

## EVALUATING THE WORKING EFFICIENCY OF TRANSPORTATION MEANS AT MEAT PROCESSING WORKS

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### **Abstract**

*Transportation works are important link of every production activity and they considerably affect the producing costs. The study present the analysis of working efficiency of transportation means using the example of meat processing factory. To solve the problem, the structure of transporting routes covered at analyzed works, number and localization of goods receive sites as well as the amounts and types of transportation means used must have been determined. Then the software making possible to evaluate the efficiency of transportation means work at a production facility was worked out. Calculations were performed using data from meat processing works in Górnio. The work efficiency results for particular vehicles used to transport produced goods to shops were presented in a form of indicators in tables.*

*Performed study revealed that mean amount of carriages under analyzed conditions was 0.492 t, average effective work time 1.39 h, average operative work time 6.5 h, mean uploading and unloading time 2.2 h. Average efficiency of transportation means during the effective time was 0.37 t/h, while during operative time 0.07 t/h, mean labor inputs 10.9 working hours, mean distance covered with no load 36.9 km, whereas with a load 69.3 km.*

**Keywords:** *transport, work efficiency, meat processing*

### **1. Introduction**

Transport is a very important link of every producing system. The share of activities associated with a transport, depending on the production type, varies and reach up to above 50% of all works made. Raw material supply, product shifting at all production stages, delivery of a final products to receivers are activities that make up a considerable percentage of the total costs. Production and distribution costs greatly affect the prices, which are one of the most important factors determining the market success of a product. Decrease of transportation costs can be achieved by various methods. Resources in outer transport associated with raw material supply and product distribution, are largest. Works upon new solutions applied for diesel engines have been conducted all the time; their purpose is to decrease the unit fuel utilization [4, 8], or applying alternative fuels [1]. The transportation organization is an important element that should be subjected to detailed analysis. In the case of advanced transportation networks consisting of large number of loads dispatch and receive points, as well as many transportation means, a man cannot organize the transportation process in an appropriate way, instead he should use a software system helping in optimizing the transport [7]. The optimization has to be performed in accordance to a particular purpose function resulting from accepted criteria. Kuboń and Cupiał [6] gave list of 6 criteria for transport optimization. Within the time criterion, minimization of transportation process duration or maximization of effective work time utilization, which can be used at limited transportation terms. The route criterion may be composed of three purpose functions: minimum of the total route helpful at designing the optimum schemes of uniform loads transport applying uniform transportation means, minimum route with no load, or maximum utilization of a route with load at

limited terms, reserves of transportation means, and necessity of taking a load with the return courses, minimum of average distance at the necessity to ensure the transportation work and saving exploitation materials. The efficiency criterion is applied at limited terms and large amounts of transported material. Minimization of means is a purpose function for the criterion of needs for technical means – applied at reduced transportation means reserves. Minimum inputs for a given work can be a purpose function for the work criterion – it can be applied at limited labour reserves or maximum; or maximum work effectiveness – applied at limited labour reserves and work terms. The inputs criterion can be realized in accordance to purpose function of transportation costs minimization under condition that the economic assessment of transportation means is made or investment inputs for technical means are minimized, if there is no doubt that applying a given variant is equivalent to other ones, from a point of view of own costs.

Providing a manager with the access to information on the efficiency of transportation means utilization is crucial. Staff of Department of Agricultural Machines and Devices, University of Agriculture in Cracow (Kokoszka et al. [2, 3], Kuboń [5], and many others), are involved in works on similar subjects.

## 2. Aim of study

Making decision on transportation process realization by assessing the types of transportation means, devices for uploading and unloading, number of people, or a sequence of receive points visited by particular vehicles, determines the efficiency of transportation means, which in turn affects the profits. Taking into account the owner's need to monitor the way of vehicles utilization, a solution was presented below.

The study aimed at evaluating the efficiency of transportation means work on an example of meat processing works, through determining:

- conditions the transport is made,
- work efficiency of transportation means,
- labor inputs,
- route utilization,
- load capacity utilization.

