Energy Efficiency Classification of Agricultural Tractors in Korea

Chang Seop Shin[1], Kyeong Uk Kim[1,2*], Kwan Woo Kim[3]

[1]Department of Biosystems and Biomaterial Science and Engineering, Seoul National University, Seoul, Korea
[2]Research Institute for Agriculture and Life Sciences, Seoul National University, Seoul, Korea
[3]Foundation of Agricultural Technology Commercialization and Transfer, Suwon, Korea

Abstract

Purpose: This study was conducted to classify the energy efficiency of 131 tractor models tested during from 2006 to 2010 in Korea. **Methods:** Four sub-indexes were developed using the fuel consumptions at 60% and 90% of rated speed with partial loads and at pull speeds of 3.0 km/h and 7.5 km/h with maximum drawbar pull. Weighting factors of the sub-indexes were also considered to reflect the characteristics of tractor's actual working hours in Korea. Four sub-indexes were integrated into a classification index. Using the developed classification index, a five-classification system was made on the basis of normal distribution of tractors over the classification range. Percentage of 1st grade interval was expected to be close to 15%, 2nd grade 20%, 3rd grade 30%, 4th grade 20%, 5th grade 15%. **Results:** Number of 1st grade was 21, 2nd grade 23, 3rd grade 39, 4th grade 33, 5th grade 15 among 131 models. **Conclusions:** Classification index was developed by integrating four sub-indexes. By the classification method using developed index, distribution of classified tractors was acceptable for practical application.

Keywords: Agricultural tractor, Classification Index, Energy efficiency

Introduction

The number of agricultural tractors sold in Korea has been increasing during the period from 2005 to 2010 (e.g. 10,121 units in 2005 and 13,891 units in 2010). The total number of agricultural tractors used in Korea was 267,871 in 2011(MIFAFF, 2011). Fossil fuel consumed by agricultural tractors in Korea is increasing as the increase of tractors.

Saving energy has become a big issue throughout the world. Many countries have legislated effective energy saving. Classification of energy efficiency is an indirect way to reduce fuel consumption. Grading energy efficiency of products can provide customers with the information on decision-making. To implement energy efficiency classification to agricultural tractors is very important from the energy saving perspectives. The classification of agricultural tractors by energy efficiency has been introduced in foreign countries. In Spain, based on OECD 1 and 2, classification index was developed using fuel consumption and power data, and 214 tractor models were classified by those indexes (Gil-Sierra et al., 2007). In France, classification of agricultural tractors by energy efficiency was carried out by joint scientific work of Spain and France(OECD, 2009). In Turkey, 55 tractor models were classified by seven-classification system.(OECD, 2012).

In Korea, research for the classification of agricultural tractors by energy efficiency has begun recently. Equation to predict fuel consumption for partial loads at non-rated speeds was developed and five-classification method using a certain index was suggested (Kim et al., 2010).

To implement energy efficiency classification, a classification index should be developed based on the fuel consumption data. The test report on OECD tractor can

*Corresponding author: Kyeong-Uk Kim
Tel: +82-2-880-46; Fax: +82-2-873-2049
E-mail: kukim@snu.ac.kr

provide reasonable data for Korean tractors. However, since Korean test procedure is not the same as OECD one, we need to develop new one for Korean tractors.

This paper presents an index development procedure based on Korean agricultural tractors test reports and a five-classification method was developed for energy efficiency classification procedure.

Materials and Methods

Available data

There are different methods between OECD and Korean ones. Unlike the OECD test, Korean test method follows Korean version. Among the test procedure the available codes were selected. Table 1 compare the OECD test method and Korean one to develop classification index.

Index zones

Four zones in OECD tractor test report were chosen to develop a classification index (Table 2).

Sub-index C_{rate}

Five operational points in the rated speed zone were chosen from the torque curve (Figure 1). and the sub-index C_{rate} was defined as the average value of specific

volumetric fuel consumption (SVFC) over all points.

$$
\begin{aligned}
C_{rate} &= \frac{1}{5}\left(SVFC_1 + SVFC_2 + SVFC_3 \right. \\
&\quad \left. + SVFC_4 + SVFC_5\right) \\
&= \frac{1}{5}\sum_{i=1}^{5}\frac{Q_i}{P_i}
\end{aligned}
\tag{1}
$$

where , P_i = power at point i, i =1, 2, 3, 4, 5 (kW)
Q_i = fuel consumption at point i (L/h)

