Analysis of hydraulically driven fire fighting water monitor trailer

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Abstract
When a place catches fire it is well observed fact that a large amount of time is wasted by the fire man to extinguish fire due to huge distance present between the place of the fire and the water hose or water monitor. Because of which large amount of water is wasted due to evaporation of water loss during jet impact. It is impossible to take water monitor close to fire because of high temperature. Hence, an effective fire fighting cannot be done there as it requires delivery of water at right time, right place and in adequate quantity. To reduce the distance present in between water and place of the fire a new method of fire fighting by the use of hydraulically driven vehicle is developed by author. The vehicle uses the pressurized water from the pump to move forward taking into account the property of straitening, elongation and buckling of hose. When the water is pumped, then pushing force developed due to straitening property of the fire hose is used to move the vehicle. This paper presents the study of behavior of the steel subjected to fire and effect of fire on the mechanical properties of the trailer. The response of the trailer which includes stress distribution and displacements under various loading conditions are to be observed. The method used in the numerical analysis is finite element technique using Ansys software. The result shows that the stresses developed lie within the range and ensure infinite life. Ways of fire protection of steel are also suggested to increase the time spend inside the fire without affecting the properties of the steel.

Keywords: hydraulically driven vehicle; straitening; elongation; buckling

Introduction
Firefighting is an act of extinguishing destructive fire. For extinguishing fire quickly or more effectively it is required to deliver extinguishing material at right place, right time and in adequate quantity. For small size fire this is possible because water monitor can be taken closer to the fire but if the size of the fire is large water monitor cannot be brought nearer to the fire due to human limitations. Also a huge amount of extinguishing material gets wasted or evaporated. Hence a large amount of time is required for fire fighting. When water is pumped from long distance, then stream of water gets spread in air. As a result of spreading, water stream gets converted in to small particles. Some of these particles get evaporated before stream actually reaches to the fire. This evaporation reduces water that is used for fire extinguishing at the same time increases energy required, time and also water requirement.

Manual driven firefighting trailers cannot enter the heat zone due to human limitation. In such cases remote controlled vehicles are required for the purpose of fire extinguishing. Electric motors, batteries etc. cannot be used in desired field because of chances of explosion or melting of other circuitry. To deal with such problems, a hydraulically driven vehicle is developed by Author. The vehicle can reach nearer to the place of fire and use the available water
economically. The vehicle uses the properties of straightening, elongation and buckling of hose for generating driving force. As the flow of water is continuous within the hose, hence it can easily bear a high range of temperature.

The trailer uses the hydraulic energy available to move forward. Water and water pumps are easily available with fire tenders, hence there is no problem of driving the vehicle. The vehicle does not consume any water therefore wastage of water does not take place. Also the same water can be used for fire extinguishing purpose. The vehicle is a useful aid in preventing the life of fireman as well as it increases the efficiency of fire fighting.

**Review of Literature**

This chapter presents the theoretical frame of references used in achieving the objective of the dissertation. The theories developed by different researchers for the analysis of the various mechanical elements and mechanical systems are used as reference for the analysis of proposed design of Fire Fighting Trailer.

1. **RPS proposal of Design and development of hydraulically driven fire fighting trailer.**

The proposal presents a hydraulically driven firefighting trailer traveling on hydraulic energy. A new method is developed to eliminate the limitations or disadvantages of a conventional firefighting trailer. In conventional firefighting method, firefighter cannot go near to the fire due to temperature limitations. Due to this, the act of fire extinguishing is to be done from a distance which makes it incapable and inefficient of extinguishing fire. To eliminate this limitation, a new method of fire fighting by the use of hydraulically driven vehicle is developed by PRASHANT S. KADU under the guidance of Dr. H. T. THORAT. The vehicle uses the pressurized water from the pump to move the vehicle forward, taking into account the property of straitening, elongation and buckling of hose. When the water is pumped, then pushing force is developed which is used to move the vehicle. This particular dissertation is an analysis of the proposed design of trailer developed by PRASHANT S. KADU. Modeling of the trailer is performed with the help of modeling software Pro-E wildfire 4.0. Analysis has been carried out in analysis software Ansys Workbench 11.0.

2. **Fluid Mechanics and Hydraulic Machines, Publication, New Delhi, 1995-96, 568-571.**

The chapter of Flow through Pipe of this book consists of the study of turbulent flow of the fluids through pipes and close conduits. Various theories, assumptions are explained in the prescribed topic. The chapter studies various loss of energy in the pipe, loss of energy due to friction. Loss of energy due to sudden enlargement of pipe and sudden contraction in the pipe is studied in this book.

The concept of sudden contraction in the pipe is referred from the book. It is applied for the calculation of the forces acting on the trailer. When pump is switched on the water starts flowing through fire hose pipe. Then the hose pipe is suddenly gets contracted in between rollers of the trailer. Due to this sudden contraction in the pipe, a pressure wave of high intensity is developed just before the roller. This increase in pressure exerts force on the trailer to drive the trailer forward.

3. **Palm beach county fire rescue: Driver operator manual, Chapter 3**

This manual gives the information of how to produce effective water stream by using knowledge of hydraulics. The manual will help to provide knowledge of developing a system for
effective water streams and an understanding of fire system stream management. An adequate supply of water delivered properly is essential for successful extinguishment. The friction losses in hose pipe calculations are given in the manual. The nozzle reaction calculations at various pressures and at various flow rates are done in the paper. The concept of relay pumping is also explained in the manual.

