# Some Results of Research on Fuel Consumption of Freight Train in Ulaanbaatar Railway Company

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**Abstract:** The Ulaanbaatar Railway company spends 60% of all expenses for the locomotive. 44% of total expenses of locomotive are spent on diesel fuel consumption cost. Currently, there are few research works on effective determining of the fuel consumption norm in Mongolia. To determine this problem based on scientific basis has theoretical and practical significance. In this research, we have mentioned some research results on steam train fuel consumption.

**Key words**: Rheostat, correction, machine operator, locomotive, steam train

## Introduction

To reduce moving parts' fuel consumption is one of the main policies in the rail transport. 44% of total expenses of locomotive are spent on steam train fuel consumption.
Freight train fuel consumption expenses depend on many factors. Also, one of the machine operator's real work estimation is fuel amount used for travelling. It depends on operator's skill, train weight, road condition, weather condition, rheostat regulation and quality of maintenance.
The fuel consumption norm is determined in advance and the operator tries to spend without overestimating expenditure.
Most of the locomotive total exploitation expenses are spent on steam train tow fuel consumption.
That's why our goal is to determine the amount of the steam train fuel consumption expenses based on the research. Also, it's necessary to determine the amount of the freight train tow fuel consumption.

## 1. Fuel consumption research on freight train

The Mongolian Railway company Mongolyn Tumur Zam carries 90% of all freight transport within Mongolia. Most trains are headed by at least two locomotives. Railway development came late to Mongolia. Construction of the Trans-Mongolian line began in 1947, reaching Ulan Bator from the north in 1950 and the Chinese border in 1955. Before that the only railways in Mongolia had been a 43 km (27 mi) line (opened in 1938) connecting the coal mines at Nalaikh to the capital and a Soviet-built 236 km (147 mi) freight-only branch (completed in 1939) from Borzya on the Trans-Siberian Railway to Bayantumen, Dornod near Choibalsan in north-eastern Mongolia.

From year to year, demand of freight train is increasing. So, it is necessary to improve the railway and use the advance technologies nowadays. To reduce the fuel consumption of moving components is one of the main strategies of the rail transport.
35% - 40% of the total locomotive exploitation expenses are spent on the fuel consumption of steam train. That's why it's very important to use fuel energy properly.

Providing the condition uses the fuel energy properly can keep the standard without reducing the steam train capacity.
Currently, increasing the productivity of the steam train can open up the conditional which reduces the production cost.

Diesel fuel consumption depends on many factors. Also, one of the machine operator's real work estimation is fuel amount used for travelling. The fuel consumption norm is determined in advance and the operator tries to spend without overestimating expenditure.
We have defined that calculating method of locomotive fuel consumption norm refer to the pressure on one shaft, road condition, season, weather and operator's driving skill.

Steam train tow fuel consumption depends on many factors such as train weight, it's speed, weather, technical safety, human activity, quality of fuel, resistance of movement, train brake and road condition .
We have approved that improving driver's job skill can save the fuel, reduce the fuel loss of the consumption expenses and lengthen the time between maintenances.
In the past, supervisors didn't estimate driver's driving skill when they determined the freight train fuel consumption norm.
We think that it was mistaken decision which was made by the chairman.

To study the fuel consumption which is being changed relating to many factors based on the scientific basis will probably be innovative. Technical and economic indices of an engine affect steam train design and exploitation more.
Annual expenses of the steam train are shown in the following list:

| | | |
|---|---|---|
| 1. | Fuel | 44% |
| 2. | Lubricating materials | 2.5% |
| 3. | Preparation | 1.5% |
| 4. | Salary of locomotive brigade workers | 13% |
| 5. | Steam train maintenance | 8.2% |
| 6. | Cost of wear and tear | 17.2% |
| 7. | Recurrent expenses | 10.2% |
| 8. | Railway board expenses | 3.4% |

As the mentioned above, the steam train tow fuel consumption depends on the engine fuel consumption directly.

Table 1.Locomotive diesel engine's indices

| Indices | 10D100 | 2D100 | 11D45 | 14D40 | 1A-5D49 | PD1M |
|---|---|---|---|---|---|---|
| Normal capacity, kWt | 2210 | 1470 | 2200 | 1470 | 2250 | 880 |
| Coefficient of air excess<br>Cylindrical $\alpha$<br>Sum $\sum\alpha$ | 2.0<br>2.82 | 1.85<br>2.58 | 1.84<br>2.61 | 2.0<br>2.78 | -<br>2.15 | 2.1<br>2.28 |
| Combustion maximum pressure $p_z$, МПа | 15.1 | 8.6 | 10.8 | 10.6 | 11.1 | 6.4 |
| Fuel it's consumption,g/ kWt/h | 218 | 240 | 231 | 218 | 204 | 224 |

We have done the survey on 14D40 engine.