Sub-index C_{PTO}

Similarly, sub-index C_{PTO} can be obtained using the fuel consumption data at the five operational points in the
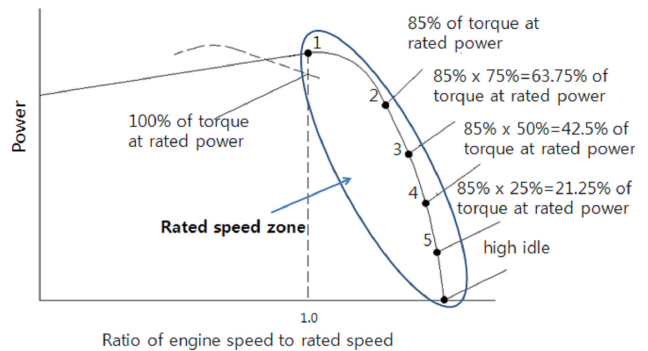

Figure 1. Five operational points for sub-index C_{rate}.

Table 1. OECD test vs. Korean test				
Test	OECD CODE 2		Domestic	Available data
	Maximum power test		included	
	Test at full load and varying speed		included	
Main power take-off		at rated engine speed	included	
	Tests at varying load	at standard power take-off speed [540 or 1000 min^{-1} (rev/min)]	not included	engine speed(min^{-1}), power(kW), fuel consumption(L/h)
Fuel consumption tests	Tests at varying load at five extra points for calculating fuel consumption characteristics		not included	
Drawbar power and fuel consumption test, unballasted tractor	The power available at the drawbar of the unballasted tractor over a range of different gears/speed settings		included	

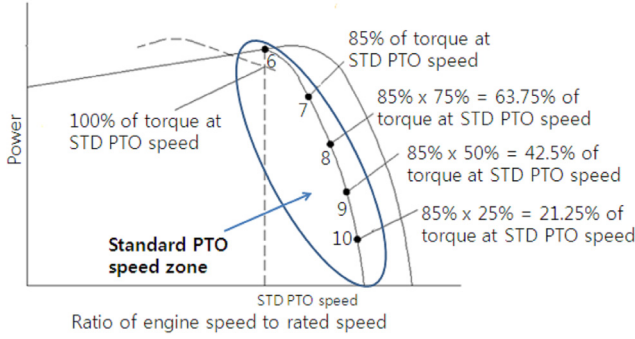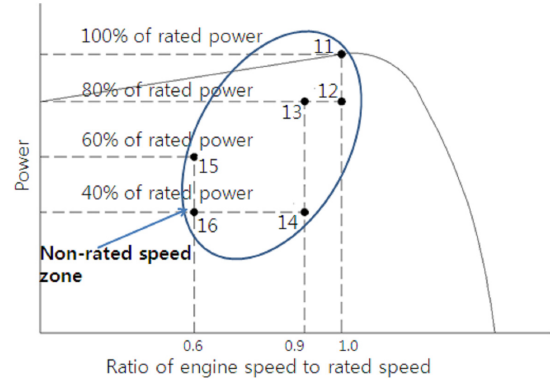| Table 2. Four Zones for developing classification index	
Name of Zone	Meaning of Zone
Rated speed	Varying load at rated engine speed with full throttle
Standard PTO speed	Varying load at standard PTO speed with full throttle
Non-rated speed	Partial load at reduced speeds with reduced throttle
Drawbar	Drawbar performance at pull speeds of 3.0 km/h and 7.5 km/h

Figure 2. Five operational points for sub-index C_{PTO}.

varying load test at the standard PTO speed (Figure 2).

Using power and fuel consumption data, the sub-index C_{PTO} can be determined by equation (2).

$$C_{PTO} = \frac{1}{5} \left(\frac{Q_6}{P_6} + \frac{Q_7}{P_7} + \frac{Q_8}{P_8} + \frac{Q_9}{P_9} + \frac{Q_{10}}{P_{10}} \right) \qquad (2)$$

Sub-index C_{PART}

Fuel consumption data from the OECD tractor test reports were used for four partial load points from 13 to 16 (Figure 3), because there are no available data in Korean ones, and these data were employed to use Kim's model (Kim et al., 2011). Similarly, using the fuel consumption data at four partial load points and adding two more points (11 and 12) which represent the maximum rated power, sub-index C_{PART} can be calculated as equation (3). It should be noted that the specific volumetric fuel consumptions at the partial load are weighted twice than those at the maximum rated power to reflect the usage characteristics of tractors in Korea.

