are using are going to get exhausted in near future. The solar vehicle is a step in saving these nonrenewable sources of energy. The basic principle of Solar/Electric Powered Hybrid Vehicle (SEPHV) is to use energy that is stored in a battery during and after charging it from a solar panel. The charged batteries are used to drive the motor which serves here as an engine and moves the vehicle in reverse or forward direction. The electrical tapping rheostat is provided to control the motor speed. This avoids excess flow of current when the vehicle is supposed to be stopped suddenly as in normal cars with regards to fuel. This idea, in future, may help to protect our fuels from getting extinguished. This view ignited us to develop SEPHV. This multicharging vehicle can charge itself from both solar and electric power. The vehicle is altered out of a two-wheeler vehicle by replacing its engine with a 48 V brushless DC (BLDC) motor. Supply to the motor is obtained from a battery set of 12 V, 24 AH. The household electric supply of 230 V is reduced with a step-down transformer to 48 V and then it is converted to the DC with a rectifying unit to charge the battery of four solar panels. Each with a rating of 20 Watts are attached to the top of the vehicle to grab the solar energy and is controlled with the help of MCB controller. The SEPHV can be driven by 48 Watt BLDC motor consisting of four 20 Watts photovoltaic (PV) panel in the voltage rating of 18.38 V. The power which is absorbed by the PV panel is stored into the four 24 AH 12 V batteries. When there is absence of sun, electric power supply act as an auxiliary energy source. For controlling speed of the motor, a switch is designed with four tapping, provided with different values of resistance at each tapping. It acts as a speed control switch for SEPHV. This type of technique is developed to reduce the running cost and increase the running efficiency of the vehicle. The performance of SEPHV was found to be satisfactory for the load of four people with the average speed of 40 Km/h. The total cost of the vehicle is 18000 INR

paper presents evaluation of effect of in-wheel electric motors mass on the performance of active suspension system by using one of more common control methods which is Linear Quadratic Regulator (LQR).Unsprung mass is one of the important parameters which effects on road holding and ride comfort behaviors in the vehicles, this effect obtained in this work by comparing the performance of the system using standard tire and tire with In-Wheel Electric Motor. Also,modeling and simulation of quarter car model completed to construct the Simulink model of the system using MATLAB software. The study summarized bad effect of increasing the weight of tires by add In-Wheel Motors to the system on the road traction and the vehicles drivers comfort, at the same time the

Nowadays the electric vehicle motorization control takes a great interest of industrials for commercialized electric vehicles. This paper is one example of the proposed control methods that ensure both safety and stability the electric vehicle by the means of Direct Torque Control (DTC). For motion of the vehicle the electric drive consists of four wheels: two front ones for steering and two rear ones for propulsion equipped with two induction motors, due to their lightweight simplicity and high performance. Acceleration and steering are ensured by the electronic differential, permitting safe and reliable steering at any curve. The direct torque control ensures efficiently controlled vehicle. Electric vehicle direct torque control is simulated in MATLAB SIMULINK environment. Electric vehicle (EV) demonstrated satisfaction.

III MODELING AND ANALYSIS

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. Perhaps the single development that has impacted manufacturing more quickly and significantly than any previous technology is the digital computer.

Computers are being used increasingly for both design and detailing of engineering components in the drawing office. Computer-aided design (CAD) is defined as the application of computers and graphics software to aid or enhance the product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. Computer-aided design systems are powerful tools and in the mechanical design and geometric modeling of products and components.

There are several good reasons for using a CAD system to support the engineering design

Function:

- To increase the productivity
- To improve the quality of the design
- To uniform design standards
- To create a manufacturing data base

- To eliminate inaccuracies caused by hand-copying of drawings and inconsistency between
- Drawings

PRO/ENGINEER

Pro/ENGINEER, PTC's parametric, integrated **3D CAD/CAM/CAE solution**, is used by discrete manufacturers for mechanical engineering, design and manufacturing.

Created by Dr. Samuel P. Weisberg in the mid-1980s, Pro/ENGINEER was the industry's first successful parametric, 3D CAD modeling system. The parametric modeling approach uses parameters, dimensions, features, and relationships to capture intended product behavior and create a recipe which enables design automation and the optimization of design and product development processes.

This powerful and rich design approach is used by companies whose product strategy is

family-based or platform-driven, where a prescriptive design strategy is critical to the success of the design process by embedding engineering constraints and relationships to quickly optimize the design, or where the resulting geometry may be complex or based upon equations. Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design.