In order to achieve the assumed goals, a structure of transport realized at studied works, evaluate the number and localization of loads supply sites, amount and types of transportation means used, software making possible to assess the work effectiveness of transportation means, perform calculations, and verify the correctness of created software, should be determined.

## 3. Studied object and methods

The meat works SMAK-Górno was founded in 1991. Its main activities are: swine slaughter, swine halves dissection, meat products production: ham, smoked products, offal products, and poultry products (production capacity up to 15 tons daily). Works sells its products in 10 own shops and about 500 other trading centers in Podkarpacie (85% of trade, mainly Przemyśl, Jarosław, Lesko, Sanok, Krosno, Jasło, Dębica, Tarnobrzeg, Stalowa Wola, Nisko, Rzeszów, Ropczyce, Sędziszów), Lublin (5% of trade, mainly Lublin and neighborhood), and Małopolska region (10% of trade, mainly Gorlice, Myślenice, Kraków). It is continuously supervised by veterinary control, and possesses traditional and modern technologies. SMAK-Górno pays special attention to storage and transport conditions, which obviously affects the high quality of its products [10].

The works has 20 vehicles for its own, including 11 trucks of up to 1500 kg capacity each and 4 vehicles of higher capacities. Detailed data on trucks are presented in Tab. 1. When delivering raw material to production or distributing products to receivers, 4 cars make their routes 6 days

a week, 2 cars – five days, and 4 cars – four days a week. Other vehicles are used depending on the needs. The shortest route covered by a single car is about 120 kilometers daily. Average length of a route is about 200 kilometers. Four times a weeks, cars cover about 350 kilometers each, while once a week – 520 kilometers. Vehicle of the largest capacity (for live swine transport) makes its routes five times a week at the route length of about 150 kilometers.

Tab. 1. List of vehicles used at SMAK Górnio meat processing works

No	Make of a vehicle	Type of vehicle	Registration number	Year of production	Total weight/ Load capacity
1	STAR 1142	Truck	RZE 12GH	1992	11650 4150
2	IVECO 120 E18	truck, eurocarg cooler	RZE L204	1998	11990 5010
3	IVECO STRALIS AD 260S35 Y/P	truck, special for livestock	RZE 47KX	2004	23500 11100
4	IVECO DAILY 65C15	truck, cooler	RZE 82JY	2004	6500 3100
5	IVECO DAILY 35S12	truck, cooler	RZE 80JY	2004	3490 1150
6	IVECO DAILY 35S12	truck, cooler	RZE 81JY	2004	1490 1150
7	IVECO DAILY 35C14	truck, isotherm	RZE 3G95	2006	3490 750
8	IVECO DAILY 35C14	truck , isotherm	RZE 3G94	2006	3490 750
9	VW CADDY 1.4	truck , van	RZE C005	2000	3490 750
10	DAEWOO SUPA MATIZ	truck	RZE 4N76	2006	1690 675
11	DAEWOO SUPA MATIZ	truck	RZE 01SA	2005	1340 564
12	DAEWOO SUPA MATIZ	truck	RZE 98RF	2005	1340 564
13	DAEWOO SUPA MATIZ	truck	RZE 71HU	2003	1364 564
14	PEUGOT 206 XA 1.4 HDI	truck	RZE 54F1	2007	1210
15	PEUGOT 206 XA 1.4 HDI	truck	RZE 14F5	2007	1525 551

Many factors resulting from the specificity of the production have effects on transporting means work effectiveness; possible velocity, load capacity utilization, as well as efficiency greatly affect the amount of inputs for transport. Therefore, to evaluate the work efficiency of transportation means, a variety of general indicators are applied, including: route and load capacity utilization indicator, mean technical and exploitation velocity, as well as transport effectiveness, and work time.