$$
\begin{aligned}
C_{PART} &= \frac{1}{10} \left(\sum_{i=11}^{12} SVFC_i + 2 \times \sum_{i=13}^{16} SVFC_i \right) \\
&= \frac{1}{10} \left(\sum_{i=11}^{12} \frac{Q_i}{P_i} + 2 \times \sum_{i=13}^{16} \frac{Q_i}{P_i} \right)
\end{aligned}
\qquad (3)
$$

where, P_i = power at point i, i = 11, 12, 13, 14, 15, 16 (kW)
Q_i = fuel consumption at point i, i = 11, 12, 13, 14, 15, 16 (L/h)

Sub-index C_{PULL}

Rotovating and plowing take two most large portions of drawbar work in tractors used in Korea. Average working speeds of these two operations are generally known to be

Figure 3. Six operational points for sub-index C_{PART}.

around 3.0 km/h and 7.5 km/h respectively(Kim et al., 2010). Sub-index C_{PULL} was determined using the fuel consumption data at pull speeds (3.0 km/h and 7.5 km/h) in drawbar performance test (Table 3). These data are also available from the OECD tractor test reports. Equation (4) gives the sub-index C_{PULL}.

$$C_{PULL} = \frac{1}{2} \left(\frac{Q_{3.0}}{P_{3.0}} + \frac{Q_{7.5}}{P_{7.5}} \right) \qquad (4)$$

where, $Q_{3.0}$, $P_{3.0}$ = fuel consumption and drawbar power at close to 3.0 km/h
$Q_{7.5}$, $P_{7.5}$ = fuel consumption and drawbar power at close to 7.5 km/h

Prediction in standard PTO speed zone

In standard PTO speed zone, both power and fuel consumption should be predicted because there are no data available at standard PTO speed in Korean test report. Point 6 is the point at the standard PTO speed (Figure 4). In addition, in non-rated speed zone, fuel consumption data also should be predicted.

In the Korean test report, since power and fuel consumption data were only available at point 6 in standard PTO speed zone, ones at points from 7 to 10 were predicted for further processing.

At first, power was predicted using both power data at the standard PTO speed and power ratios of four operational points at rated speed zone (equation (5)).

$$P_i = P_6 \times \frac{P_{i-5}}{P_1} \quad (i = 7, 8, 9, 10) \qquad (5)$$

Then, the fuel consumption at the standard PTO speed

Table 3. Example of points from which sub-index C_{PULL} is derived in drawbar zone (Daedong Co., Ltd. RE071002)

number of speed changing step [main-sub (step)]	power (kW)	tractive force (kN)	pull speed (km/h)	engine rpm (rpm)	wheel slip (%)	specific volumetric fuel consumption (g/kW·h)	specific energy (kW·h/L)	temperature			ambient condition		
								fuel (℃)	coolant (℃)	engine oil (℃)	outdoor tempera-ture (℃)	relative humidity (%)	air press-ure (kPa)
A-1	14.01	34.31	1.47	2432	15.0	691	1.210	22	80	96	11	50	100.9
A-2	16.52	33.66	1.77	2422	15.1	632	1.323	24	80	96	11	51	100.9
A-3	20.12	34.50	2.10	2412	15.0	538	1.555	24	80	97	11	52	100.9
A-4	24.48	34.43	2.56	2395	15.0	506	1.651	24	81	97	11	53	100.9
B-1	33.63	34.04	3.56	2377	15.1	407	2.056	25	80	97	11	53	100.9
B-2	39.97	34.37	4.19	2354	15.0	371	2.256	25	81	97	11	52	100.9
B-3	47.83	34.83	4.94	2323	15.0	341	2.449	25	81	98	12	51	100.9
C-1	51.64	34.43	5.40	2251	15.0	332	2.520	25	80	98	12	50	100.9
B-4	53.15	34.49	5.55	2126	15.0	327	2.555	25	81	97	12	49	100.9
C-2	55.71	34.09	5.88	2027	15.0	314	2.667	25	80	98	12	49	100.9
C-3	59.21	31.47	6.77	1903	12.6	299	2.794	25	80	98	13	49	100.9
D-1	59.65	26.97	7.96	1902	9.8	296	2.821	26	81	98	12	49	100.9
C-4	59.70	24.65	8.72	1907	8.7	294	2.845	26	81	99	12	48	100.9
D-2	61.40	22.38	9.88	1903	7.4	290	2.888	26	82	99	12	49	100.9
D-3	62.14	18.56	12.05	1903	5.5	284	2.941	26	81	99	13	49	100.9
E-1	61.39	16.08	13.74	1907	4.7	287	2.909	26	80	99	13	48	100.9
D-4	59.32	14.21	15.03	1904	3.9	298	2.802	26	80	99	13	47	100.9
E-2	59.67	12.84	16.73	1905	3.6	299	2.798	26	82	100	13	48	100.9
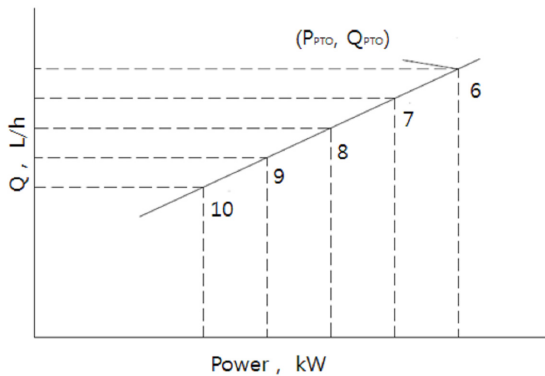
Figure 4. Fuel consumption vs. power at five operational points.