Companies use Pro/ENGINEER to create a complete 3D digital model of their products.The models consist of 2D and 3D solid model data which can also be used downstream in finite element analysis, rapid prototyping, tooling design, and CNC manufacturing. All data is associative and interchangeable between the CAD, CAE and CAM modules without conversion. A product and its entire bill of materials (BOM) can be modeled accurately with fully associative engineering drawings, and revision control information. The associatively in Pro/ENGINEER enables users to make changes in the design at any time during the product development process and automatically update downstream deliverables. This capability enables concurrent engineering — design, analysis and manufacturing engineers working in parallel — and streamlines product development processes.

IV INTRODUCTION TO FEA

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition.In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

4.1 TYPES OF ENGINEERING ANALYSIS

Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in.

Vibrational analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may act on the natural vibrational frequency of the material which, in turn, may cause resonance and subsequent failure.

Fatigueanalysis helps designers to predict the life of a material or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely to occur. Failure due to fatigue may also show the damage tolerance of the material.

Heat Transfer analysis models the conductivity or thermal fluid dynamics of the material or structure. This may consist of a steady-state or transient transfer. Steady-state transfer refers to constant thermo properties in the material that yield linear heat diffusion.

RESULTS OF FINITE ELEMENT ANALYSIS

FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested. In practice, a finite element analysis usually consists of three principal steps:

1. **Preprocessing**: The user constructs a model of the part to be analyzed in which the geometry is divided into a number of discrete sub regions, or elements," connected at discrete points called nodes." Certain of these nodes will have fixed displacements, and others will have prescribed loads. These models can be extremely time consuming to prepare, and commercial codes vie with one another to have the most user-friendly graphical “preprocessor" to assist in this rather tedious chore. Some of these preprocessors can overlay a mesh on a preexisting CAD file, so that finite element analysis can be done conveniently as part of the computerized drafting-and-design process.
2. **Analysis**: The dataset prepared by the preprocessor is used as input to the finite element

   code itself, which constructs and solves a system of linear or nonlinear algebraic equations. Commercial codes may have very large element libraries, with elements appropriate to a wide range of problem types. One of FEA's principal advantages is that many problem types can be addressed with the same code, merely by specifying the appropriate element types from the library.
3. **Postprocessing**: In the earlier days of finite element analysis, the user would pore through reams of numbers generated by the code, listing displacements and stresses at discrete positions within the model. It is easy to miss important trends and hot spots this way, and modern codes use graphical displays to assist in visualizing the results. A typical postprocessor display overlays colored contours representing stress levels on the model, showing a full field picture similar to that of photo elastic or moiré experimental results.

