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Modification of Hydraulic System of Tractor for Removal of Magnetic Particles from Hydraulic Oil

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Abstract:- In a tractor hydraulic/transmission oil contamination is a serious problem as it works in such environment, these contamination may be in different forms dust particles, water, oxidation & corrosion products ,wear metal particles. Metal wear particles plays a significant role in failure of hydraulic system such as jamming of control valve, worn out of sealing element etc. Removal of these metal wear particles is a serious problem. In present work modification in design of hydraulic system of tractor is proposed for removal of magnetic particles with the help of magnetic filter. In this work magnetic filter with centrally placed magnets (Ceramic oxide)of flux density 0.35T in the form of circular discs surrounded by a wire mesh filter cartridge mesh size (160µm) is used in suction side of hydraulic system of tractor.

Keywords: Magnetic filter, viscous fluid, Hydraulic system, Tractor, Magnetic wears particles.

I. INTRODUCTION

India is an agriculture dependent country & tractor is an important appliance used for agriculture. Efficient & proper working of its every system is important for agriculture; hydraulic system of tractor is an important system of tractor for agricultural work.In tractors generally differential gear box housing is used for hydraulic oil reservoir. Transmission oil is used as hydraulic fluid in tractors such as in powertrac, farmtrac, ford, sonalika as shown in fig. 1. As the oil used for hydraulic system helps in transmission system with gears, bearings & other components degrade due to produce worn out particles from these components in continuous and varied operating conditions. For efficient running of hydraulic & transmission system of tractor with minimum failures, it is important to remove these worn out particles from hydraulic/transmission oil. When a system is new it works efficiently with less failures, but after a period of time wear of components starts and wear particles mixes in to hydraulic/transmission oil & system efficiency reduces with large number of failures due to clogging of filters In hydraulic/transmission oil contaminants may be in different forms such as wear particles, dust, water, corrosion products etc. A magnetic filter consists of magnet with filter cartridge & this magnet may be in different form such as sphere, rod, wire, disc, plates etc. In present magnetic filters are used in different application, these magnetic filters may be of different types such as drain plug, collection plates, rod magnet, spin on wire wraps [1,2]. In this work a magnetic filter with permanent magnetic disc placed centrally surrounded by a wire mesh filter cartridge is used. Until now magnetic filters are used for removal of magnetic particle in different industrial applications such as in water cleaning, coolant cleaning in manufacturing industries, power plant oil filtration [3, 5,6-9,10]. A magnetic filter is used with wire mesh cartridge is more resistant to wear particles compare to classically used filter & it can work at high temperatures & with high viscous oil. Filtration rate in a magnetic filter is 3 to 10 times faster than a classical filtration technique [11]. In tractor oil used in transmission/hydraulic system is highly viscous, filtration of micro wear particles from this oil is difficult with small mesh size cartridge & it will lead to high pressure drop which leads to system failure. Removal of these small micro metal wear particles can be done with the help of magnetic filter of large mesh size cartridge with magnets, this involve negligible pressure drop [12] & allows any dissolved additives in lubricating oil to pass unhindered. The objective of this work is modification of present hydraulic system to remove the micro metal wear particles from hydraulic oil.

II. METHODOLOGY

A. General hydraulic system of tractor

In a general hydraulic system (as shown in fig. 2) of tractor the different components are reservoir, pump, control system (distributor), piston cylinder assembly, filters (suction filter, pressure filter, return filter), valve (control valve, relief valve), pipes. In this hydraulic system contaminated fluid is passed through the suction, pressure, & return filters, some contaminants are removed by these filters but the metal wear particles are micro size solids, cannot retain by these filters &flow with hydraulic oil to the hydraulic components (pump, control valve, piston cylinder assembly), these wear particles causes failure of these components & finally to the subsequently system failure.

