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A Review on Design and Modification of Tractor Braking System

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ABSTRACT

The present Agriculture tractor industry is growing very fast and facing more competition in market due to globalization of market. So Industry requires more durable and robust designed components. Brake system plays a major and significant role in commercial and agriculture vehicles. Fundamentally, brake system is compliances to the automobile. The function of the brake is to de-accelerate or stop the vehicle whenever required. So every component of brake system should be reliable and durable, and should stands against any critical failure. Conventionally Agriculture tractors have two types of brake system, Mechanical Brake, Hydraulic Brake. Objective of this study is to design and improve of braking system of tractors and uniformity of both brakes. This research study provides the fruitful direction to researchers and manufacturer to design and modify brake system without extra burden. This Review paper concluded that brake system can be improved without much dismantling and small change in design.

Keywords: - Brakes, Tractor, Mechanical Braking System, Hydraulic Braking System, Disc, Air Brake

1. Introduction

Now a days, Market demands very high quality, reliable, robust product. Tough international competition generated a less survival for average products. To survive in market is to make products reliable and cost effective. Therefore tractor manufacturers & commercial vehicle industries are updating their products as very reliable and for more financial benefits, they are producing cost effective products. Agriculture tractor industry is also growing day by day, and they are trying to full fill Farmer need. Besides this, Safety is a first concern about the tractor. And brake system is a completely related the safety of driver and others on road. If there is a tractor or vehicle, a braking system also exists. Nobody can imagine a tractor without braking system. Brake required stopping the tractor or de-accelerating the tractor. For braking application a force is required to counter the tractor kinetic energy. This energy is generated by different source. In hydraulic brake system, braking force is applied by hydraulic fluid, this transfer the force generated by foot on brake pedal. In heavy vehicles assistant system is also required, like vacuum assisted hydraulic brake system. In air brake system, braking force is generated by compressed air. And Cambers are used to convert this pressure into mechanical force. Chamber is simple composition of diaphragm and piston rod.

In hydraulic brake system, pedal force is converted into high pressure to brake the tractor. In this type of braking system pedal forces play an important role. But human can apply average 600Newton force. So assistance from other support system is required to generate desired braking force.

2. Brake System

World's first production tractor is the John-Deere (1924) designed by Karl Benz a German engine designer and automobile engineer (as shown in fig 1.). This tractor was equipped with Petrol Powered four stroke piston engines. This was four wheel tractors with front mounted engine.

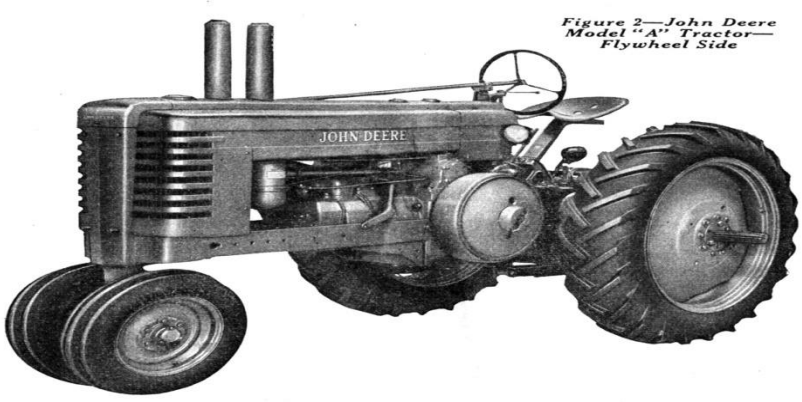

Fig.1:- John Dear Tractor

This tractor was equipped with manual leather shoe brake on rear wheels. A lever was right side of driver seat, when driver pulled the lever, a friction force was created by a shoe pad against the tire and slowly the rear wheels started to stop and when the driver releases the lever the again the tractor starts to move and this braking system was not very successful and very slow braking process to stop the tractor.

This braking system was used to stop slow speed of tractor. Brakes can be of different types according to requirement like manual or powered. Braking system of a tractor has shown in the fig. 2. In starting age, tractors had very less weight and speed so these create very less moment of inertia, therefore the tractors required very less braking force to brake the tractor; first tractor was Ford Model T in 1913. This vehicle was equipped with manual type Braking System, in manual type braking, mechanical power (manual force by leg or hand) is used to stop the vehicle. This vehicle was equipped with service brake as well as park brake also.

