DEVELOPMENT OF HYDRAULIC BRAKE DESIGN SYSTEM APPLICATION

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ABSTRACT

The brakes which are actuated by the hydraulic pressure (pressure of a fluid) are called hydraulic brakes. Hydraulic brakes are commonly used in the automobiles. The Present research work aims at studying the analysis and development of hydraulic brake design system. Also, various performance parameters can be easily calculated and with the help of these parameters results are shown in the form of graphs. The research incorporates Brake Performance and Temperature Calculation for given Vehicle Name and Vehicle Category.

Index Terms-*Vehicle Model, Brake Model, Pedal Travel Design Assumptions, Temperature Module.*

I. INTRODUCTION

The **hydraulic brake** is an arrangement of braking mechanism which uses brake fluid, typically containing ethylene glycol, to transfer pressure from the controlling mechanism to the braking Mechanism. Hydraulic brakes work on the principle of Pascal's law which states that "pressure at a point in a fluid is equal in all directions in space". According to this law when pressure is applied on a fluid it travels equally in all directions so that uniform braking action is applied on all four wheels.

A typical brake system component is as shown in fig 1 given below. In a hydraulic brake system (HBS), when the brake pedal is pressed, a pushrod exerts force on the piston(s) in the master cylinder, causing fluid from the brake fluid reservoir to flow into a pressure chamber through a compensating port. This results in an increase in the pressure of the entire hydraulic system, forcing fluid through the hydraulic lines toward one or more calipers where it acts upon one or two caliper pistons sealed by one or more seated O-rings. The brake caliper pistons then apply force to the brake pads, pushing them against the spinning rotor, and the friction between the pads and the rotor causes a braking torque to be generated, slowing the vehicle. Heat generated by this friction is either dissipated through vents and channels in the rotor or is conducted through the pads, which are made of specialized heat-tolerant materials such as kevlar or sintered glass.

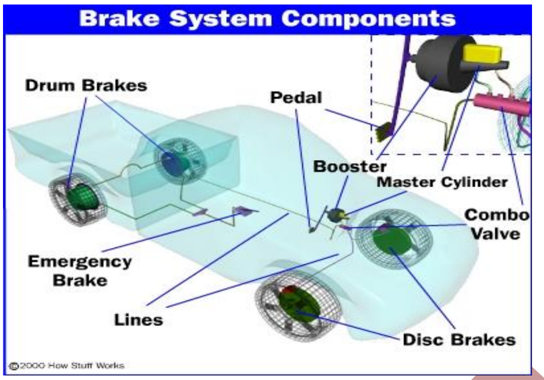


Figure 1: Brake System Components

Subsequent release of the brake pedal/lever allows the spring(s) in my master cylinder assembly to return the master piston(s) back into position. This action first relieves the hydraulic pressure on the caliper then applies suction to the brake piston in the caliper assembly, moving it back into its housing and allowing the brake pads to release the rotor. The hydraulic braking system is designed as a closed system unless there is a leak in the system, none of the brake fluid enters or leaves it, nor does the fluid get consumed through use.

All the input values are added in software named "netbeans" and one calculate button is provided over there. By clicking that button output of given vehicle data is calculated. Graphs obtained from buttons that are provided in output page. Name of button is similar to that of graph. By clicking that button graphs can be plotted in the form of smooth curves.

II. HBS – INPUT

HBS input consists of Vehicle Model, Brake Model, Pedal Travel Design Assumptions and Temperature Module.

1. Vehicle Model

It consists of the total data of the vehicle like vehicle name, vehicle category and the parameters like gross vehicle weight, front and rear axle weight, height of CG etc.

Vehicle Data

Table I: Vehicle Model - Inputs

Vehicle Name	D1	
Vehicle Category	N1	

Regulation	IS	
Parameter	Laden	Unladen
Gross Vehicle Weight (kg)	2950	2000
Front Axle Weight (kg)	1240	1160
Rear Axle Weight (kg)	1710	840
Height of CG (m)	750	650
Wheel Base (m)	3150	
Tyre Dynamic Radius	374	

2. Brake Model

It consists of

(a) Actuation

Actuation includes data of Tandem Master Cylinder and booster.

(b) Valve Type

Valve Type includes data of Valve and Laden, Unladen Pressure.

(c) Foundation Brakes

Foundation Brakes includes data of Wheel diameter, Disc diameter and Brake Factor etc.