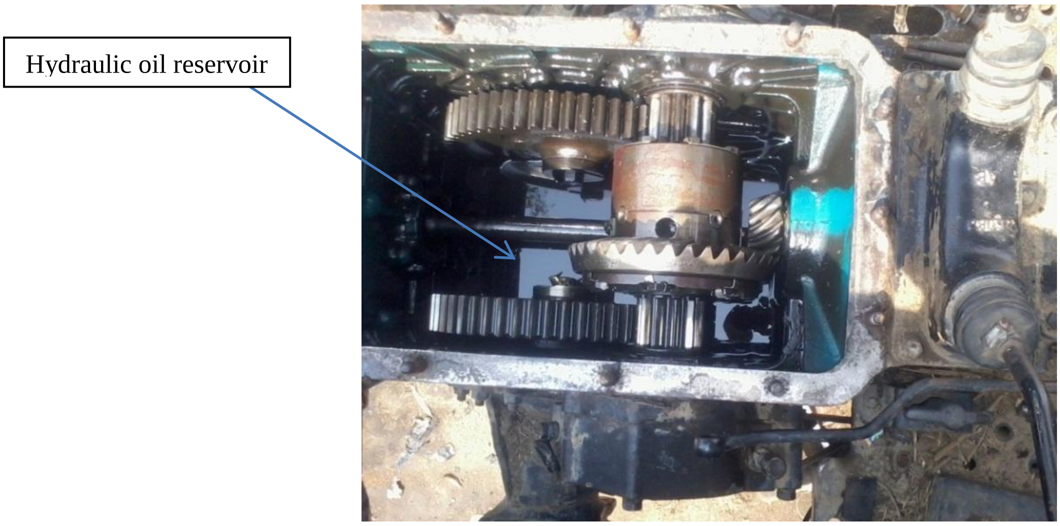

Fig.1. Hydraulic oil reservoir for tractor

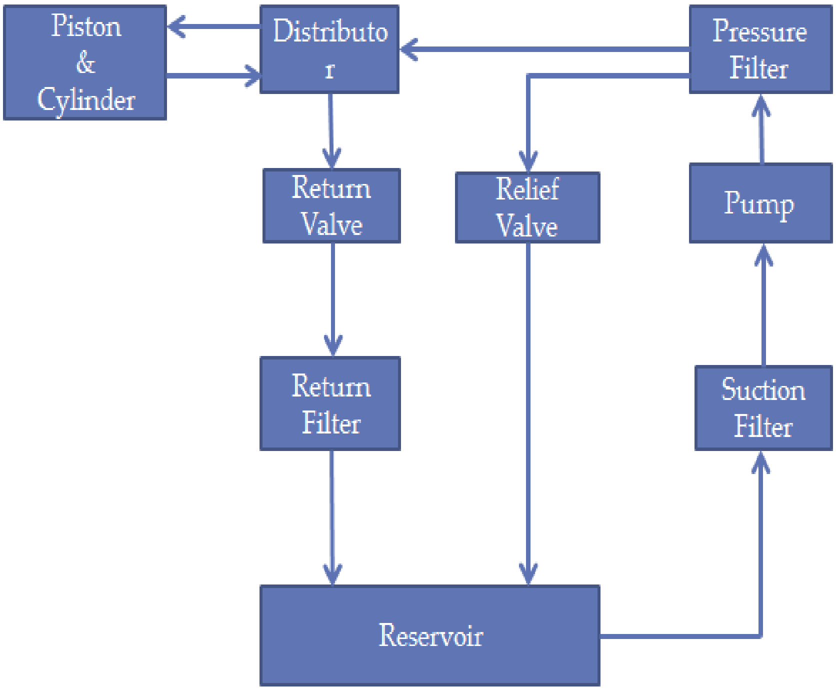

Fig.2. Block diagram for a general hydraulic system of Tractor

B. Fault Tree Analysis (FTA)

A fault tree Analysis can be simply described as an analytical technique, whereby an undesired state of system is specified (usually a state that is critical from a safety standpoint), and the system is then analysed in the context of its environment and operation to find all credible ways in which the undesired event can occur. The fault tree itself is a graphical model of the various parallel and sequential combinations of faults that will result in the occurrence of predefined undesired event. The faults can be events that are associated with component hardware failures, human errors, or any other pertinent events which can lead to undesired event. A fault tree thus depicts the logical interrelationships of basic events that lead to the undesired event- which is the top event of fault tree.

For study the failure of components of hydraulic system & to find the root cause of failure of different components fault tree analysis is done. A fault tree diagram is shown in fig.3 for failure of pump of a general hydraulic system of tractor.

From the fault tree diagram for failure of pump of hydraulic system it is found that failure of pump occurs by different causes, most of these causes are generated by contaminated fluid.to eliminate the contaminants from fluid.

