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Up-shift Spectrum Analysis of 29 Tractors Available in India

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Abstract: To know the present status of up-shift pattern of Indian tractors a representative up-shift analysis of different 29 models of tractors selected from 8 different companies has been performed. The analysis has proved most of the models produced in India have irregular up-shift pattern. This irregular up-shift pattern may be one of the main reasons of shift discomfort, unpredictable ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. Design of gearbox of some models showed regular up-shift. So the present study reveals that ample scope is there to improve the design of gearbox of Indian tractors in the light of up-shift analysis.

Key words: Tractor, gearbox, India, up-shift, agriculture, mechanization

INTRODUCTION

Tractor has a great importance in the mechanization of Indian agriculture, which is considered as one of the pivotal factors to achive self-sufficiency in food production. In 1961-62, during the nascent stage of Indian tractor industry, import contribution was 77% out of 3877 number of total tractor sold in that financial year. At present India holds 1st rank in world in number of unit tractor sold. India holds fourth position in world for total number of tractor in use after USA, Japan and Italy (Anonymous, 2004). Tractor is the main source of power especially in the northern zone states like Punjab, Haryana, UP and partly in other three zones of India. Tractor sales are much higher in the northern states where wheat is grown. However, due to agro-ecological diversities, high population density and socio-economic disparities, a diverse mechanization scenario is seen in India. Tractor intensity for 2003-04, varies from 1.92 tractors/1000 ha in Assam to 71.43 tractors/1000 ha in Punjab, with an all-India average of only 17.03 tractors/1000 ha. (Singh, 2006). Year-wise tractor sale in last decade have been given in Fig. 1.

The condition of tractor market is available from Fig. 2. It is clear from Fig. 2 that only northern zone consumes 65% of total tractor sale. Tractorization is going on in other three zones slowly. These three zones as well as the northern zone have tremendous potentiality of future growth. Again export market is also increasing on an average 30-40% rate. Export market includes developed countries like USA, different European countries to third world countries like Bangladesh, Srilanka etc. (Mondal, 2004).

Tractors, manufactured in India, have some inherent advantages as well as disadvantages in design. Up-shift is considered as one of the important parameter for a user-friendly and successful gearbox design of tractors. Designing efficiently entails disciplined methodology in the treatment and analysis of information (Browning, 1978; Mondal, 2004). A design criteria satisfying requirements established

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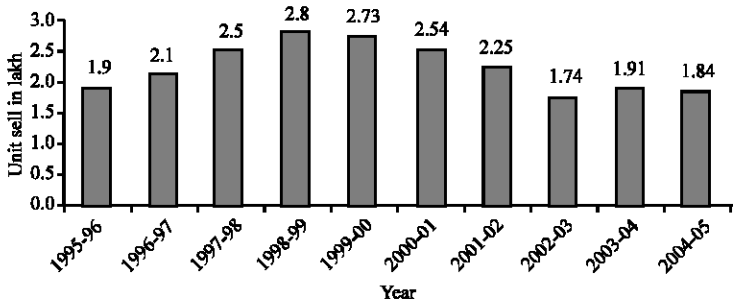