zone was predicted by equation (6). The slope of the regression line correlating the fuel consumption and power, which are predicted at five operational points in standard PTO speed zone in Figure 2, is the same as the regression line for five operational points in rated speed zone like Figure 4. P_{PTO} and Q_{PTO} were defined as the power and fuel consumption at the standard PTO speed.

Varying load at the standard PTO speed, the slope of the regression line of fuel consumption versus power is the same as the regression line of varying load at the rated speed.

$$Q_i = a(P_i - P_{PTO}) + Q_{PTO} \qquad (6)$$

where, a = slope of fuel consumption vs. power curve at the rated engine speed with varying load (L/kWh)

P_i = power at point i, i = 7, 8, 9, 10 (kW)

Q_i = fuel consumption at point i, i = 7, 8, 9, 10 (L/h)

P_{PTO} = power at standard PTO speed (kW)

Q_{PTO} = fuel consumption at standard PTO speed (L/h)

This prediction equation is based on the assumption that the slope of regression line of fuel consumption vs. power at standard PTO speed zone is the same as at the rated speed zone.

Error percentage of prediction in standard PTO speed zone

Nine sets of the test reports from the OECD CODE 2 were selected to evaluate our data, power and fuel consumption. The range of the error percentage at power prediction was from 0.1% to 9.54%, and its mean value was 3.28%. The range of the error percentage at fuel consumption was also from 2.05% to 12.24%, and its mean value was 5.3%.

Prediction of fuel consumption in the non-rated speed zone

In the non-rated speed zone, fuel consumption data at point from 12 to 16 (Figure 3) was predicted as a function of the speed ratio. A quadratic equation was also applied to model the power and fuel consumption at full load as a function of the speed ratio.

Fuel consumptions were predicted by using the equation (7) developed by Kim et al. (2011).

$$Q_i = s_1 n_c^2 + (s_2 - aa_p)n_c + s_3 + aa_p n_i$$

$$n_c = \frac{-(k_2 - a_p) + \sqrt{(k_2 - a_p)^2 - 4k_1(k_3 + a_p n_i - P_i)}}{2k_1}$$

(7)

where, a = slope of fuel consumption versus power at the points from 1 to 5 in rated speed zone

a_p = slope of power versus speed ratio at the points from 1 to 5 in rated speed zone

n_i = ratio of reduced speed *i* to rated speed.

n_C = ratio of speed at intersection between speed-power curve at full load and the line passing through any point with slope a

