

## Study on the Performance of PTO Power of Different Tractor Models for Three Decades

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**ABSTRACT:** Improvement in Indian agricultural tractor performance over the three decades were analyzed using the data from 25 diesel tractors tested at the Central Farm Machinery Training and Testing tractor test laboratory from 1987 to 2017. The five most popular and well established tractor manufacturer's models of Indian origin were taken for the study. These tractor models selected on the basis of availability on Indian farms and their popularity among the farmers. These models of five manufacturers were coded as S, EI, T, M and ES for the study purpose. This study was based on the basis of test procedure of PTO power of general purpose agricultural tractors in the range of 30-35 hp. After the study, it was observed that the average maximum PTO power was increased by 9.28, 6.53, 15.83, 11.62 and 13.82 % for the models S, EI, T, M and ES, respectively, as compared with initial values.

**Keywords.** PTO power, Tractor, Tractor performance.

### INTRODUCTION

One of the major power source in Indian agriculture sector is a tractor. A tractor is an engineering vehicle specifically designed to deliver a high tractive effort (or torque) at slow speeds for the purposes of hauling trailers or machinery (Previati *et al.*, 2007). Most commonly, the term "tractor" is used to describe a farm vehicle that provides the power and the traction to mechanize agricultural tasks which includes tillage, sowing, threshing, harvesting with required corresponding torque or speed (Stoss *et al.*, 2013). Production of tractors in India was started by Eicher Good Earth Limited in 1961 (Singh and Doharey 1999), though the initial boost in the demand for tractors came after the advent of the Green Revolution in the late 1960's. The first tractor with fully indigenous technology, i.e., Swaraj tractor, was produced in 1974 by Punjab Tractors Limited, based on a model developed by the Central Mechanical Engineering Institute, Durgapur (Sarkar, 2009). Demand of tractors in the country was met through importation until 1961 when Eicher Tractors Ltd. and Tractors and Farm Equipment Ltd started manufacturing tractors with foreign collaborations. Meanwhile many other industries started manufacturing tractors such as Gujarat Tractors Ltd (1963), Escorts Ltd (1966), International Tractors (India) Ltd. (1966) and Hindustan Machine Tools Ltd (1977). Punjab Tractors

Ltd. started their production with indigenous technology in 1974 (Singh, 2004).

In the present study the performance of Indian tractor analysed for the period of 30 years, i.e., from 1987 to 2017. The PTO power were considered as criteria for the study of tractor performance. This study provides Indian tractor performance information which helps farmers, dealers to make good marketing decision, and manufactures to compare the performance of their products with models for product development. It also helps tractor buyers for selecting a suitable tractor as per their need.

### MATERIALS AND METHODS

#### A. Selection of tractor models

Different sizes of tractors are manufactured in India ranging from less than 25 hp to more than 55 hp but most popular range is 30-35 hp and this range accounting for over 45% of tractor industry volumes. The five most popular and well established tractor manufacturer's models of Indian origin were taken for the study. These tractor models selected on the basis of availability on Indian farms and their popularity among the farmers. For the study purpose these models of five manufacturers were coded as S, EI, T, M and ES for the study.

The commercial test reports of selected tractor models (General purpose agriculture tractor) in the range of 30-35 hp of Central Farm Machinery Training and Testing

Institute (CFMT&TI), Budni (Madhya Pradesh) were used for the study. Selected parameter, i.e. PTO power (kW) was analysed to observe the changes in tractor performance in three decades from 1987 to 2017. Each

model was selected randomly from a particular manufacturer (Table 1) and the report release year in bracket shows year of model.