Fig. 1: Tractor sale in India from 1995-96 to 2004-05

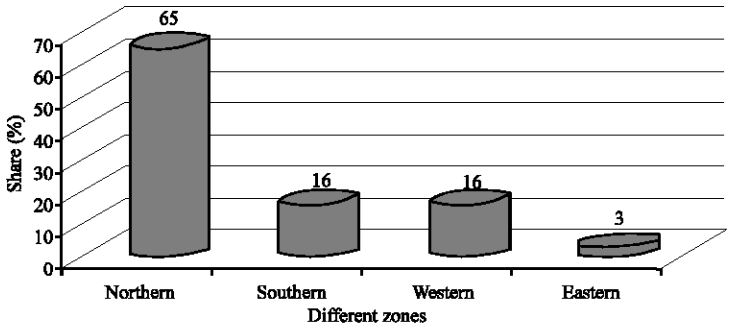

Fig. 2: Market share of different zones in India for tractor

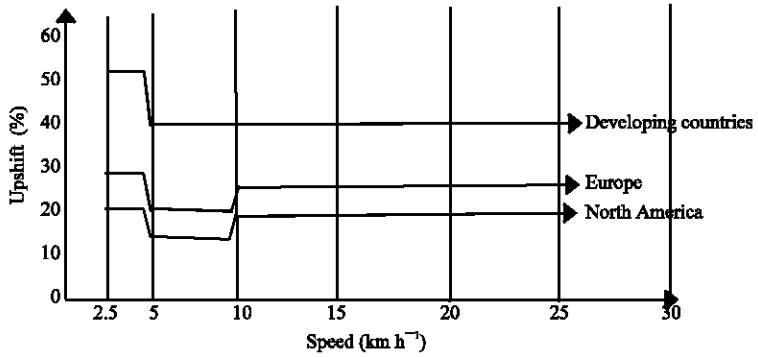

Fig. 3: Up-shift spectrum of transmission system of three major market

through sound theoretical analysis, evaluation, test and simulation techniques has greater chances for success. Gear spacing decision considers factors of cost, efficiency, performance and complexity. The transmission in the developing region tractor had fewer speeds and hence greater speed spacing. Speed spacing of major models were averaged for each of the four speed spectrums in the three markets (Fig. 3) (Browning, 1978; Mondal, 2004).

The authors could not found any up-shift spectrum analysis of Indian tractor in available literature. The objective of the paper is to analyse of up-shift spectrum of Indian tractors and finding out suitable improvement suggestions in light of that analysis.

MATERIALS AND METHODS

Land fragmentation is a major problem of Indian agriculture. According to the need of Indian market, tractor market is also divided into main three segments viz. less than 30 hp segment, 30-40 hp segment and more than 40 hp segment. Less than 30 hp segment constituted 22% of total market, whereas those figures for 30-40 hp and more than 40 hp segment were 57 and 21%, respectively in 2001. For the present study Indian tractor industry has been classified into two broad categories i.e., less than 40 hp and more than 40 hp segment. As less than 40 hp segment has been proved to be the major segment, 2-3 models from each company have been chosen from this segment depending on availability. Again 1-2 models from each company have been chosen depending on availability from the minor segment (i.e., more than 40 hp). The analysis has been carried out at Kharagpur, India during 2003. Ground speed data in different gears have been collected from commercial test reports of respective models, published by Central Farm Machinery Training and Testing Institute (CFMTTI), Budni. Percent up-shift of all the selected tractor models have been calculated by Eq. 1.

$$\text{Percent up-shift} = \{(\frac{\text{Speed in Gear2}}{\text{Speed in gear1}})\text{-}1\}\times 100 \quad (1)$$

RESULTS AND DISCUSSION

Figure 4 showed that Arjun 445 and B275 models of less than 40 hp segment of Mahindra tractor have negative up-shift values which would create problem during field operation as H1 gear had less speed than previous (L4) gear. But the problem of negative up-shift was rectified in 605 model of more than 40 hp segment (Fig. 5). It has been noticed than both the segments have high and irregular up-shift values. This irregular up-shift pattern may cause shift discomfort, unpredictable ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. Higher values of up-shift, even more than 70% up-shift value have been noticed (L1-L2 and H1-H2 shifts for B275 model). High value of up-shift may lead to higher fuel consumption due to power-load mismatch.

Escorts tractors (Fig. 6 and 7) have lot of irregularities in up-shift spectrum and the value varied from more than 70% (L2-L3 and H2-H3 shifts for F70 and 60DX models) to 20% for both less than 40 hp and more than 40 hp segments. High value of up-shift may lead to higher fuel consumption due to power-load mismatch. This irregular up-shift pattern may cause shift discomfort, unpredictable