Based on a study by Şek [9], general technical, exploitation, and economic indicators referring to transportation means work were determined, which allowed for assessing the efficiency of carriage performed:

- a) carriage capacity: as a sum of loads transported within inner and outer transport determined on a base of driving cards.
- b) transportation means equipment: on a base of a poll and qualitatively expressed as the total and unit load capacity of transportation means.
- c) working time of transportation means [h]:

$T_i$  - effective time (driving with a load),  
 $T_{02}$  - operating time (driving with a load and empty + time of uploading and unloading),  
 $T_{04}$  - labor time ( $T_{02}$  + time for technical and technological stops),  
 $T_{07}$  - exploitation time ( $T_{04}$  + time of organizational breaks).

d) work efficiency of transportation means [t/h]:

- during effective time ( $W_i = Q/T_i$ ),
- during operating time ( $W_{02} = Q/T_{02}$ ),
- during labor time ( $W_{04} = Q/T_{04}$ ),
- during exploitation time ( $W_{07} = Q/T_{07}$ ),

where  $Q$  – quantity of transported tons.

e) labor inputs [working hours]:

$$N_{rbh} = (T_z * i_z) + (T_f * i) + (T_w * i_w),$$

where:

$T_z$  - uploading time [h],  
 $i_z$  - number of stuff employed at uploading [os],  
 $T_w$  - unloading time [h],  
 $i_w$  - number of stuff employed at unloading [os],  
 $T_j$  - driving time with a load and empty [h],  
 $I$  - number of stuff employed during driving with a load and empty [os].

f) route utilization [%]:

$$B = L_i / (L_o + L_i)$$

where:

$L_o$  - length of driving with no load,  
 $L_i$  - length of drive with a load.

g) load capacity utilization [%]:

$$C = Q / Q_c,$$

where:

$Q$  – weight of a single load [kg],  $Q_c$  – load capacity of transportation mean [kg].

h) driving velocity [km/h]:

- technical:  $v_t = L/T_i$ , [km/h],
- exploitation:  $v_e = L/T_{07}$  [km/h]:

where:

$L$  - distance with a load,  
 $T_i$  - driving time with a load and empty,  
 $T_{07}$  - exploitation time.

i) indicator of loading works mechanization [%J]:

$$P_m = Q_m / (Q_m + Q_v) * 100$$

$Q_m$  - mechanically-done loading works [t],  
 $Q_v$  - manually-done loading works [t].

## 4. Results

To evaluate the efficiency of transportation means utilization, a software was worked out based on Borland Delphi ver. 7.0 environment. Minimum system requirements for the application are: timing 200MHz, 32 MB RAM, screen and graphic card displaying at least 800 x 600 pixels pictures. The software consists of forms, where particular components are located. Fig. 1 presents form for adding and editing the driving cards. The window contains data on subsequent route points, detailed address, receiver code, weight of transported loads, number of containers, kilometers driven, and current meter reading. The field for vehicle selection is placed at the bottom

of the form. Values of the component begin from the registration number and make of a car, and ending with the notes on the vehicle type. After selecting the vehicle, detailed information on it (year of production, driver's name, total and maximum weight, permissible load) are displayed on the right.

The screenshot shows a software window titled "Wprowadzanie danych". It contains a table with 16 rows of vehicle data. The table has columns: Lp, Miejscowosc, Adres, Kod, Masa, Pojemniki, Kilometry, and Stan licznika. Row 5 is highlighted. To the right of the table are three buttons: "Oblicz efektywność", "Zapisz kartę", and "Powrót do menu głównego". Below the table is a section for editing card data, including a dropdown menu for vehicle selection, a date field (29.02.2008), and fields for loading/unloading personnel. On the right of this section is a box with vehicle details: Marka (IVECO DAYLY ~ 65C14), Nr rej. (RZE 3G94), Rodzaj (ciężarowy, izoterma), Masa całkowita (3490 kg), Ładowność (750 kg), Kierowca (Dziadosz Wiesław), and Rok prod. (2006). At the bottom of this section are three buttons: "Dodaj pozycję", "Edytuj pozycję", and "Usuń pozycję".