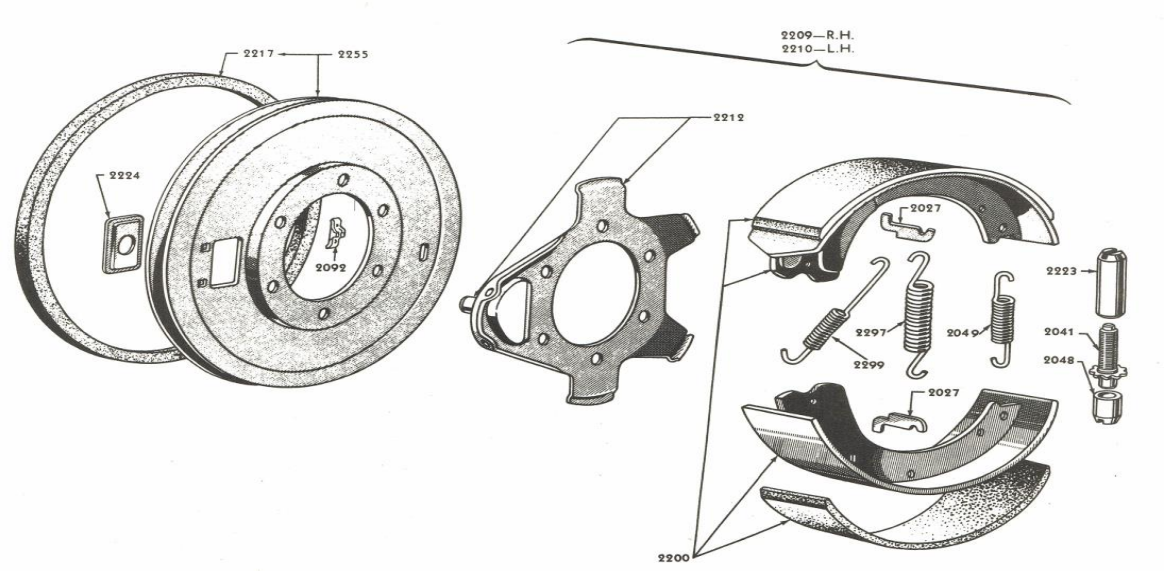

Fig. 2. : - Braking system of Tractor

3. Braking Assembly

In commercial vehicle, Mainly Hydraulic and Air Brake systems are used. Hydraulic brake required an assisted boost to minimize the pedal force. Mainly we use vacuum to assist the boost to minimize pedal effort. Hydraulic Brake system is used only for less than 7000 kg GVW Vehicle. Air Brake system can be used for any type of commercial vehicles, but due to high weight of air brake system components we only use air brake system for more than 7000 kg GVW Vehicle. Fig. 3. Show mechanical braking system.

Fig 3. :-Brake assembly of Mechanical Brake System

4. Detailed Review

Cam disc and balls is evaluated in early years of mechanical brake system with the need of system that can fixed the Actuator Fork cum tie rod with the rear axle casing for proper Braking. Different types of design are already patented; some have different sizes of brake housing and liners. Over many years a lot of technical researches are done on its design and optimization. In mostly optimization works, FEA is done with help of CAE tools. We also studied other automobile component`s FEA to understand and finalize our research methodology. We studied technical papers related to brake disc layout research to understand the application of it to minimize the scrap and maximize the cost. Some of them are related to our work so we selected those and studied thoroughly. Some technical papers also published related to Brake disc design.

An algorithm used to optimize the braking mechanism was presented. This algorithm used for the uniformity of both the left and right hand side brakes. This overcame the restrictions of time consuming. These were quick and provide the economical layout and blank orientation. Minkowski sum algorithm is used to optimize the orientation of blank. This algorithm is comfortable with CAD tool. Further it can be inbuilt in CAD tool. This research is cost-cutting and martial scrap minimization principle. [1] A mathematical approach of need of relay valve in hydraulic brake system is analyzed. This system did not so much successful because of stopping of rear wheels in case of tractor braking, because in case of tractors the front wheels are not managed by braking mechanism. [2] Load analysis on brake disc and balls, and measured pressure on brake drum. Researchers conceptualized and optimized the cam diameter using Altair Hyper works- Optistruct. Optistruct is an important tool to optimize design for minimizes weight and high strength components. Topology optimization is mathematical technique that gives an optimized design and stress plots for a component as per given space. Researchers started their work with study of current product design and then they decide the constraints of Design Space. That space is supposed to optimize considered as design space and both brake lever and actuator fork cum tie rod. They applied load conditions, constraints and assembly fixtures CAD and then they put max load as per load condition on that arrangement. Optistruct gave space geometry of component that shows Stress directions and concentration area. Researchers used this data to make 3D of modified/ concept design.