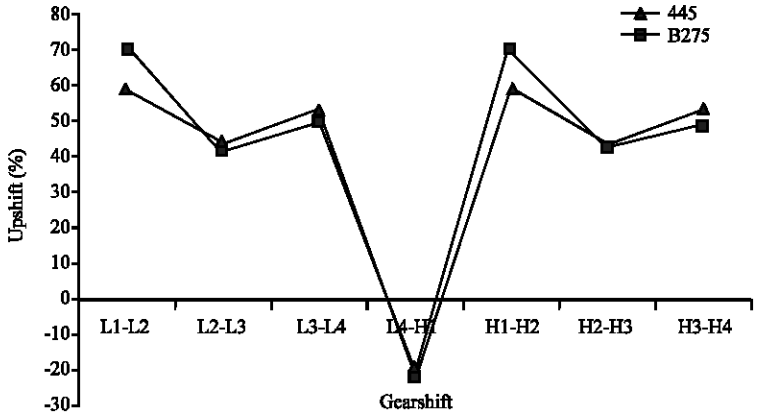

Fig. 4: Up-shift spectrum of less than 40 hp segment of Mahindra tractor

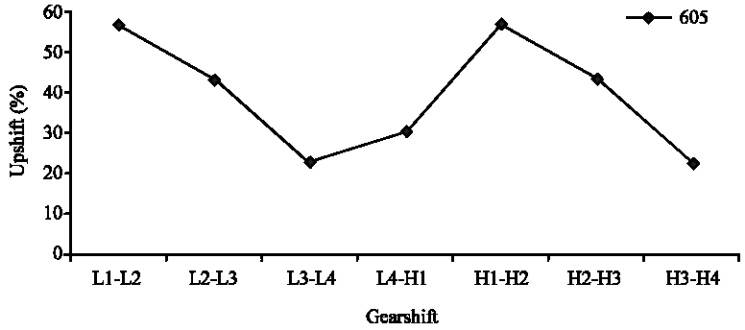

Fig. 5: Up-shift spectrum of More than 40 hp segment of Mahindra tractor

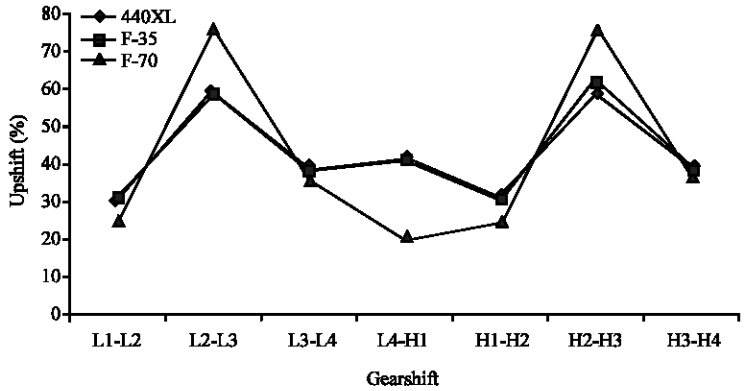

Fig. 6: Up-shift spectrum of less than 40 hp segment of Escorts tractor

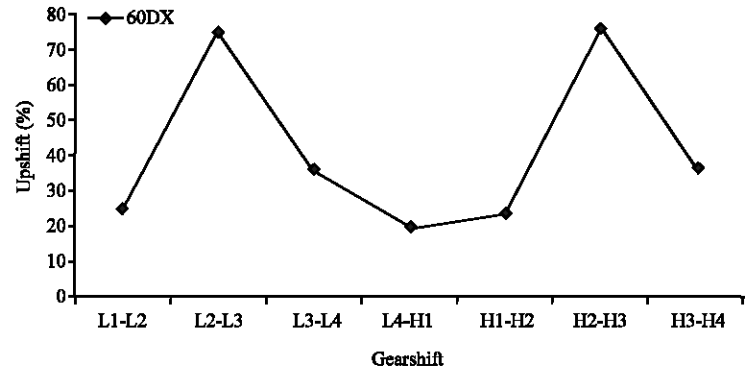

Fig. 7: Up-shift spectrum of more than 40 hp segment of Escorts tractor

ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. It is a disadvantageous property of these tractors.

Model 312 and 368 of Eicher tractor (Fig. 8) showed negative up-shift value, which is not desirable. Those particular models also exhibited very high (more than 80%) up-shift values. But model 364P showed regular but high (nearly 40%) up-shift value. Less number of gear options lead to high up-shift value. It is expected that regular up-shifts values of this model would lead to better