P_i = engine power at reduced speed *i*, kW

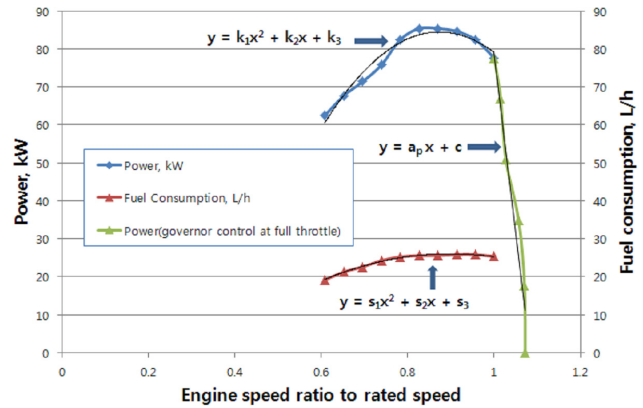s_1, s_2, s_3 = coefficients of quadratic equation of power as a function of speed ratio for full load

Figure 5. Power and fuel consumption graph as a function of speed ratio at the full load.

k_1, k_2, k_3 = coefficients of quadratic equation of fuel consumption as a function of speed ratio for full load

Classification index, C_i

The classification index C_i was obtained by integrating the 4 sub-indexes with different weighting factors and is given as

$$C_i = \frac{1}{7}\left(C_{rate} + 2C_{PTO} + 2C_{PART} + 2C_{PULL}\right)$$

(8)

As C_i is the smaller, the energy efficiency becomes the better because C_i is specific volumetric fuel consumption.

Weighting factors for C_{PTO}, C_{PART}, C_{PULL} were multiplied by 2 to reflect the actual time of tractor usage in Korea.

In 2010, time used for each operations was shown in Table 4 (RDA, 2011).

From Table 4, the usage time of drawbar is very similar to the value of PTO. It can be inferred that the same weighting factor was applied to PTO and drawbar zone.

In addition, percentage of total power versus the rated power for actual operation is 70% (Kim et al., 2011).

Table 4. Scope of each grade for 131 tractor models by five-classification system

Operation		Usage time per year, %	
Drawbar	transportation	17.8	45.7
	plowing	16.4	
	leveling	11.5	
PTO	soil preparation	30.3	43.1
	fertilizer spreading	6.4	
	manure spreading	6.4	
Others	loading etc.		11.2
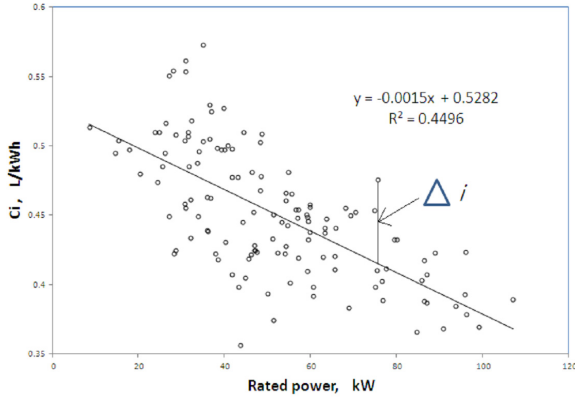
Figure 6. Scatter diagram of classification indexes of 131 tractor models.

Weighting factor of non-rated speed zone can be regarded as 2.

Because actual operation is under the non-rated speed zone, weighting factors at STD PTO speed, drawbar, and the non-rated speed zone can be regarded as the same.

Classification

The classification indexes were obtained from 131 tractor models which were tested during the period from 2006 to 2010 in Korea. Since the test was conducted by Korean test method which has different points from OECD, some fuel consumption and power data were predicted for modeling the classification indexes. Figure 6 shows a scatter diagram of the classification indexes plotted as a function of the rated power of the model tractor.

A regression analysis between the classification index and rated power has resulted in a linear equation like equation (9).

$$C_{avg} = A \times P_{rate} + B \tag{9}$$

where, P_{rate} = rated power of tractor (kW)
A = slope of regression line (L/kW^{2}h)
B = intercept of regression line (L/kWh)

Values of A and B of equation (9) became −0.0015 and 0.5282 respectively.
$\triangle_i$ was defined as the difference between the index C_i and C_{avg} for the i-th tractor (Equation (10)).

$$\triangle_i = C_i - C_{avg} \tag{10}$$

Table 5. Scope of $\triangle_i$ at each grade for 131 tractor models by five-classification system

Grade	Scope
1st	$\triangle_i < -0.03517$
2nd	$-0.03517 \leq \triangle_i < -0.01284$
3rd	$-0.01284 \leq \triangle_i < 0.013596$
4th	$0.013596 \leq \triangle_i < 0.035929$
5th	$0.035929 \leq \triangle_i$

Table 6. Scope of C_i at each grade for 131 tractor models by five-classification system