Table II: Brake Model - Inputs

1. Actuation

Tandem Master Cylinder Diameter	23.81
Tandem Master Cylinder Front Axle	60
Tandem Master Cylinder Rear Axle	60
Booster	Existing Booster
Booster Ratio	5
Input Force	95
Output Force	610
Initial Force	10
Booster Index	1
Pedal Ratio	5

2. Valve Type

Valve Type	NO Valve	
Bypass Valve	NO	
Cut in Pressure	Cut in 1	Cut in 2
Laden Cut in Pressure	0	0
Unladen Cut in Pressure	0	0
Valve Type	0	0

3. Foundation Brakes

Parameter	Front	Rear
Disc Diameter	214	282
Lining Width	140	50
Type	Non- Asbestos	Non-Asbestos
Wearable Thickness	10.80	3
Lining Area per Axle	198	568
Brake Factor	0.7	2.2
Mue Average	0.37	0.35
Wheel Cylinder Diameter	57	22.2220
Wheel Cylinder Stroke	20	12
No. of calipers per Cylinder	1	
Lift Off Pressure	0.63	3.09

2. Pedal Travel Design Assumptions

It consists of input values like TMC Dead stroke, TMC Elastic stroke and Booster Elastic stroke.

Table III: Brake Model - Inputs

1. Tandem Master Cylinder Assumptions

TMC Dead Stroke	0.7
TMC Elastic Stroke	2

2. Inputs

Expansion of Brake Hose	0.7

Booster Dead Stroke	1.5
Booster Elastic Stroke	1
Brake Pedal Free Ply	2

3. Temperature Module

Input values of Temperature Module consists of values of Input and output velocities, Brake Selection. All the input values are added to calculate the temperature raise in front or rear brake.

Table IV: Brake Model - Inputs

1. Inputs

GVW	2650
Gravity Constant	9.8
Initial Velocity	34.75
Final Velocity	0.0
Material	Grey Cast Iron
Specific Heat	419
Rotor Density	7.208
Rotor Volume	0.0

Brake Selection	Front	Rear
Fraction of Brake	0.4	

2. Output

According to Brake Selection, we can calculate the value of Brake selection in front or rear brake.

Temperature Raise in Front Brake	205.46

III. HBS - OUTPUT

Following table shows the output of given vehicle data. Output consists of Overall Performance of the vehicle, performance based on Deceleration, 0.2g Deceleration and 0.6g Deceleration.

Table V: HBS - Output

1. **Overall Performance**

Overall Performance	Passes
Type 'O' Performance	Passes
Front Only Secondary Performance	Passes
Rear Only Secondary Performance	Passes
Automatic Adjustment on Front Brake	Not Mandatory
Automatic Adjustment on Rear Brake	Not Mandatory

2. **Performance**

Parameter	Required	Laden	Unladen
Total Deceleration	0.510	1.096	1.617
Front Alone Deceleration	0.224	0.676	0.997
Rear Alone Deceleration	0.224	0.424	0.620
Vacuum failed Deceleration	0.224	0.412	0.607
Permanent Rear Deceleration	0.224	0.390	0.288
Permanent Deceleration at 0.8Mue	0.510		0.611
X-split Deceleration	0.224	0.548	0.306

3. **0.2g Deceleration**

Parameter	Laden	Unladen
Fluid Pressure (bar)	37.004	37.004
Torque/Brake (Mkg)	69.53	40.800
Drag Force/Lining Area (kg/cm^2)	6.564	1.019
Energy absorbed/Lining Area (J/cm2)	1304.1	266.1
Energy absorbed/Lining Volume (J/cm^3)	120.7	88.9

4. **0.6g Deceleration**

Parameter	Laden	Unladen
Fluid Pressure (bar)	107.853	107.853
Torque/Brake (Mkg)	204.958	126.032
Drag Force/Lining Area (kg/cm^2)	19.348	3.147
Percentage TMC Strokes used	18.917	14.224