**Table 1 : The different selected tractor models in three decades.**

Tractor manufacture	1987-1992	1993-1998	1999-2005	2006-2011	2012-2017
<b>S (Year)</b>	S1 (1991)	S2 (1994)	S3 (2003)	S4 (2011)	S5 (2016)
<b>EI (Year)</b>	EI1 (1989)	EI2 (1994)	EI3 (1999)	EI4 (2005)	EI5 (2013)
<b>T (Year)</b>	T1 (1993)	T2 (1997)	T3 (2000)	T4 (2010)	T5 (2016)
<b>M (Year)</b>	M1 (1990)	M2 (1996)	M3 (2004)	M4 (2007)	M5 (2013)
<b>ES (Year)</b>	ES1 (1996)	ES2 (1998)	ES3 (2007)	ES4 (2011)	ES5 (2013)

*B. Selected performance parameters for the study*

Agricultural tractors were being increasingly used for mechanizing agricultural operations and the tractor industry has been developed as one of the major engineering industries in the country (Mandal and Maity 2013). The increase in the manufacturer and use of tractors had necessitated application of standardized tests for evaluation of their performance on a uniformed and rationalized basis (Pochi and Fanigliulo 2009). The test was conducted for different performance parameters as per the guidelines of IS 5994:1998 i.e. specification sheet, conditions for checking of dimensions, selection of tractors, running-in, servicing & preliminary setting after running-in, and operating conditions of tractors. This section deals with testing procedures of test codes used by testing institutes for measurement of PTO performance of tractor used in the study.

*C. Test procedure for PTO power*

The IS 12036:1995 (Agricultural tractors test procedures - Power tests for PTO) provide test procedures for determining the power available at the power take-off (PTO).

**Measurement of maximum PTO power (kW).** To obtained the maximum PTO power, tractor operated at the engine speed where maximum power occurs for a period of 2 h subsequent to a warming-up period to reach stabilized running conditions. The maximum PTO power measured was the average of six readings made at regular intervals during the 2 h period for which the tractor to be used for PTO work (Eqn. 1). The value of the average maximum horse power available during two-hour maximum power test under normal ambient condition is the maximum power which a tractor can generate (Goering *et al.*, 2003) and hence, it has been accepted as a standard specification to be declared by manufacturer in their technical literature.

The maximum PTO power expressed as;

$$P = 2 \times \pi \times N \times T / (4500) \quad (1)$$

Where,

P- PTO power (kW)

$\pi$  - 3.1414

N - Engine Speed at maximum power (rpm)

T - Torque at maximum power (kN)

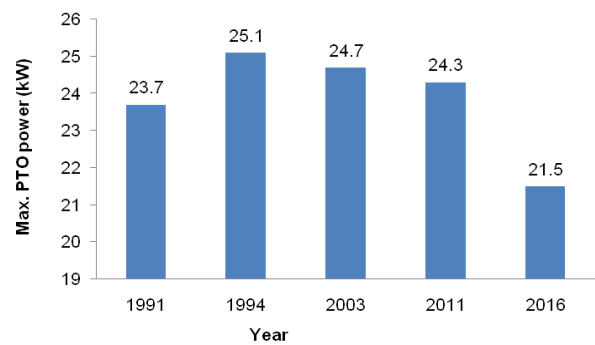
**RESULTS AND DISCUSSION**

The results of PTO performance parameter were analysed and its timeline changes were depicted in the

bar diagram for the selected models of agricultural tractor.

*A. Maximum PTO power for the models 'S'*

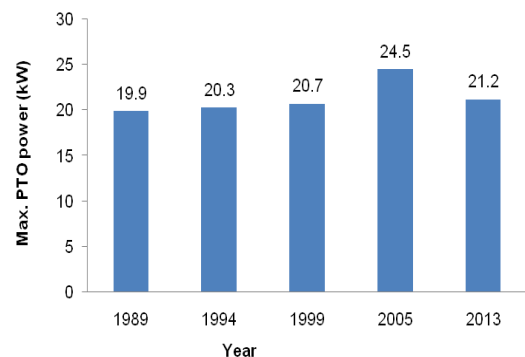
The PTO power for model S was increased up to 25.1 kW and then decreased from 23.7 to 21.5 kW i.e. 9.28% (overall) in the last three decades because the engine speed was decreased from 2007 to 1801 rpm and the corresponding equivalent torque was increased from 113.1 to 114 Nm (Fig. 1).