Grade	Scope
1st	$C_i < -0.0015 P_{rate} + 0.493031$
2nd	$-0.0015 P_{rate} + 0.493031 \leq C_i < -0.0015 P_{rate} + 0.515364$
3rd	$-0.0015 P_{rate} + 0.515364 \leq C_i < -0.0015 P_{rate} + 0.541796$
4th	$-0.0015 P_{rate} + 0.541796 \leq C_i < -0.0015 P_{rate} + 0.564129$
5th	$-0.0015 P_{rate} + 0.564129 \leq C_i$

Average and standard deviation of $\triangle_i$ can be obtained by equation (11) and (12) respectively.

$$\triangle_{avg} = \frac{1}{131} \sum_{i=1}^{131} \triangle_i \tag{11}$$

$$\sigma_\triangle = \sqrt{\frac{\sum_{i=1}^{131} (\triangle_i - \triangle_{avg})^2}{130}} \tag{12}$$

For 131 tractor models, the average $\triangle_{avg}$ and the standard deviation were obtained as 0.00038 and 0.0343 respectively. Z was the stochastic variable of the standard normal distribution of random variable $\triangle_i$ having average $\triangle_{avg}$ and standard deviation $\sigma_\triangle$, and can be expressed as equation (13) and its mean and variance are 0 and 1, respectively.

$$Z = \frac{\triangle_i - \triangle_{avg}}{\sigma_\triangle} \tag{13}$$

Inserting obtained values to $\triangle_{avg}$ and $\sigma_\triangle$, equation (13) becomes equation (14).

$$Z = \frac{\triangle_i - 0.00038}{0.0343} \text{ or } \triangle_i = 0.0343Z + 0.00038 \tag{14}$$

The number of classifications can be determined in accordance with tractor manufacturers. In this study, a five-classification system was taken. It was also assumed
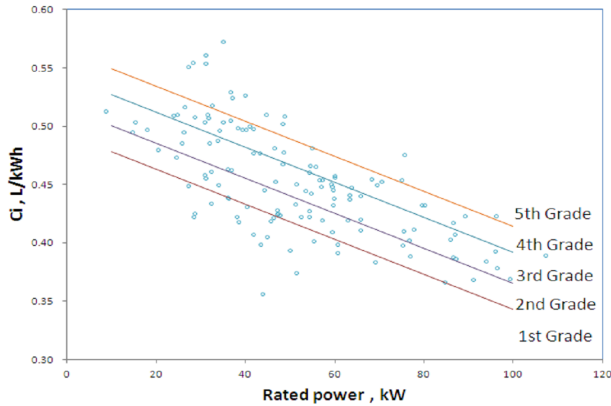
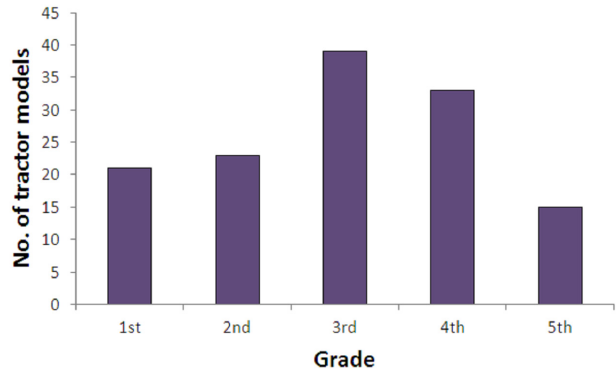**Figure 7.** Boundary line of classification grades of 131 tractor models.

Figure 8. Distribution histogram of tractors by the grades of 131 tractor models.

Table 7. Number and ratio by interval of rated power of models classified by five-classification system for 131 tractor models

Rated power<10			10≤Rated power<20			20≤Rated power<30		
Grade	Q'ty	Ratio (%)	Grade	Q'ty	Ratio (%)	Grade	Q'ty	Ratio (%)
1	0	0	1	0	0.0	1	2	15.4
2	0	0	2	2	66.7	2	1	7.7
3	1	100	3	1	33.3	3	4	30.8
4	0	0	4	0	0.0	4	3	23.1
5	0	0	5	0	0.0	5	3	23.1
Sum	1	100	Sum	3	100	Sum	13	100
Grade Avg.	3		Grade Avg.	2.3		Grade Avg.	3.3	