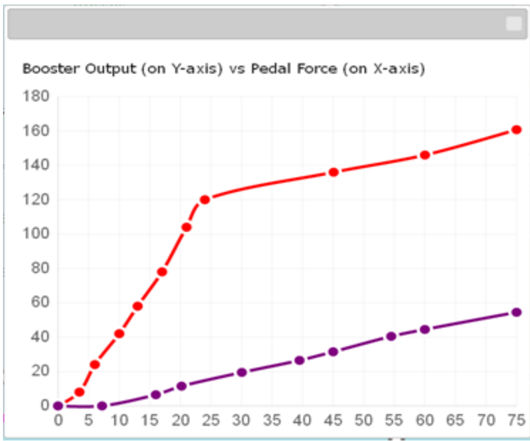
IV. RESULTS AND DISCUSSION

1. Laden Graphs

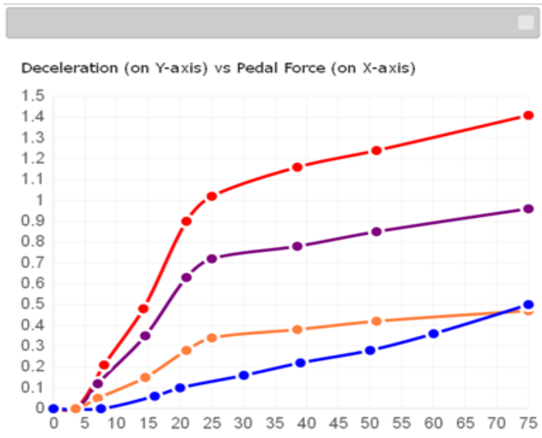
Using overall performance of the vehicle Laden and Unladen Graphs can be plotted. Results obtained in this application is as shown in fig. Booster Output, Final Line Pressure, Deceleration, Adhesion Factor, Pedal Travel are shown with vacuum and without vacuum. Different curves can be plotted by entering all input values.Gradual increase and decrease of Pedal Force can be shown for all input values. Range of Booster Output and Final Line Pressure are taken from 0-200 while Deceleration range is 0-1.5. Adhesion Factor Range is taken as 0-2.5 and Pedal Travel Range is 30-150. In Every graph Pedal Force range is taken as 0-75. By adding all input values in Hydraulic Brake System Application overall performance of vehicle can be shown and then all the performance curves are shown in the form of graphs.

0.2g performance and 0.6g performance are shown in Deceleration (on Y-axis) vs Pedal Force (on X-axis). For maximum pedal force Deceleration is 1.45. Similarly, in case of Adhesion Factor graph for maximum deceleration Adhesion Factor value is 2.25. In case of Pedal Travel Graph as Pedal Force is firstly increases and then decreases gradually. Pedal Travel Values are considered from 30.

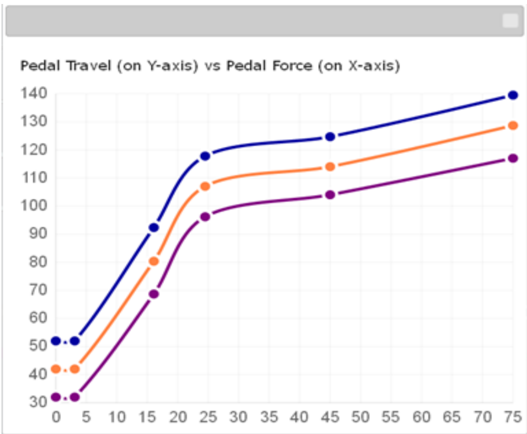
All the curves obtained in Laden and Unladen Graph are according to input values. As input values changed, curves may vary. For a given Vehicle Model overall performance of the vehicle passes and hence, we conculed that curves obtained are correct and accurate. More number of input values can give more accuracy.



