Stress Analysis of Accelerated Pedal in Composite Material
Mechanical Engineering Design

Anshul Jain¹, Ashish R. Pawar¹

¹Mechanical Engineering Department, ABMSP’s Anantrao Pawar College of Engineering & Research, Parvati, Pune,

Abstract - In today’s competitive world, Safety & operating Comfort of driver has become a very significant area. In four wheeler commercial vehicle also the major automobile maker are now paying attention to this field. In a commercial vehicle usually there are three types of foot control for functioning the accelerator, brake and cultch of the vehicle. Nowadays these control systems are also known as A B C control. Design & Location of these A,B,C foot pedals has a great effect on the driver’s safety & operating comfort as due to front axle load the pedal effort to operate these controls is higher than that of passenger cars, also due to long driving the frequency of application of these pedal is also high. Due to this, driver of the vehicle started feeling uncomfortable and its fatigue & stresses increases which leads to safety issue. In this Project we are going to study the current design & position of Accelerated pedal in one of the four wheeler commercial vehicle as per material, design, & ergonomics consideration. Here we will optimize the material & Design of the APM. In this Project we study the current design of the accelerating pedal according to material, design & ergonomic consideration and then propose the new composite design of the accelerated model. The motive of this project becomes to bring the overall Safety & comfort of the driver by making suitable design modification in the design of pedal. After successfully design the Accelerated Pedal, we validated it on the vehicle itself. For this Vehicles Outdoor Testing Department helped us in evaluating the performance of our design by subjective as well as objective testing.

Keywords— Accelerater Pedal, Static Structural Analysis, Optimization

I. INTRODUCTION

Four wheeler commercial vehicle or small commercial vehicle are normally used for transporting of materials short intra city deliveries, working on narrow village roads, long highway hauls carrying small bulky loads or even heavy cargo. This category can be characterized as less than 1000cc engine and 3.5 tons of weight. Design engineers have great challenge to provide better design which can work for small commercial vehicle as there is less space available for design and also the requirement of the components as per big commercial vehicles. Thus, it is very much necessary for the designers to provide not only a better design of parts having less space but also of minimum weight and cost, keeping design safe under all loading conditions.

Foot controls - Foot controls is the general term given to the 3 most important controls of the vehicle which are operated by the driver’s foot. These are Accelerator control pedal, Brake control pedal and clutch control pedal. The function of accelerator pedal is to open the throttle the fuel injection pump as per the drivers input through the pedal travel. Clutch and brake pedal both works on the same principle of Pascal law and principle of leverage. When the pedal is pressed the piston of the master cylinder moves and pressurized the fluid as per Pascal’s law. This pressurized fluid then goes into the slave cylinder (in case of clutch control) or wheel cylinder (in case of brake cylinder) and actuate the push rod or brake caliper.
Accelerated Pedal System - Accelerated-pedal System registers the drive’s wishes after a change in engine torque and sends a corresponding signal to the engine control unit for further processing.

Components of Accelerated Pedal System – Below are the components of the accelerated pedal system.

- Pedal lever
- Bearings
- Friction elements
- Housing
- Housing cover
- Sensor PCB
- Contact Elements
- Sensor Screw
- Sensor cover
- Wiper carrier
- Springs

A. Problem Statement
In present Accelerated pedal, we are using metal pedal lever which is taking more weight, area & force applied on it which leads to failure and also it breaks during the application in less time and also the cost of present Pedal is also high compare to benchmarking. Here we are going to change it
by Plastic pedal lever which will optimize the current design, saving in Cost, improve safety & operating comfort of the drive.

B. Objectives:
The main objectives of the proposed research work are as follows:
Design of the pedal lever for Accelerated system in composite material
To perform structural weight optimization using FEA approach without compromise in strength to reduce the weight to cost ratio.

C. Scope: The research work at project include -
Introduction of Accelerated pedal system for four wheeler commercial vehicle.
Previous work on topics related to APS. It also includes the research scope and limitations of the research work done by other researchers in the same field.
The 3D modeling of the proposed pedal lever of APS.