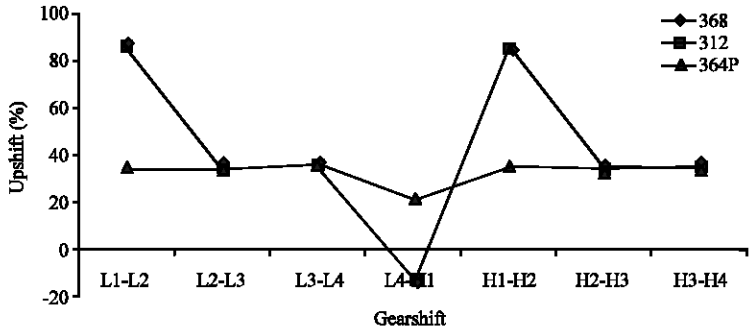

Fig. 8: Up-shift spectrum of less than 40 hp segment of Eicher tractor

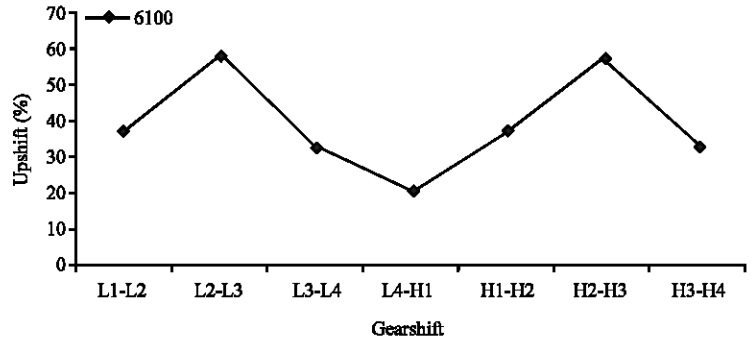

Fig. 9: Up-shift spectrum of More than 40 hp segment of Eicher tractor

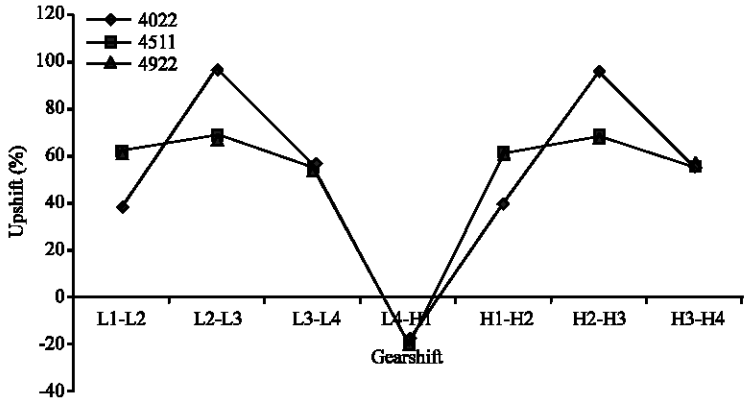

Fig. 10: Up-shift spectrum of less than 40 hp segment of HMT tractor

transmission performance. But up-shift spectrum (Fig. 9) of more than 40 hp model (6100) was again irregular. This irregular up-shift pattern may cause shift discomfort, unpredictable ground speed change etc.

All the three selected models (Fig. 10) of HMT Company showed irregular and negative up-shift values which would create problem during field operation as H1 gear had less speed than previous (L4) gear. One model (4022) showed unusual high up-shift (97.2 %) for L2-L3 and H2-H3 shifts.