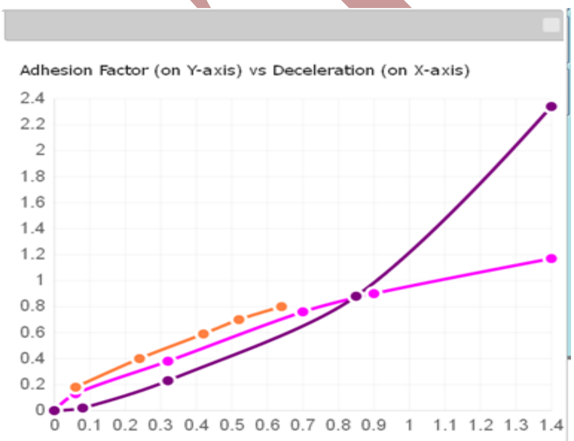
(A) Booster Output



(B) Deceleration



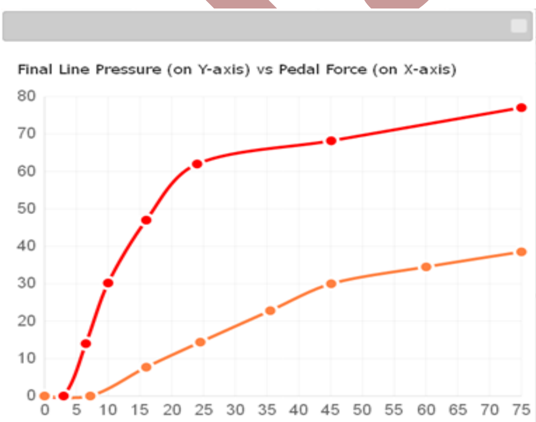
(C) Pedal Travel

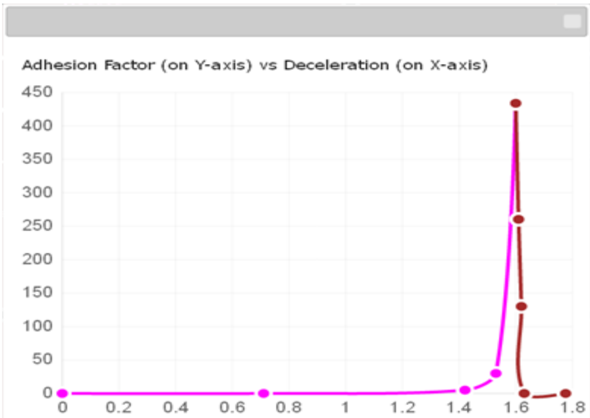


(D) Adhesion Factor

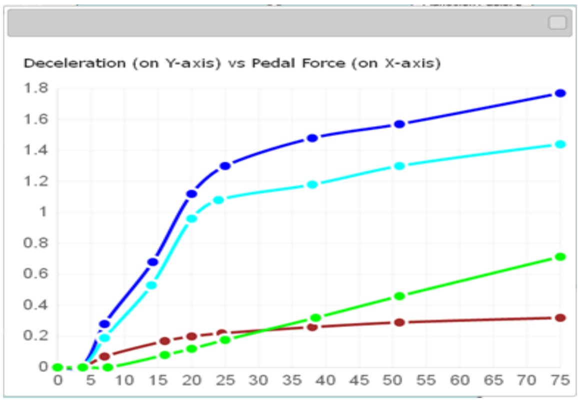
Graph 1 Laden Graphs

2. Unladen Graphs





(A) Fluid Line Pressure **(B) Adehsion Factor**



(C) Deceleration

Graph 2 Unladen Graphs

Unladen Graphs are shown in fig. Results obtained during the analysis are shown in the form of curves. Final Line Pressure, Adhesion Factor, Deceleration. Final Line Pressure, Adhesion Factor, Deceleration are shown with vacuum and without vacuum. Range of Pedal Force is from 0-75 and that of Final Line Pressure is 0-80. In case of Adhesion Factor graph, Adhesion Factor range is 0-450 and that for Deceleration its range is 0-2. In case of Deceleration graph, Deceleration range is 0-2 and Pedal Force range is 0-75.

V. CONCLUSION

From given vehicle data, it has been concluded that output is verified and overall performance of the vehicle passes. Hydraulic Brake Design System application that can be used by Design Engineer for fine tuning of design parameters & validate them.This Application has been developed in order to ensure modularity, flexibility for any vehicle configuration.

ACKNOWLEDGEMENTS

The authors wish to thanks Prof R.M.Tayde for providing sufficient input data to develop Hydraulic Brake Design System Application.

REFERENCES

[1] Savio Pereira, OmkarVaishampayan, Akshay Joshi., “ A Review on Design of Hydraulic Disc Brakes and Calculations”, PVG’s COET, Pune 411009, Volume 3, Issue 2, February 2014

(IJRST) 2015, Vol. No. 5, Issue No. III, Jul-Sep e-**ISSN: 2249-0604; p-ISSN:2454-180X**

[2] Giorgio Colombo, Ambrogio Girotti, Edoardo Rovida, "Automatic Design of a Press Brake for Sheet Metal Bending ICED: 2005, PP 15–18.

[3] Limpert Rudolf, "Brake Design and Safety, society of automotive engineers, Warrandale, Inc, Second Edition, USA, 1992, PP 11- 157,.

[4] S. Sarip, "Design Development of Lightweight Disc Brake of Regenerative Braking and Finite Element Analysis", International Journal of Applied Physics and Mathematics, Vol. 3, 2013, PP 52 – 58.

[5] P.M.Khans, V.G.Halbe, K.Rajkumar, K.N.Manjunath, Borulkar, K.C.Vora, Mahendra Mohan Rajgopal, "Development and Evaluation of Exact Brake Systems for Light commercial Vehicles", SAE Technical Paper 2005-26-063, 2005.