II. IDENTIFY, RESEARCH AND COLLECT DATA
Sagar Darge et al. This paper provides the information about Finite Element Analysis of the Lower or Upper Control arm suspension of double wishbone suspension which involve stress optimization under static loadings. The suspension system is one of the most important components of vehicle, which has impact on the safety, performance, noise level and style of it. However, these static load conditions could not represent all the severe situations of automobile parts which subjected to complex loads varying with time, especially for lower control arm of front suspension. Lower Control arm of suspension system modeled using CATIA V5. In first step of analysis area is to calculate maximum stress area. These analyses were carried using ANSYS. In order to reduce stresses and to improve structural strength Topography optimization approach is carried out in ANSYS in which a design region for a given part is defined and a pattern of shape variable-based reinforcements within that region is generated to increase Stiffness.\[1\]

Yoshiyuki Tanaka, Hidekazu Kaneyuki, This paper investigates the interaction between human sensory and motor properties at the foot during the operation of an automobile pedal, as an example of human-machine systems, and demonstrates the close relationship between the perceptual properties of force resistance at the foot and the loads for foot joints much depending on the pedal layout. Finally, based on biomechanical and perceptual analyses, a human-inspired design method of pedal dynamic properties is discussed.\[1\]

Pankaj Chhabra, Puneet Katyal and Vishal Gulati. In this Paper, Concurrent Engineering (CE) approach has been used to determine the most optimum decision on design concept and material of the composite accelerator pedal at conceptual design stage. Comprehensive studies are carried out to prepare the design specifications of composite accelerator pedal. Various design concepts are generated using the Morphological approach. In particular at design stage, CATIA is used to generate various design concepts followed by analysis on ANSYS. Simultaneously, material selection is done on the basis of past research & specifications. Rating/weighting matrix evaluation method is used to select the best concept for the profile of pedal arm on the basis of mass, volume, stress and deformation results achieved on ANSYS. The composite accelerator pedal is optimized and analyzed for safety parameters and finally prototyped using Selective Laser Sintering. The results reveals the feasibility of composite accelerator pedal with glass filled polyamide providing substantial weight saving and better properties than existing metallic pedal.\[2\]

Sam Brook, Rob Freeman, George Rosala and Felician, This paper presents the design and development of an ergonomic data measurement system for driver–pedals interaction. The work
focuses in particular on the actuation of the acceleration and brake pedals, and aims to support the development of a deeper understanding of the factors influencing the driving comfort associated with the right leg. The ergonomic data measurement system integrates five subsystems: an electrogoniometry system and a pressure-pads system to monitor driver’s positioning and movements, an electromiography system to observe the muscular activity of the lower leg, the vehicle on-board diagnostic system, a GPS system and an audio-visual system for providing environment and driving situation information. A validation exercise involving a series of test drive events confirmed the system capability to record meaningful objective comfort data which can differentiate between driving postures and styles. [3]

Yoshiyuki TANAKA, Teruyuki ONISHI, This paper has discussed the integration of human impedance properties into a human-machine system composed of the variable impedance-controlled robot. Focusing a human-machine interface system manipulated by the lower extremities, human leg impedance properties during maintained leg posture were investigated according to the leg posture and foot force. Next a set of basic tests was carried out to evaluate the designed control structure with the database of the measured human impedance by using the developed experimental device.[4]

B. Bowonder, K.J. Sharma, This paper has discussed the product development cycle time line. Managing product development cycle time has been one of the critical competencies needed for meeting the competition. Using a series of approaches the product development process has been made concurrent. Overlapping phases of development involves intense interactions among team members, cross-functional teaming, use of information technology enablers and frequent reviews among team members, customers and suppliers. Taking up product development along with manufacturing process specifications improves manufacturability as well as assimilation. Many firms, including automobile firms and aerospace manufacturers have been able to reduce the product development cycle time along with the reduction in failure rates and rework. Enhancing horizontal interactions and early specification of deliverables facilitates coordination, paving the way for reducing time to market and product costs.[5]