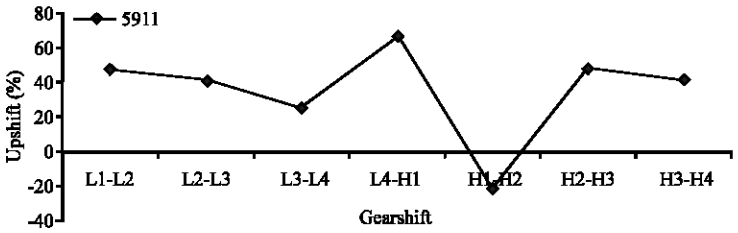

Fig. 11: Up-shift spectrum of more than 40 hp segment of HMT tractor

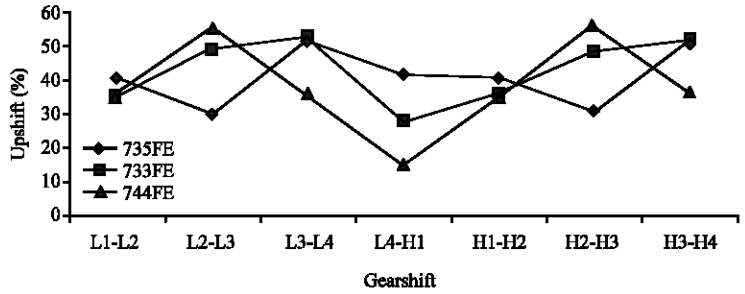

Fig. 12: Up-shift spectrum of less than 40 hp segment of PTL tractor

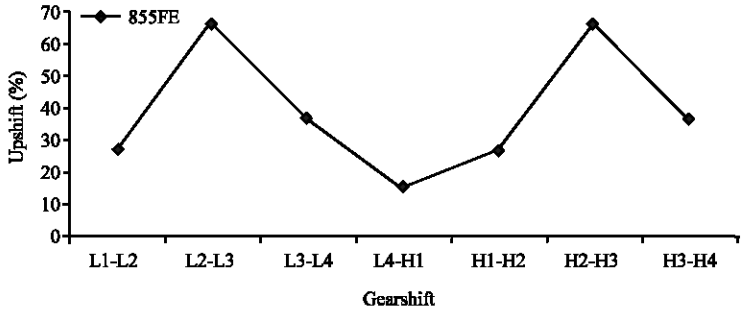

Fig. 13: Up-shift spectrum of more than 40 hp segment of PTL tractor

Representative of more than 40 hp segment of HMT Company, 5900 model also showed high, irregular and negative up-shift (H1-H2) (Fig. 11). This irregular up-shift pattern may cause shift discomfort, unpredictable ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. This is a drawback of design of HMT tractors.

Both less than 40 hp segments and more than 40 hp segment (Fig. 12 and 13) of PTL tractors showed irregular and high up-shift values. Two models, namely 733FE and 735FE, showed better up-shift pattern than 744FE and 855FE. High and irregular up-shift pattern may cause shift discomfort, unpredictable ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. It is a disadvantageous property of these tractors. It creates a necessity of introduction of regular and low up-shift concept in future design.

Less than 40 hp segment (Fig. 14) of tractor of TAFE showed irregular up-shift values. One model, namely, 4410 showed better up-shift value than the other (241DIJ). High and irregular up-shift

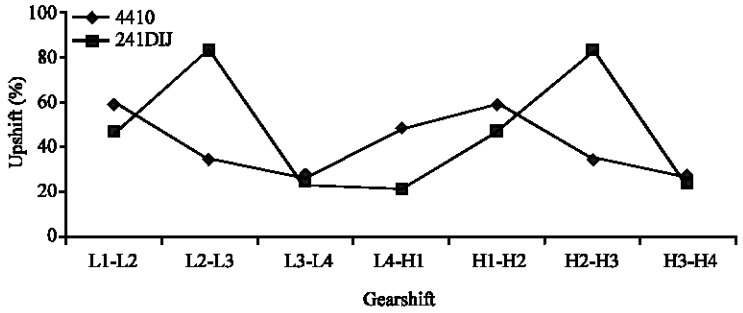

Fig. 14: Up-shift spectrum of less than 40 hp segment of TAFE tractor

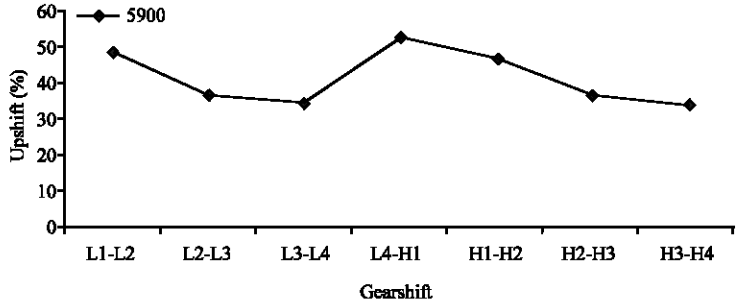

Fig. 15: Up-shift spectrum of More than 40 hp segment of TAFE tractor

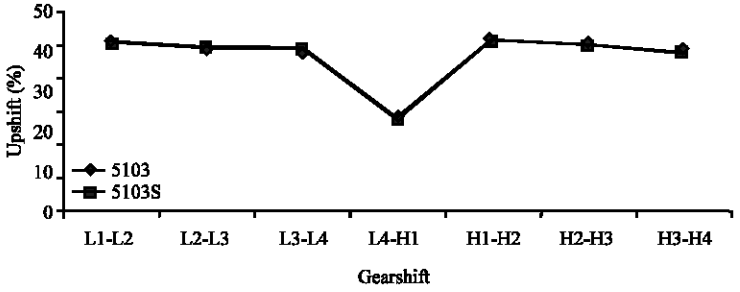

Fig. 16: Up-shift spectrum of less than 40 hp segment of L & T John Deere tractor

pattern may cause shift discomfort, unpredictable ground speed change, shortening of life of gear-shift associated parts etc. It is a disadvantageous property of these tractors. Representative of more than 40 hp segment (5900 model) (Fig. 15) showed some improved up-shift values, which may ensure better performance of transmission of this model.

The analysis revealed that L & T John Deere models, both less than 40 hp segment (5103 and 5103S models) (Fig. 16) and more than 40 hp (5203 model) (Fig. 17) segment, showed more or less regularized up-shift values. But less number of speed options resulted in high values of up-shift (nearly 40%). This regular up-shift pattern may alleviate the problem of shift discomfort, unpredictable ground speed change, higher noise and vibration etc. These results proved that tractors of L & T John Deere had superior transmission system from up-shift point of consideration.

