A Review of some useful Techniques to improve Efficiency of a Farm Tractor

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Abstract **- After reviewing several research papers of various authors that were wrote to increase the efficiency of a farm tractor, we have prepared this review article in which we will discuss, what are the various factors on which the efficiency of farm tractor depends and we will also discuss about the various techniques to increase the efficiency of a farm tractor for tillage equipments specially for cultivator. The major factors on which the farm tractor efficiency depends are - shift up and throttle back, Tillage depth, Travel speed, Tyre inflation, Mechanical front wheel drive. The above explained factors effectively influence the tractor's energy efficiency and fuel savings. In this review article we will deeply study and analyse the factors which affects the efficiency of farm tractor for field cultivation operation. This study will help us and also other researchers to evaluate the impacts of various techniques on tractor's fuel efficiency. After this study we can also select any one technique in order to check whether that particular technique is practically improving the tractors efficiency or not. After analysing all the techniques we can also develop a new technique to improve the tractor's fuel efficiency.**

Index Terms **- farm tractor, field cultivation, efficiency, techniques.**

INTRODUCTION

The cost on diesel fuel is one of the largest cost that the farmers have to be spend in agriculture, various tractor operation require large amount of diesel fuel. So if by using some techniques the consumption of diesel may be decreased than it will be very beneficial for farmers from the economic point of view and if consumption of diesel will decrease then pollution from harmful emission from engine will also decrease, it will also be good for the environment.

The speed at which tractor engines are operated, travel speed of tractor in the field, the load which tractor pull and gear ratio all have a major influence on the fuel efficiency of the farm tractor. Running equipment at correct speed and loads can save significantly on fuel costs. There are several techniques which can be applied to improve efficiency of farm tractors, but which technique will improve the efficiency of farm tractor will depend on the operation and the implement which is attached to tractor. There may be chances that some techniques improve he efficiency of tractor for any particular field operation may also decrease the efficiency of tractor while performing some other field operation. So, it requires a detailed study and analysis to decide that which technique should be applied on which field operation. So in this review article we are analysing various techniques to improve the tractors fuel efficiency.

After analysing various research articles, we are now discussing some techniques to improve the farm tractor efficiency.

SHIFT UP, THROTTLE BACK

Robert Gresso, Robert Pitman [1]: Shift up, Throttle back means shifting up to a higher gear and reducing the engine speed. This is a fuel saving technique which is applicable for light drawbar loads, to get maximum efficiency from a Farm Tractor, its engine should be operated almost equal to its rated capacity but there are many field operations (such as Light Tillage, Cultivating by using less draft, Disc Harrow etc) which do not require the rated power or full power of tractor. Sometimes it also happens that the agricultural equipments which are designed for small horsepower tractors are used with higher horsepower tractor. For such type of lighter load operations considerable amount of fuel can be saved by shifting to a higher gear and reducing the engine speed. Normally Shift up throttle back can be used when loads require less than 65% of tractor's power. It is generally safe to reduce engine RPM by 20% to 30% of the rated RPM. Check

the operator's manual for specific recommendations for your tractor.

When using this technique of “Shift up and Throttle back" the most important things to be remember is that the tractors engine should not be overloaded because the overloading of an engine requires more fuel and it is more harmful for engine's life. Excessive black smoke is one indication of an overloaded diesel engine. To check the engine whether it is overloaded or not, work on the tractor for a short time at the desire speed and throttle setting. Then, rapidly open the throttle. If the engine readily picks up speed, it is not overloaded and the original throttle setting is suitable. If the engine does not respond quickly, shift down a gear or increase the engine speed again. Check for engine overload at the new setting.

The fuel saving practice of "Shift up throttle back" or "gear up and throttle back" involves reducing engine speed to 70% to 80% of rated engine speed and shifting to a faster gear to maintain the desired field speed and implement productivity. This practice is suitable for light drawbar loads (less than 65% of full power) when reduced PTO speed is not a problem. Remember, do not overload the engine.

Mark Hanna, Dana Peterson [2] : Tractor operators can take the advantage of this fuel economy technique by selecting an appropriate gear for the tractor operation in the field. Information from NEBRASKA/OECD (Organisation of Economic Cooperation and Development) tractor tests show potential for fuel savings at reduced drawbar loads. It should be kept in mind that the "Shift up throttle back" technique is not suitable when using power take off (PTO) powered implement such as rotavators or threshers. PTO shaft speed is directly related to engine speed because PTO implement requires a standard shaft speed input (1000 or 540 RPM), tractor engine speed can't be reduced. Instead, the engine speed is maintained at a level to produce standard PTO speed.