International Standard ISO 16121-1-The aim of this part of ISO 16121 is to supply the designer of commercial vehicles with information about how to develop an overall ergonomic concept for the driver’s workplace. The recommended requirements on the driver’s workplace for line-service buses made in this part of ISO 16121 are based on the scientific conclusions of the research project “Driver’s workplace in the line-service bus”. It contains basic requirements for an ergonomic and comfortable seating position, which is essential to keep drivers in a good state of health. As per this standard the depth of the footwall shall be at least 350 mm forward of OHP (operator heel point). The width of the driver’s workplace must be chosen in such a way that sufficient distance to the cab covers and sufficient leg freedom are available, included space for seat swivel. For the protection of the fingers a clearance distance of 25 mm from the outer extremities of the seat shall be kept. In low-floor buses, the driver's workplace should be arranged on a platform. It is recommended that this platform be at a height of 200 ± 50 mm above the floor and be reached by a single step. If the platform height is greater than 250 mm, steps with equal height shall be provided with a maximum height of 250 mm and a minimum height of 125 mm. The accelerator pedal and brake pedal should be arranged in such a way that the foot movement is rotational during operation. [6]

AIS -035/2006, the aim of this standard is the arrangement of the foot control of the vehicles. Foot controls in a vehicle do not require the driver to see them while driving. The driver needs to be familiar with the foot controls of different makes of Vehicles. In this regard the arrangement of the foot controls is important for safety. While preparing this AIS considerable assistance is derived
K K Dhande, N I Jamadar and Sandeep Ghatge, In recent years, the conventional brake, accelerator and clutch pedals of automotive vehicles are replaced by polymeric-based composite pedals. The purpose of replacement from metallic pedal to polymeric-based composite material is to reduce the weight, cost and improve material degradation by corrosion. In this paper four different sections of polymeric based brake pedals are analyzed as per the design parameters received from General motors. The sections are analyzed and arrived at a winning concept based on stiffness comparison. A full scale model is developed from the winning concept, while developing full scale model an ergonomic study has been made on few hatch back and SUVs car’s to improve the driver’s comfort and reduce fatigue due to breaking operation. The pedal is modelled using CATIA software and analysis is carried out in ANSYS software. The results have shown polymeric-based composite material meets the requirements of manufacturer’s specification and can be replaced with present metallic Pedal. Weight reduction of 66.7% is achieved by using composite material.

III. METHODOLOGY

IV. NUMERICAL ANALYSIS

4.1 Static Structural Analysis:

4.1.1. Material Properties:
1. Glass Filled Polyamide
2. Tensile Modulus : 5800 MPa
3. Poisson’s ratio : 0.31
4. Density : 8.4x10^-6 kg/mm³
5. Mass of the body : 281 Gram

4.2.2. Finite Element Analysis:

Design of Proposed Accelerator pedal is done by using Pro-e as per following-
Fig. No. 1 Front view of proposed Accelerated pedal

Fig. No. 1 Side view of proposed Accelerated pedal

Stress analysis of proposed Accelerated pedal

Fig. No. 4 Displacement analysis of existing Accelerated pedal

V. RESULTS

First of all for comparison of cost & weight for existing & proposed pedal is as below

<table>
<thead>
<tr>
<th>Pedal Design</th>
<th>Existing</th>
<th>Proposed</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (Gm)</td>
<td>350</td>
<td>281</td>
<td>-25%</td>
</tr>
<tr>
<td>Cost (INR)</td>
<td>850</td>
<td>740</td>
<td>-15%</td>
</tr>
</tbody>
</table>
As per ergonomics the design is improve so the drive fatigue is reduced

<table>
<thead>
<tr>
<th>Design Of Accelerator Pedal System</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Design</td>
<td>706</td>
<td>329</td>
</tr>
<tr>
<td>New Design</td>
<td>798</td>
<td>341</td>
</tr>
</tbody>
</table>

Table: Position of the pressure point w.r.t H point

VI. CONCLUSION

Experimental results shows that the Stress level & Deflection in proposed composite pedal is minimum as compared with Existing metallic pedal. So there is scope in other parts too to change the material from existing Metallic to Composite one for weight saving & Cost advantageous too.

REFERENCES


III. Sam Brook, Rob Freeman, George Rosala and Felician Campean, Ergonomic Data Measuring System for Driver-Pedals Interaction, SAE INTERNATIONAL, 2009


VI. INTERNATIONAL STANDARD ISO 16121-1 (Road vehicles -Ergonomic requirements for the driver's workplace in line-service buses)

VII. AIS 035/2006.(Automotive Vehicles -The Arrangement of Foot Controls of Vehicles)