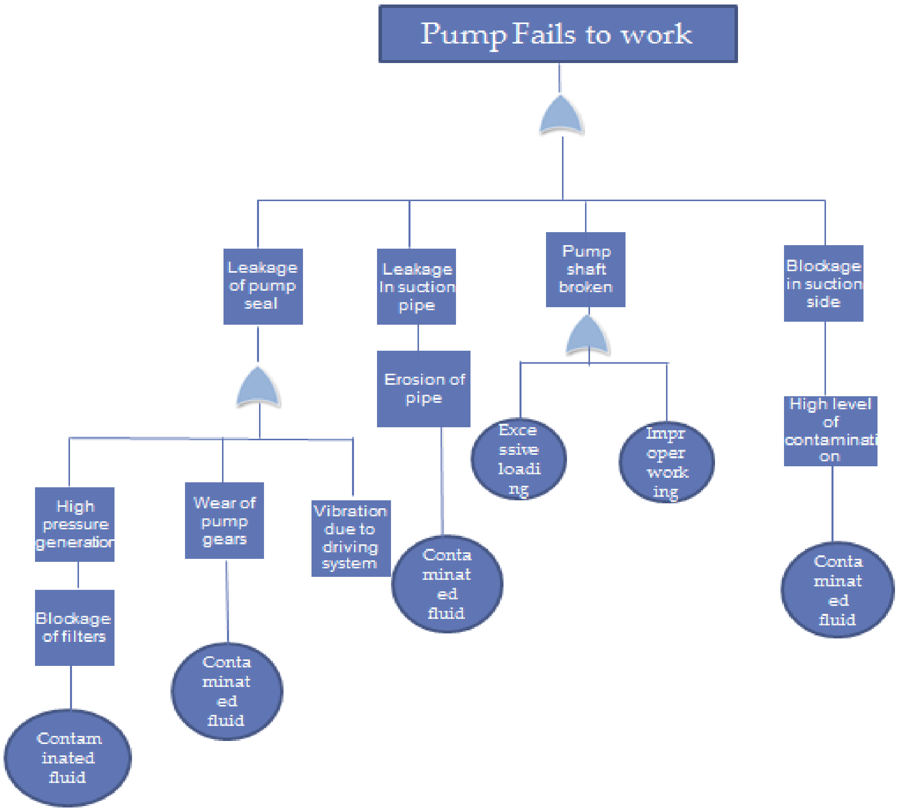

Fig. 3.Fault Tree Diagram for failure of pump of hydraulic system of tractor

C.Magnetic filtration

Magnetic filtration is a process to separate the magnetic particles from fluid with the help of magnetic field & it is based on magnetic phenomenon & magnetic properties of fluid.In magnetic filtration with a High Gradient Magnetic Filtration (HGMS) the matrix could be made in three flow(as shown ii fig. 4) these are-capture variant: transversal configuration (A) for which the flow of fluid, magnetic field & wires of cartridge are reciprocally perpendicular; Longitudinal configuration (B) for which the flow of fluid & magnetic field are parallel to each other & perpendicular to wires; axial configuration (C) for which the flow of fluid and the cartridge wires are parallel and magnetic field is perpendicular [13].

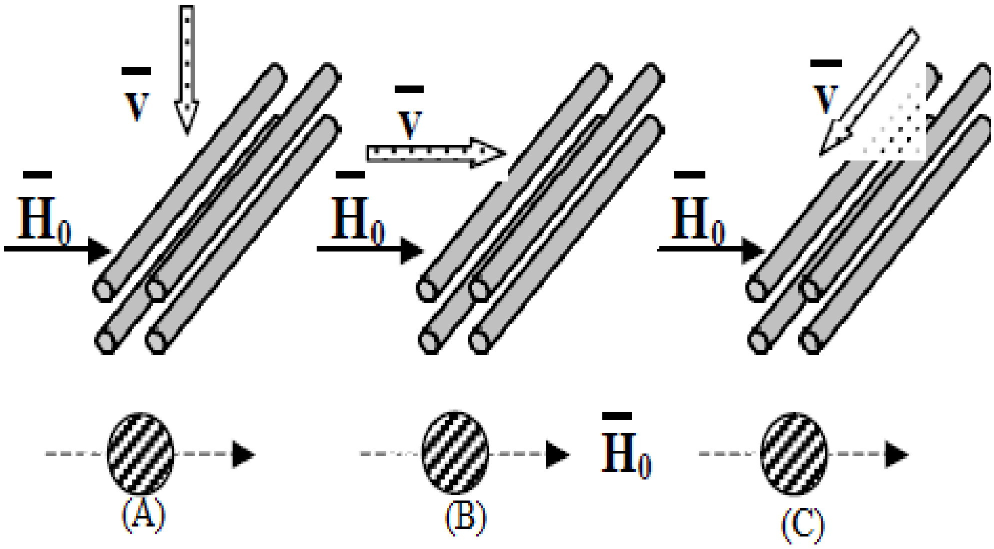

Fig. 4: Flow – capture configurations for HGMS ordered matrices: transversal (A), longitudinal (B) and axial (C).

D. Working of magnetic filter

A magnetic field is generated with the help of ferromagnetic materials placed at a particular distance and magnetic gradient is generated. Separation of magnetic particles from the fluid is most effective when there is a strong magnetic gradient (rate of change of field strength with distance) from low to high. In other words, the higher the magnetic gradient, the stronger the attracting magnetic force acting on particles drawing them toward the loading zones as shown in fig.5 [1]. The strength of the magnetic gradient is determined by flux density, spacing and alignment of the magnets.