Larger horsepower tractors are frequently required to do drawbar work at only 50-75% load or less. Shifting to a higher gear and reducing engine speed for partial drawbar loads can save 10% to 20% of fuel depending on tractors and load conditions. Avoid overloading the engine when engine speed is reduced. This technique is not suitable for PTO work when PTO shaft speed must be maintained by engine speed.

BALLASTING TRACTORS FOR FUEL EFFICIENCY

Jay Harmon, Dana Peterson, Mark Hanna [3] : Proper ballasting plays an important role in transferring as much engine power as possible to the drawbar, but to accomplish this ballasting is not a easy task, it takes so much time and analysis to decide the correct ballasting. Too little weight or ballast results in excessive drive wheel slippage and an obvious waste of fuel. On the other hand, carrying too much ballast on a tractor dramatically lowers wheel slip but results in greater rolling resistance as the tractor sinks too far into the soil, causing wheels to be constantly climbing out of a deep rut.

Most efficient transfer of power from drive axles to the drawbar generally depends on wheel slippage which again dependent on surface of soil. On firm, untilled soil, wheel slip should be in a range of about 6% to 13% more slippage is allowed on a tilted surface, 8% to 16% with slightly more yet on a non cohesive sandy soil. Conversely optimal wheel slip is about 4% to 8% on concrete. Checking wheel slippage on tractors equipped to display this information provides an easy check to determine if the tractor is optimally applying fuel and horsepower to the drawbar.

TILLAGE DEPTH

Dana Schweitzer, Mark Hanna [4] : It is observed in most of the cases that consumption of fuel in tillage operations is directly related to tillage depth. Sometimes due to lack of knowledge, farmers operate their tillage implement at an inappropriate draft setting, which results in more fuel consumption. Tillage depth is not a generalized parameter, there are so many factors according to which tillage depth varies like, type of crop, type of soil, horsepower of tractor ...etc. So by considering all these factors we should select tillage depth in such a manner that it should not be too shallower, on the other hand it should not be too deep. Fuel savings with shallow tillage depth ranged from 7 % to 41%.

MECHANICAL FRONT WHEEL DRIVE OR4WD DRIVE

Mark Hanna, Dana Schweitzer [4], Kepner, Baine [6]: In mechanical front wheel drive tractors, front wheel

of tractor also provide traction. In four-wheel drive tractor all four wheel gets power from gear box which makes them suitable for various types of applications with power to all the four wheels. There is no doubt that four-wheel drive has better traction to the ground than the two-wheel drive tractor. So if we are considering a tractor to be versatile and perfect for a variety of applications, then four wheel drive tractors will be a better choice. A four-wheel drive tractor can be used for tillage, livestock operations, crop protection, haulage, loader applications ...etc. A four wheel drive tractor has better traction, more pulling power, more fuel efficiency, longer service intervals and more application versatility.

Since in mechanical front wheel drive all four wheels provides traction, so for tillage operations 4WD tractor will be more appropriate because there will be no slippage of tyres and quality of work will also be better,

TRAVEL SPEED

Mani, Indra and Panwar [8]: Travel speed is responsible for the time required to complete the job and hence it affects the productivity. Maximum times, the farmers try to complete work as soon as possible, so reducing field speed is not very appealing option. Although the tractor's travel speed affects energy use, in some cases impact on fuel consumption is only upto small extent, such as when reduced engine speed and a higher gear ratio is used for faster travel speed. Fuel intake can sometimes decrease with higher tillage speed if significant variations in drawbar load are balanced by operating the tractor engine at a more fuel saving combination of greater torque and lower engine speed.

Travel speed was compared 11 times during operations that included chisel ploughing, disking, field cultivation, and hauling corn. An increase in travel speed increases fuel consumption in 9 of 11 comparisons, although the effect was mixed in two. Fuel savings averaged 15% ranging up to 59%.

TYRE INFLATION

Mark Hanna, Dana Schweitzer [4], Ricketts, C.J. and Weber, J.A. [9]: Proper tyre inflation affects the ability of your tractor to transfer power to the soil. Tyres should be inflated to the appropriate pressure, considering the conditions such as roadway travel or severe field slopes. In over inflated tyre the contact of tyre lugs with soft soil reduces and wheel slippage may occur which will increase fuel consumption. Past research has frequently shown excess fuel consumption if tyres are over inflated.