30≤Rated power<40			40≤Rated power<50			50≤Rated power<60		
Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)
1	4	14.3	1	5	20	1	2	8
2	4	14.3	2	6	24	2	7	28
3	6	21.4	3	5	20	3	9	36
4	7	25.0	4	5	20	4	6	24
5	7	25.0	5	4	16	5	1	4
Sum	28	100	Sum	25	100	Sum	25	100
Grade Avg.	3.3		Grade Avg.	2.9		Grade Avg.	2.9	

60≤Rated power<70			70≤Rated power<80			80≤Rated power<90		
Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)
1	3	25.0	1	0	0.0	1	0	0
2	5	41.7	2	1	11.1	2	0	0
3	3	25.0	3	4	44.4	3	5	62.5
4	1	8.3	4	1	11.1	4	2	25
5	0	0.0	5	3	33.3	5	1	12.5
Sum	12	100	Sum	9	100	Sum	8	100
Grade Avg.	2.2		Grade Avg.	3.7		Grade Avg.	3.5	

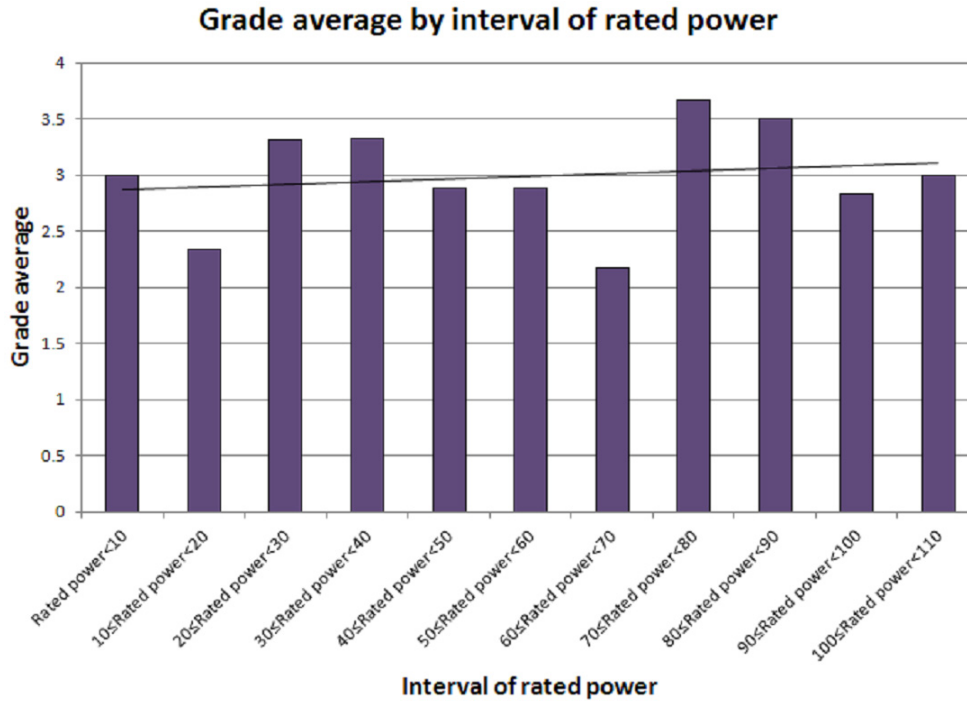| m90≤Rated power<100			100≤Rated power<110		
Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)
1	1	16.7	1	0	0
2	1	16.7	2	0	0
3	2	33.3	3	1	100
4	2	33.3	4	0	0
5	0	0.0	5	0	0
Sum	6	100	Sum	1	100
Grade Avg.	2.8		Grade Avg.	3	

Grade average by interval of rated power

Figure 9. Grade average of classified tractors by rated power of 131 tractor models.

Table 8.	Number and ratio by year of models for 131 tractor models							
	2006			**2007**			**2008**	
Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)
1	2	13.3	1	2	5.6	1	4	13.8
2	3	20.0	2	3	8.3	2	9	31.0
3	3	20.0	3	15	41.7	3	6	20.7
4	5	33.3	4	10	27.8	4	6	20.7
5	2	13.3	5	6	16.7	5	4	13.8
Sum	15	100	Sum	36	100	Sum	29	100
Grade Avg.	3.133333		Grade Avg.	3.416667		Grade Avg.	2.896552	
	2009			**2010**				
Grade	Q'ty	Ratio(%)	Grade	Q'ty	Ratio(%)			
1	4	12.1	1	9	50			
2	7	21.2	2	1	5.6			
3	12	36.4	3	3	16.7			
4	8	24.2	4	4	22.2			
5	2	6.1	5	1	5.6			
Sum	33	100	Sum	18	100			
Grade Avg.	2.909091		Grade Avg.	2.277778				