Among steel, aluminum and composite, composite material brake pedal analyzed as preferable in terms of material weight. In this research, low weight materials aluminum and polymer composite are compared with conventional steel for weight reduction of brake pedal and different cross section also studied. Cad tool CATIA is used to design 3D of components and ANSIS is used to analyze different cross section under different load conditions. [3] The Dynamic analysis of mechanical/ Air brake system is done by help of M-Works based on Modelica language. Air brake system is a complicated system so this is not easy to do dynamic analysis with actual components. M-Works has a flexibility to represent actual air brake components with predefined basic standard pneumatic components. Pedal force or plunger force is taken as input signal and brake chamber`s air pressure as output signal. Graph between plunger force and generated pressure is plotted as per results from analysis. Researchers found that Brake chamber`s pressure is consistent with plunger force Under this research, dynamic model of mechanical brake system of tractor trailer is studied. For the study or simplification of research, pneumatic components were replaced with basic predefined component for mathematical model. This analysis showed the dynamic characteristics of air brake system and we also analyzed time delay in front and rear brake system which can help to improve the mechanical brake system performance.[4]A flatten dimensions are used as input to system. Then 2D Drawing was transferred into AutoCAD and customized the blank layout. This research showed that this is not time consuming process and require no extra effort. This system was integrated with AutoCAD and it gave sufficient result but not satisfactory. [5] Disc brake is assembled with an actuator fork. This assembly is a part of brake housing. This invention seems a very helpful in to reduce tractor weight and simplifies assembly processor. This invention is suitable for low GVW tractors. This is not suitable for high duty agriculture tractor because of high braking force. And the brake assembly cannot stand with high load. [6] Material is also studied for suitability. This research is totally practical based. Requirement of engine mountings are also analyzed practically, and its impacts also considered. Engine should be mounted on the torque axis. This opposes the tractor to rotate in torque direction. Distance from the planes for the rear and front engine mountings to centre of gravity should follow the requirement of centre of percussion. This will allow that the elastic centers shall be come over the torque axis. [7] Stress analysis, displacement analysis and model analysis of disc of disc brake. Disc of mechanical/Air brake system of Larsen & Toubro tractor is 3D CAD made with the help of ProE (Creo) and it is FEA analyzed with the help of ANSYS. Disc material is also finalized. Researcher studied High Carbon steel, grey cast iron and manganese steel for suitable material. Stress analysis, Displacement analysis and model analysis are completed for the all the material. And Grey cast iron is finalized suitable material for Disc. [8] A tractor brake disc assembly this is most used type. A according to this patent, brake disc with liner struck with housing when applied brake pedal for both sides. This design is feasible with conventional tractor braking system.. A pivot is provided for actuator fork cum tie-rod. [09] Experiment method was used to validation of brake disc. They did analysis on physical model, they setup some fixture of testing rigs to analysis the assembly for the Fatigue Testing, Researcher setup a rig testing fixture. High vibration in tractor may cause failure of brake.[10] Finite element analysis of tractor brake pedal by Hyper work solver optistuct`s topology, 3D CAD is made in Solid Work. Existing and updated design are FEA analyzed and compared. Theoretical analysis also done for the pedal. This research analyzed the best suitable material under specified load and boundary conditions. Analytical and practical both studies done on the brake pedal. And their results also analyzed and compared. But uniformity of both the brakes did not achieve. [11]

5. Conclusion and prospects

In this review study, it is concluded that the material in braking system should be proper distributed with stress concentration areas. For the proper design of component, this has been recommended that Factor of safety should be more than 1. This gives a buffer stress zone to design; it will strengthen design in worst load conditions. Brake disc brake and balls will stand under 5600 Newton without static Failure. In Mechanical/Air Brake System, brake disc function is critical to proper braking force generation, if brake cam disc deflects more than a designed limit, that can be affect the braking force. So displacement of brake assembly should be minimum. Economy percentage of bar Layout is not recommended below 60%. Below this range, any design cannot be economical. But Economy percentage of bar Layout should be maximum for economical design.

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