For each tractor which is going to be tested the front and rear axle weight was measured. Correct inflation was determined by weight and tyre size used, according to the tyre manufacturer's website and tractor's operating manual. Allowance for extra inflation was made for over the road travel of mounted equipment which added weight to the rear axle or if steep side slope (as defined by the tyre manufacturer) were present. In each case correct tyre pressure was compared to an over inflated pressure. Consistently demonstrating fuel savings with this technique was difficult. Less fuel was used in 3 of the 5 comparison using correct inflation but fuel savings were just 1% to 2% in these cases. Two test with negative savings were conducted with single tractor at one farm location. These tests may have been affected by good traction conditions where soil contact by additional tyre lugs was not a factor in fuel consumption.

CONCLUSION

In this review article, we have read several research papers and analyze them. The techniques which we reviewed Shift up throttle back, tillage depth, mechanical front wheel drive, ballasting tractor for fuel efficiency, travel speed, tyre inflation. All these techniques were affecting the efficiency of farm tractor, but the fuel savings were different for all the techniques. In some techniques fuel saving was more and in some techniques, it was less as compared to other technique. And it is also a fact that all these techniques have their limitations, they only save fuel and maintain quality of work if we apply them by considering their limitations, such as shift up throttle back technique is very useful and it saves fuel up to considerable amount, but normally "shift up throttle back" can be used when loads require less than 65% of tractor's power or it provides good savings on fuel when tractor work on partial or lesser drawbar loads. So this is the limitation of "shift up throttle back" technique. Similarly, for all other techniques there are some limitations, but if we apply all the above techniques by considering the conditions of their

application then definitely, they will provide significant savings on the fuel.

So in nutshell we can conclude that all techniques which we have discussed in this review article are useful and they improve the efficiency of farm tractor, but the savings on fuel by them is different for all technique, but one thing we have to keep in mind that the savings on fuel with particular technique also depends on the various factors like the suitability of technique, horsepower of tractor, condition of soil, size of agricultural equipment and the agricultural operation. If we use these techniques by considering the above points, then definitely they will contribute to the savings of fuel and hence improve the efficiency of a farm tractor.

REFERENCES

[1] Gear up and throttle Back to save fuel farm energy November 17, 2015 (20151117) Gear up and Throttle Down - Saving Fuel. Grisso, R and Pitman, R. Virginia Co-operative Extension, 2009. Robert Gresso, Extension Engineer, Virginia Tech, Robert Pitman, Agriculture Engineer, Virginia Tech.

[2] Shift up and throttle back to save tractor fuel, (PM 2089 m, March 2011). Authors: Mark Hanna, extension ag engineer, Stuart Birrell, Professor, ag and biosystems engineering. Dana Petrogen, program coordinator, Farm Energy Dana Petersen, Program coordinator, Farm Energy Conservation and efficiency initiatives, Iowa State University.

[3] Farm Energy (Ballasting tractors for fuel efficiency) (PM 2089g July 2010).Authors:Mark Hanna, extension ag engineer; Jay Harmon, Professor, ag and biosystems engineering. Dana Petersen, Program Coordinator Farm Energy Conservation and Efficiency Initiative, Iowa State University extension.

[4] Farm Energy: Case studies (PM 3063 D October 2015).Authors:Mark Hanna, Extension agriculture engineer Dana Schweitzer, Program, Coordinator for the IU Farm Energy, Initiative at Iowa State University Extension and Outreach.

[5] Selecting engine and Travel speeds for optimal fuel efficiency. (Farm energy - March 23, 2012 (201220323). Authors: Robert Grisso Extension Engineer, Virginia tech Zane, R. Helsel Extension specialist in Agriculture Energy, Rutgers University

[6] Kepner, R.A. Baine, R and Bager, E.L. 2000 Principles of farm machinery, C.B.S. Publishers & Distributions, New Delhi, 26 p.

[7] Mani, Indra 1989 Pattern of tractor energy utilization in different agricultural operations, Division of Agricultural Engineering, IARI, New Delhi

[8] Mani, Indra and Panwar, J.B. 1990 Tractor-implement system performance at part loads. Paper presented in the international Agricultural Engineering Conference, 3-6, Dec. 1990, Bangkok, Thailand.

[9] Ricketts, C.J. and Weber, J.A. 1961 Tractor engine loading, Agricultural Engineering Today, 42: 236-239.

[10] Introduction to Energy Efficient tractor and field operations/pages/29604/ introduction to energy efficient tractor and field operation.

[11] Tractor and Field Operations Energy Efficiency checklist and tips.

[12] Tractor drivers who gear up and throttle back may save big backs (Montana State University 2006)

[13] The concept of tractor efficiency. The Cereal Knowledge Bank (CKB) 2009.

[14] Machine cost estimates by William F. Lazarus University of Minnesota.

[15] Using Tractor Test Data for Selecting Farm Tractors.