For FORD models, the analysis revealed that for both less than 40 hp segment (3230 and 3030 models) (Fig. 18) and more than 40 hp (Fig. 19) segment all the up-shift values were more or less

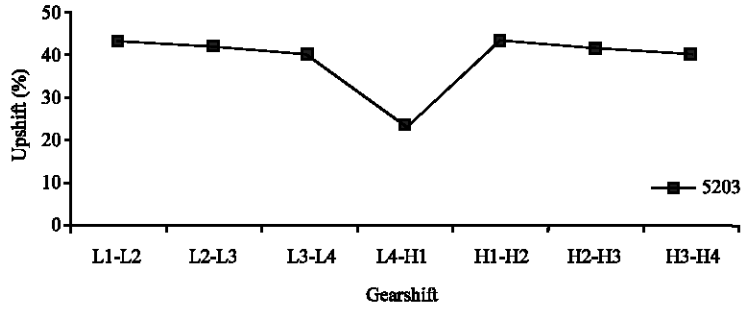

Fig. 17: Up-shift spectrum of more than 40 hp segment of L and T John Deere tractor

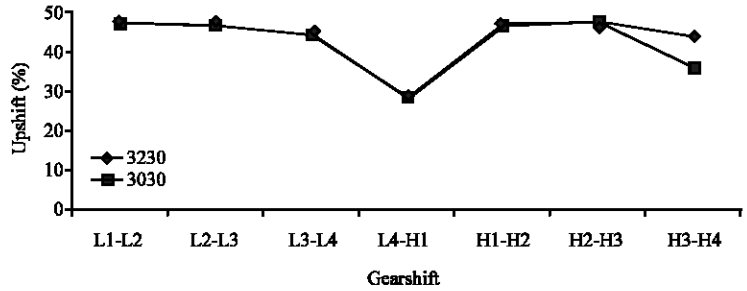

Fig. 18: Up-shift spectrum of less than 40 hp segment of FORD tractor

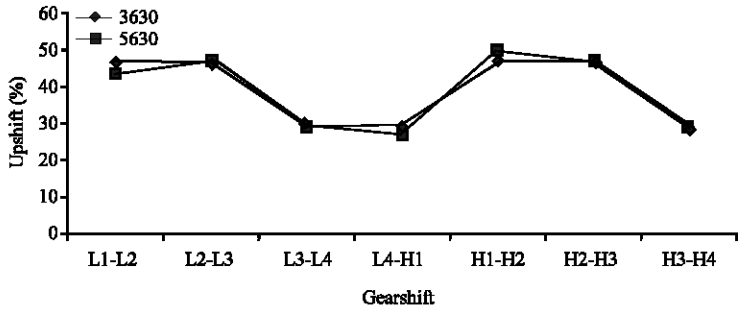

Fig. 19: Up-shift spectrum of More than 40 hp segment of FORD tractor

regularized. But less number of speed options lead to high values of up-shift (nearly 40%). This regular up-shift pattern may alleviate shift discomfort, unpredictable ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. These results proved that tractors of FORD had superior transmission system from up-shift value point of view.

CONCLUSIONS

An exhaustive up-shift spectrum analysis of 29 Indian tractors has been carried out. It is clear from that analysis that the most of the transmission systems available in Indian tractors have high as well as irregular up-shift value, which is not desirable. Some tractor models exhibited very high

(more than 80%) up-shift values, which may contribute to shift discomfort, unpredictable ground speed change, higher noise and vibration, speed mismatch, higher hand ball impulse, shortening of life of gear-shift associated parts etc. Some tractor models showed negative up-shifts, which were also disadvantageous. The study also revealed that some companies have started to maintain regular up-shift for their models. In these cases also less number of speed options led to regular but high up-shift values. Low and regular up-shift value is an essential part for proper design of transmission system, which results in better overall performance. The present analysis revealed the need of regular up-shift and more number of speed options to improve the performance of Indian tractors. So the present study reveals that ample scope is there to improve the design of gearbox of Indian tractors in the light of up-shift analysis.

DISCLAIMER

Mentioning model name of specific companies does not indicate that authors are endorsing any of the brands. Data used in this paper are collected from materials published from 1997 to 2003. Any design change, not covered in the test reports, is beyond the scope of this study

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