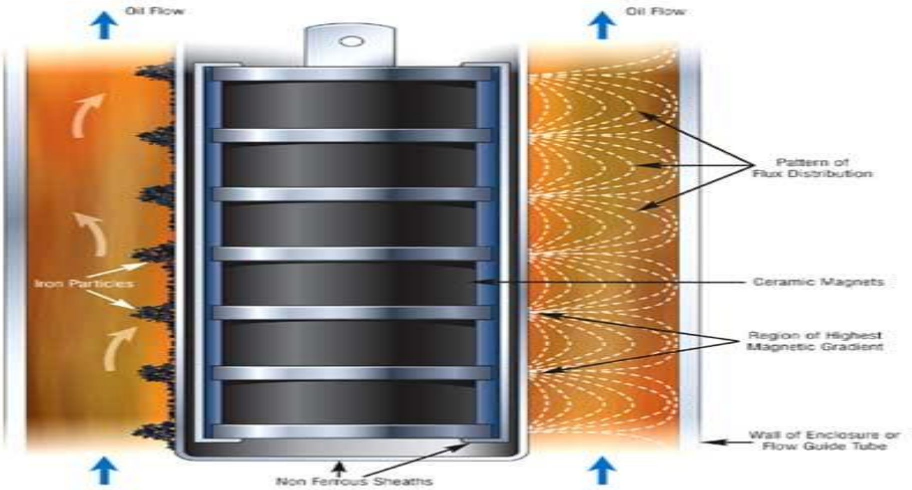

Fig.5. Magnetic filter showing pattern of flux distribution and the collected dirt

E. Performance of magnetic filter

The Performance of a magnetic filter for cleaning a contaminated fluid is given by following equation [4,10];

$$\psi = \lambda[1 - \exp(- \zeta)]$$

Whereψ is performance of filter (or filtration efficiency; difference between inlet and outlet concentration divided by inlet concentration) λ is the fraction having ferromagneticproperties in the mixture and f is thelogarithmic filter efficiency coefficient, which is dependenton geometric, magnetic, hydrodynamic and rheologicalparameters of the filtration system.

Factors affecting the performance of magnetic filter are; number of filtration cycles, filtration velocity, viscosity of fluid, size of magnetic particles, magnetic field intensity, pressure of fluid in system, temperature of fluid, mesh size of cartridge. At the time of selection of filter for a hydraulic system consideration of these parameters is important.

To remove these contaminants (mainly magnetic particles) modification in tractor hydraulic system is proposed& a block diagram for modified hydraulic system for tractor is shown in fig.6.

In the proposed hydraulic system a magnetic filter is fixed in suction line of hydraulic system before suction filter, this filter remove the wear out particles from fluid and reduces the wear of components of system such as pump, valves, pipe lines.

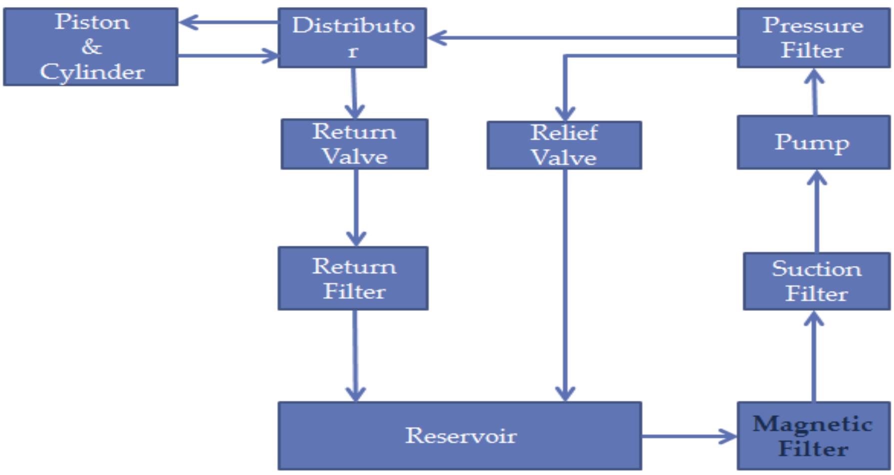

Fig.6. Block diagram for modified hydraulic system of tractor

III. CONCLUSIONS

Magnetic filter can play a significant role in removing worn out particles which is an outcome of progressive wear of system & its components. This proposed modification can effectively reduce the frequency of unexpected breakdown, more over economically significant amount of money can be saved on account of frequent oil change & component replacement. Therefore proposed methodology by way of FTA for given system (as for hydraulic pump of tractor) can save bulk huge amount of money & thereby productivity losses, in agricultural driven economy.

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