that percentage distribution over the five classification was 15% for the first, 20% for the second, 30% for the third, 20% for the fourth and 15% for the fifth grades. Based on this classification, the Z value for each grade was obtained from a statistical table (Kim et al., 2010). Substituting the Z values into equation (13) and solving for $\triangle_i$ for each grade yields scopes like Table 5.
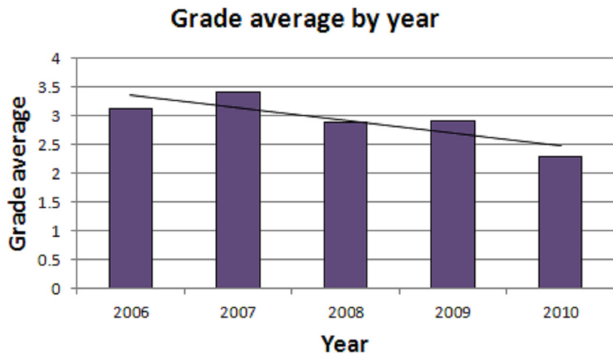
$\triangle_i$ was substituted into equation (9) and (10) to calculate C_i subsequently, Table 6 shows the conversion of Table 5.

Results and Discussion

131 tractor models in Korea were classified by energy efficiency with the developed indexes. Figure 7 shows the

Figure 10. Grade average of classified tractors by year of 131 tractor models.

Table 9. Number and ratio of models by area of product classified by five-classification system for 131 tractor models

Domestic		
Grade	Q'ty	Ratio, %
1	19	19
2	16	16
3	27	27
4	27	27
5	11	11
Sum	100	100
Grade Avg.	3.0	
Import		
Grade	Q'ty	Ratio, %
1	2	6.5
2	7	22.6
3	12	38.7
4	6	19.4
5	4	12.9
Sum	31	100
Grade Avg.	3.1	

boundary of each grade of 131 tractor models classified by the five-classification system.

As the rated power is the bigger, an energy efficiency becomes the better (Figure 7).

Figure 8 shows distribution of 131 tractor models classified by the classification grades. Although the distribution is not exactly the same as intended, it is acceptable for a reasonable classification.

After classifying by energy efficiency, the classified models were sorted by a several criterion.

At first, 131 tractor models were sorted by rated powers. Number and ratio of models sorted by rated powers were shown in Table 7.

Grade average of models sorted by rated powers was shown in Figure 9. Generally, an energy efficiency becomes

better as the rated power grows. However, it was not clear in our case, because of lack of data set.

Next, 131 tractor models were sorted by year, and their number and ratios were shown in Table 8.

Grade average of models was sorted by year (Figure 10). An energy-saving technology has taken effect over years.

Finally, 131 tractor models were sorted by area of product (Table 9). Domestic tractor models were more energy efficient than the imported tractor models by 0.06 in grade average.

Summary and Conclusions

This study was conducted to classify the energy efficiency of 131 tractor models produced from 2006 to 2010 in an authorized testing institution of South Korea. Four sub-indexes were developed using the fuel consumptions at 60% and 90% of rated speed with partial loads and at pull speeds of 3.0 km/h and 7.5 km/h with maximum drawbar pull. Weighting factors of the sub-indexes were also considered to reflect the characteristics of tractor's actual working hours in Korea. Four sub-indexes were integrated into a classification index. Using the developed classification index, a five-classification system was made on the basis of normal distribution of tractors over the classification range. Followings are conclusions of this study.

(1) The test result 131 tractor models produced from 2006 to 2010 were used to develop the classification index by energy efficiency.

(2) When fuel consumption data are not available at the standard PTO speed with varying load, a prediction method was adopted to supplement those data. proposed. At partial load at 60% and 90% of rated speed with partial load, the fuel consumption data at each operational point was predicted by another prediction model(Kim et al., 2011).

(3) Methods were proposed for the development of a classification index with four sub-indexes. A five-classification system(Kim et al., 2010) based on the normal distribution of classified tractors was carried out.

(4) Five-classification distribution of tractors can be used to rate tractors by energy efficiency.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgements

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