Lp	Miejscowosc	Adres	Kod	Masa	Pojemniki	Kilometry	Stan licznika
2	Raniżów	Rynek 7	349	34	2	18	73709
3	Kolbuszowa	Rzeszowska 7	985	90,2	5	15	73724
4	Rzeszów	Broniewskiego 24A	4628	103,7	7	31	73755
5	Rzeszów	Okulickiego 10	7439	27,6	2	1	73756
6	Rzeszów	Podchorążych 3	4334	19,2	2	3	73759
7	Rzeszów	Podchorążych 3	7926	10,6	2	0,5	73759,5
8	Rzeszów	Warszawska 5/7	4650	10,5	1	1	73760,5
9	Rzeszów	Bohaterów 2	4626	44,2	4	2	73762,5
10	Rzeszów	Bohaterów 5	7829	22,2	2	0,5	73763
11	Rzeszów	Bohaterów 62	4645	51	4	0,5	73763,5
12	Rzeszów	Dąbrowskiego 60	612	50,7	4	2	73765,5
13	Rzeszów	Dąbrowskiego 79	4629	56,1	3	0,5	73766
14	Rzeszów	Krzywoustego 12	4634	22	2	0,5	73766,5
15	Rzeszów	Asnyka 12	4303	34	4	4	73770,5
16	Górno	Górno 104	Smak	0	0	8	73778,5

Fig. 1. Form for editing the driving card data

Below car selection component, there is editing field containing date of the driving card. Panel of stuff employed at uploading or unloading is located on the right of the date field. Bottom part of the form contains three buttons for moving between card's fields. The first one is for adding new

The screenshot shows the "Dane karty" editing panel. It includes a dropdown menu for vehicle selection (currently showing "[ RZE 3G94 ] - IVECO DAYLY ~ 65C14 - ciężarowy, izoterma"), a date field (29.02.2008), and fields for loading/unloading personnel. On the right is a box with vehicle details: Marka (IVECO DAYLY ~ 65C14), Nr rej. (RZE 3G94), Rodzaj (ciężarowy, izoterma), Masa całkowita (3490 kg), Ładowność (750 kg), Kierowca (Dziadosz Wiesław), and Rok prod. (2006). Below this is a section for "Pozycja na karcie" with fields for Miejscowosc, Adres, Kod odbiorcy, Masa towaru [kg], Ilość pojemniow, Ilość kilometrów, and Stan licznika. At the bottom are three buttons: "Zapisz", "Anuluj", and "Czyść".

Fig. 2. Editing panel from the driving card

item, second for editing the item, and third for deleting the item from the list on card. Clicking any of the first two buttons results in displaying the panel for adding or editing the item on the card's list. The panel is presented in Fig. 2.

It consists of several editing fields that may accept identical values as corresponding fields on the driving card. At the bottom, there are three buttons. The first one is for adding-editing the driving card item. Second, deletes input changes. Button "Czyść" deletes text from editing fields. On the right, there are three function buttons. Each is responsible for another action. Button marked „Oblicz efektywność” makes calculating procedures, then opens the result form discussed

further. Second button writes entered data to a file. Data are written to a file with „\*.cat” extension. Format of the file is „packed record”, thus it is not possible to edit the file using other software. During the writing, the software suggests the file name in a format „registration\_number\_card\_date.cat”. Suggesting the file name ensures the right order of written driving cards in a database. The third button of the form is for returning to the main form of the application. Its clicking makes the loss of all unwritten data. Last mentioned form is for results and it is presented in Fig. 3.