The calculation of the nozzle reaction is calculated by referring the procedure from the manual. The effect of nozzle reaction results in toppling of the trailer. Hence the nozzle reaction is necessary in the stability analysis of the trailer.

4. European guideline: Guideline No. 7:2005 “Safety distances between waste containers and building”.

This literature explains the safety distance between volume of fire and wall of building. The safety distances are estimated by using three different volume of fire. It gives the different methods of preventing the spread of fire from structures in a yard into a building. The calculations regarding height and temperature of the fire plume is also given in this literature. The relation between the height and temperature is referred to estimate the temperature at given point.

5. Oral Buyukozturk and Franz-Josef Ulm, Materials and Structures

This paper studies the likely failure mechanisms that may have ultimately led to the collapse of World - Trade Center towers, on September 11, 2001. This analysis is based on material to structures approach, in which both the characteristic behavior of the structural material and design details are studied. It has detail study of effect of fire on the property of the steel. The study of intensity of fire depending on material is explained. The paper observes the performance of structural steel under high temperature.

The analysis of trailer under various ambient temperatures requires the necessity of study of change in property of structural steel at various temperatures. The analysis refers the principles given in the paper.

6. S. R. Satish Kumar and A. R. Santha Kumar, Design of steel structures, Indian Institute of Technology, Madras

This book has details of steel structure subjected to fire. The rate of heating of structural steel is explained in detail. The study of change of mechanical properties of steel at elevated temperature is given in the book. The protection of steel from fire and ways of fire protection is also explained. The methods of protection of the trailer from the fire are referred from this book. The protection of trailer from fire is necessary to increase the time that trailer can spend inside the fire before the thermal damage to the material of the trailer. More the time spend by the trailer inside the fire, more the volume of fire extinguish.


This paper describes the juice extraction unit, various components of juice extraction unit. Power requirement calculations, designing of various components of juice extraction unit are explained. Paper also analyses the performance assessment of machine under various samples of sugarcane. The power or force required to pull the hose pipe reeled on the wheel of the trailer is calculated in the dissertation. The various
considerations for calculating the force is referred from the paper. The calculation is done by taking the reference from this paper.


This paper presents the static analysis using numerical analysis of truck chassis of commercial vehicle. The method used in numerical analysis is finite element technique. The tool used for finite element analysis is Ansys software. The result of analysis observes the response of the truck chassis which includes the stress distribution and displacement under various loading condition. Some modifications are also suggested to reduce the vibration and to improve the strength of the truck chassis.

The paper helps in selecting the factors which are to be considered (for example selecting element size) for static analysis of the trailer. The interpretation of the Ansys result is well explained in the paper.


This paper shows the need of weariness investigation of part. It gives the insights with respect to the accessibility of business exhaustion apparatus. It likewise gives trouble of taking care of the weakness device. It clarifies the weariness investigation in Ansys workbench 11.0 Fatigue examination is clarified by taking a contextual investigation of uniting bar.

The weakness examination of the trailer did by utilizing completely turned around stacking condition. The exhaustion examination has been completed utilizing programming Ansys workbench 11.0. The exhaustion investigation of trailer is finished by taking the reference from the paper.


This book depicts that mechanics possesses a special position in the physical sciences in light of the fact that it frames premise of such a large number of fields of study. In its broadest sense, mechanics may be characterized as the science which depicts and predicts the state of rest or movement of bodies under the activity of strengths. In a smaller sense, mechanics may be isolated into zones which, with some cover are of discrete enthusiasm to physicists' and to designs.

Advancement of power outline by considering the different strengths taking so as to follow up on the trailer is finished the references from the book. Ordinary response between the wheel of the trailer and ground are computed by taking the references from the book. The impact of spout response on the steadiness of the trailer is ascertained by taking the references from the book.


A writing audit has been led to accumulate data identified with the extinguishment of real tank fires and applicable vast scale flame stifling tests. The point was to hunt down information that could be utilized for approval of froth spread models. Altogether, 480 tank fire episodes have been recognized worldwide since the 1950s and the data gathered has been incorporated into a database. A rundown of the episodes with some
information is given in this report. Out of the 480 flame occurrences, just around 30 flames have given important data to model approval. A more definite synopsis of the current information from these flames is likewise given in this report.

Discussion

The proposed design lacks a steering mechanism which makes it difficult to control the direction of motion of the trailer. A steering mechanism can be developed which can steer the trailer to desired location. A control system needs to be developed for the nozzle which will help to cover a larger fire affected area. If temperature sensors are provided, one can easily monitor the temperature of the trailer. This will help to avoid thermal damage of the trailer.

Conclusion

The objective of this paper was to survey and determine various forces acting on the proposed design of trailer. Static analysis is to be done of the trailer under loading conditions and at the different ambient temperatures. Determination of effect of back pressure on the stability of the trailer is to be analyzed. Also to propose methods of protection of trailer material from fire.

The forces were determined using the concept of increase in pressure due to sudden contraction in hose pipe. The static analysis of the trailer was carried out considering various hydraulic forces acting on the trailer at different temperatures. The analysis shows that the stresses and deformation developed in the trailer are within the allowable limit.

REFERENCES / LITERATURE CITED


[12] Prof. S. R. Satish Kumar and Prof. A. R. Santha Kumar, Indian Institute of Technology Madras, Design of Steel Structures.