**Fig. 1.** Changes in maximum PTO power for the models S.

*B. Maximum PTO power for the models 'EI'*

The PTO power for model EI was increased from 19.9 to 21.2 kW i.e. 6.53% (overall) in the last three decades because the engine speed was increased from 2136 to 2150 rpm and the corresponding equivalent torque was also increased from 89.1 to 94.3 Nm (Fig. 2).

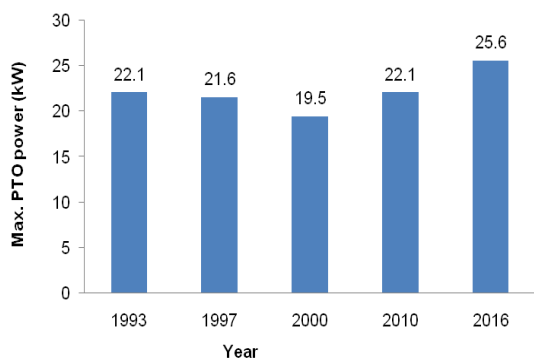


**Fig. 2.** Changes in maximum PTO power for the models EI.

*C. Maximum PTO power for the models 'T'*

The PTO power for model T was dropped to 19.5 kW and then increased from 22.1 to 25.6 kW i.e. 15.83%

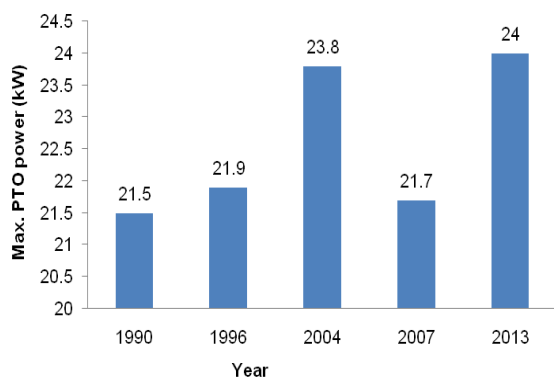
(overall) in the last three decades though the engine speed was almost constant 1999 to 2001 rpm but the corresponding equivalent torque was increased from 113.5 to 122.1 Nm. This may be due to change in engine energy use and fuel consumption pattern (Fig. 3).



**Fig. 3.** Change in maximum PTO power for the models T in last three decades

#### D. Maximum PTO power for the models 'M'

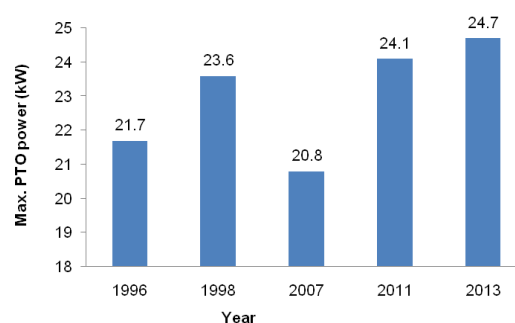
The PTO power for model M was increased from 21.5 to 24 kW i.e. 11.62% (overall) in the last three decades while the engine speed was decreased from 2323 to 1925 rpm and the corresponding equivalent torque was increased from 88.6 to 119.2 Nm. This may be due to change in engine design and fuel consumption pattern (Fig. 4).



**Fig. 4.** Changes in maximum PTO power for the models M in last three decades.

#### E. Maximum PTO power for the models 'ES'

The PTO power for model ES was dropped to 20.8 kW and then increased from 21.7 to 24.7 kW i.e. 13.82% (overall) in the last three decades because the engine speed was increased from 2177 to 2202 rpm and the corresponding equivalent torque was also increased from 95 to 106.9 Nm (Fig. 5).



**Fig. 5.** Change in maximum PTO power for the models ES.

## CONCLUSIONS

The maximum PTO power was improved for the model T from 22.1 to 25.6 kW i.e. 15.83%. It was observed that as the equivalent crankshaft torque was improved and that caused the maximum PTO power to increase. The maximum PTO power was observed 25.6 kW for model T5 during the year 2016 as compared to the other tractors in last three decades. The minimum PTO power was observed 19.5 kW for model T3 during the year 2000 as compared to other tractors in the three decades, i.e., 1987 to 2017.

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**Conflict of Interest.** None.

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