V .CFD ANALYSIS OF IN WHEEL

5.1 VELOCITY AT 20M/S

TEMPERATURE

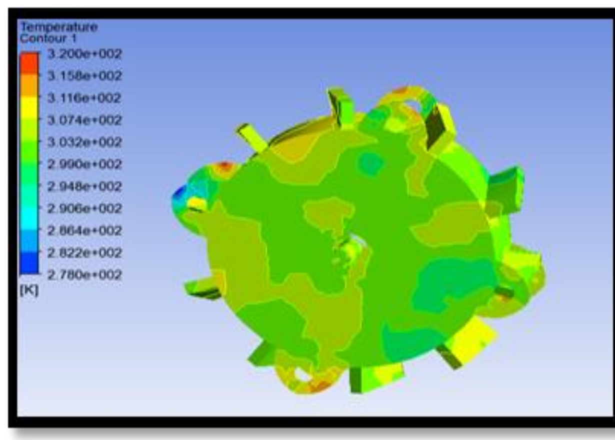

FIG4:MASS FLOW RATE AT 20M/S

5.2VELOCITY AT 30M/S

TEMPERATURE

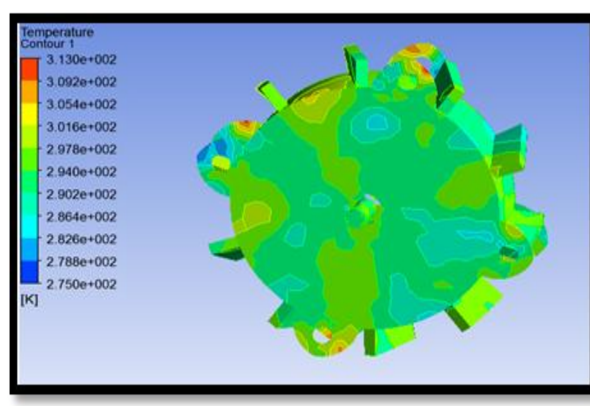

FIG5:MASS FLOW RATE AT 30M/S TEMPERATURE

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5.3 VELOCITY AT 50M/S

TEMPERATURE

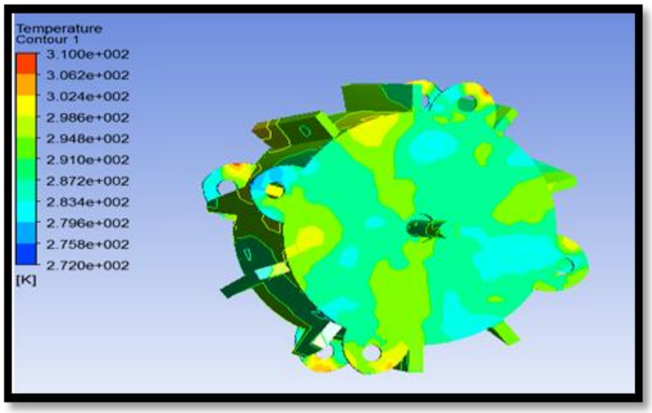

FIG6:MASS FLOW RATE VELOCITY AT 30M/S

5.4VELOCITY AT 50M/S

TEMPERATURE

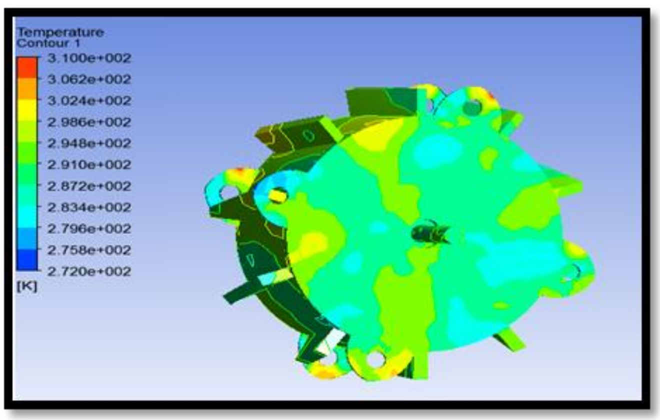

FIG7:MASS FLOW RATE AT 50M/S

5.5VELOCITY AT 60M/S

TEMPERATURE

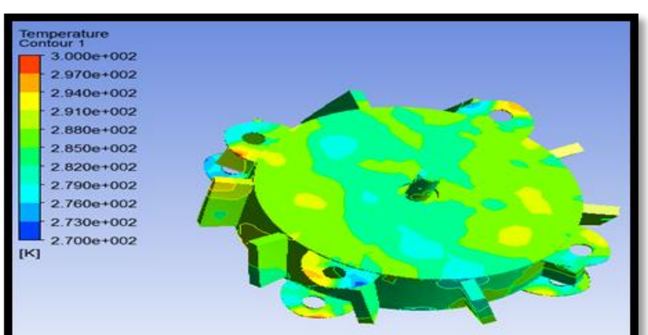

FIG8:MASS FLOW RATE AT 60M/S

5.6 MATERIAL- ALUMINUM ALLOY

TEMPERATURE

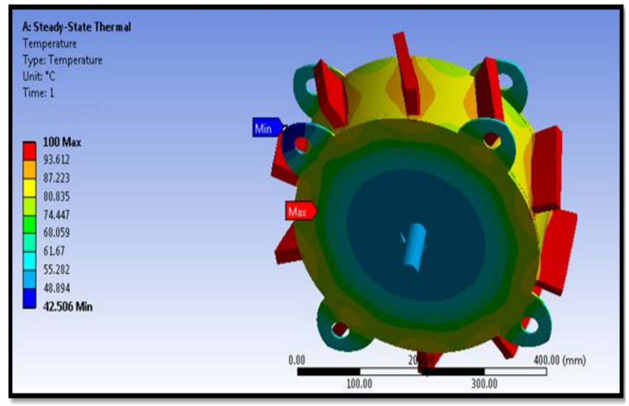

FIG9:TEMPERATURE DISTRIBUTION OF ALLUMINIUM ALLOY

5.7HEAT FLUX

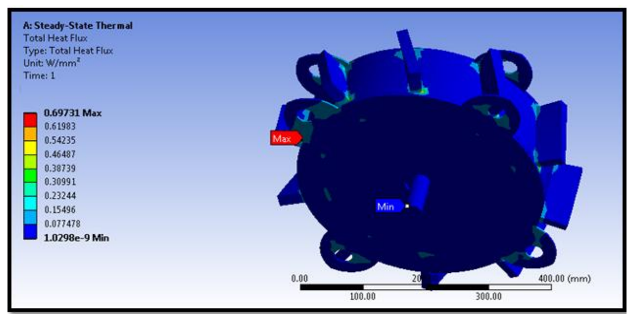

FIG10:HEAT FLUX OF AL ALLOY

VI CONCLUSTION

Design and analysis is successfully completed by using various materials and finded the various parameters using Ansys.The in-wheel electric motor is fitted right into the wheel rim of the vehicle. Locating the Electric motor in or behind the wheel offers many advantages. It eliminates the need for the Conventional engine, transmission differential and the other power train components.

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