## 1. Locomotive fuel consumption regressive related to train weight

We have defined that the following equation depends on the freight train weight and fuel. Also, we have selected 3rd grade operators and carried out the calculation based on 119 travel results.

If tabling a correlation:
X-train weight (tone ) Y-fuel consumption (km/h).

| **x** | **y** | **$X^2$** | **$Y^2$** | **xy** |
|---|---|---|---|---|
| 1565 | 1425 | 2449225 | 2030625 | 2230125 |
| 1356 | 700 | 1838736 | 490000 | 949200 |
| 278.8 | 690 | 77729.44 | 476100 | 192372 |
| 858 | 1700 | 736164 | 2890000 | 1458600 |
| 851 | 1175 | 724201 | 1380625 | 999925 |
| 845 | 1800 | 714025 | 3240000 | 1521000 |
| 760 | 325 | 577600 | 105625 | 247000 |
| 1771 | 1250 | 3136441 | 1562500 | 2213750 |
| 1384 | 1175 | 1915456 | 1380625 | 1626200 |
| 2266 | 1135 | 5134756 | 1288225 | 2571910 |
| 2106 | 975 | 4435236 | 950625 | 2053350 |
| 1730 | 875 | 2992900 | 765625 | 1513750 |
| 1794 | 750 | 3218436 | 562500 | 1345500 |
| 2562 | 1175 | 6563844 | 1380625 | 3010350 |
| 1267 | 625 | 1605289 | 390625 | 791875 |
| 2909 | 1050 | 8462281 | 1102500 | 3054450 |
| 2362 | 975 | 5579044 | 950625 | 2302950 |
| 1262 | 400 | 1592644 | 160000 | 504800 |
| 540 | 538 | 291600 | 289444 | 290520 |
| 1934 | 1300 | 3740356 | 1690000 | 2514200 |
| **107983.8** | **121791** | **144234429** | **162010289** | **123299174** |

If we describe average of collections:

$$\bar{\mathrm{X}} = \frac{1}{n}\sum X_i = \frac{1}{119} \bullet 107983.8 = 907.42$$

$$\bar{\mathrm{Y}} = \frac{1}{\mathrm{n}}\sum \mathrm{Y_i} = \frac{1}{119} \bullet 121791 = 1023.45$$

If we describe average squired gradient:

$$\sigma_X^2 = \frac{1}{\mathrm{n}}\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{X_i^2} - (\bar{\mathrm{X}})^2 = 1205134.605$$

$$\sigma_Y^2 = \frac{1}{\mathrm{n}}\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{Y_i^2} - (\bar{\mathrm{Y}})^2 = 1352628.9$$

From it, if we describe the correlated variation:

$$r_{XY} = \frac{n\sum_{i=1}^{n} X_i \bullet \mathrm{Y_i} - \sum_{i=1}^{n} X_i \bullet \sum_{i=1}^{n} \mathrm{Y_i}}{\sqrt{\left[n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2\right] \bullet [n\sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2]}} = 0.82$$

As seen from this correlated variation, the dependences relate to each other.
α=0.05 for belief level, the correlation coefficient which was described by collection method selects in p=0.95 technicality .
If we check influence:

$\mathrm{t_{турш}} = \dfrac{\mathrm{r} \bullet \sqrt{\mathrm{n}-2}}{\sqrt{1-\mathrm{r}^2}} = 15.49$ $t_{1-\alpha,k} = t_{0.95,117} = 13.35$ болж $\mathrm{t_{турш}} > t_{1-\alpha,k}$ belief in dependence was approved.

If we describe correlated variation:

$$k_{XY} = \frac{1}{n}\sum_{i=1}^{n} X_i \bullet Y_i - \bar{X} \bullet \bar{Y} = 1028323.3$$

To write the regressive equation, we have defined the following coefficients:

$$r_{y/x} = \frac{k_{XY}}{\sigma_X^2} = 0.853$$

$$r_{x/y} = \frac{k_{XY}}{\sigma_Y^2} = 0.76$$

As a result of math solving, the regressive equations were mentioned below.

$y_x - \bar{y} = 0.853(x - \bar{x})$ $\qquad$ $x_y - \bar{x} = 0.86(y - \bar{y})$

$y_x = 0.853x - 774$ $\qquad$ $x_y = 0.86y + 880.167$

**Conclusion**

1. As a result of the research, the freight train locomotive fuel consumption was solved by the regressive equation relating to the train weight.

2. As a result of the regressive equation, we have concluded that it's necessary to renew the amount of fuel consumption is used in UB Railway company relating to load weight.

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