**obliczenia**

**TABELA WYNIKÓW EFEKTYWNOŚCI ŚRODKA TRANSPORTOWEGO**

Wielkość przewozów [t]	0,54
Czas pracy środków transportowych fhj [h]	
- czas efektywny - Ti	1,01
- czas operacyjny - T02	5,71
- czas załadunku - Tz	2,05
- czas wyładunku - Tw	2,05
Wydajność pracy środków transportowych [t/h]	
- w czasie efektywnym - Wi	0,5
- w czasie operacyjnym - W02	0,1
Nakład robocizny - Nr <sub>bh</sub> [rbh]	9,8
Wykorzystanie przebiegu	
- odległość jazdy bez ładunku - Lo [km]	30,00
- odległość jazdy z ładunkiem - Li [km]	50,60
- wykorzystanie przebiegu - B [%]	62,8
Wykorzystanie ładowności - C [%]	7,2
Prędkość jazdy [km/h]	50

>> Powrót <<

>> Zapisz wyniki <<

Fig. 3. Form of results

The results form consists of three components, two buttons, and the table of results. The table of results lists calculations for particular efficiency indicators of a given transportation mean. It presents such values as: carriage capacity, effective and operative time, uploading and unloading times, work efficiency during effective and operative times, labor inputs, route and load capacity utilization, as well as working velocity of a transportation mean. The file is written in csv format, and fields are separated with the semicolon. Due to that format, results can be exported to outer files of Microsoft Excel® or other worksheet. To export a file, button marked with „>> zapisz wyniki <<” should be pressed. The last component is for the return to previous form.

Using presented software, calculations were performed and their results in a form of variables describing work effectiveness of selected trucks, were presented in Tab. 2, 3 and 4.

Tab. 2. Work effectiveness results for car RZE 82JY

Date	Load [kg]	Ti [h]	T0[h]	Tz	Tw	Wi	W02	Nrbh [wh]	Lo [km]	Li [km]	B [%]	C [%]
25.02.2008	487	2.04	6.68	1.95	1.95	0.24	0.07	10.6	37	102	73.4	18.2
26.02.2008	509.8	1.62	7.08	2.2	2.2	0.31	0.07	11.5	53	81	60.4	19.3
27.02.2008	742.5	2.22	9.52	3	3	0.33	0.08	15.5	65	111	63.1	27.8
28.02.2008	412.6	1.27	5.91	1.8	1.8	0.33	0.07	9.5	52	63.4	54.9	15.6
29.02.2008	823.9	1.78	8.94	3.15	3.15	0.46	0.09	15.2	43	89	67.4	30.6
01.03.2008	465.6	1.72	7.32	2.3	2.3	0.27	0.06	11.9	50	86	63.2	18

Tab. 3. Work effectiveness results for car RZE 3G95

Date	Load [kg]	Ti [h]	T0[h]	Tz	Tw	Wi	W02	Nrbh [wh]	Lo [km]	Li [km]	B [%]	C [%]
24.02.2008	189.1	0.96	3.58	0.95	0.95	0.197	0.05	5.5	36	48	57.1	30.3
25.02.2008	521.9	2	7.2	2.45	2.45	0.261	0.07	12.1	15	100	87	82.7
26.02.2008	617.6	1.14	8.16	3.15	3.15	0.542	0.08	14.5	36	57	61.3	99.1
28.02.2008	428.5	1.05	6.77	2.5	2.5	0.408	0.06	11.8	36	52.5	59.3	70.5

Tab. 4. Work effectiveness results for car RZE 80JY

Date	Load [kg]	Ti [h]	T0[h]	Tz	Tw	Wi	W02	Nrbh [wh]	Lo [km]	Li [km]	B [%]	C [%]
25.02.2008	538.3	1.11	6.51	2.4	2.4	0.483	0.08	11.3	30	55.7	65	55.2
26.02.2008	587.9	1.09	5.99	2.15	2.15	0.538	0.1	10.3	30	54.6	64.5	58.6
27.02.2008	447.4	1.07	5.97	2.15	2.15	0.418	0.07	10.3	30	53.5	64.1	46.4
28.02.2008	214.9	1.2	3.6	0.9	0.9	0.179	0.06	5.4	30	60.2	66.7	21.8
29.02.2008	535.2	1.01	5.71	2.05	2.05	0.529	0.09	9.8	30	50.6	62.8	53.7

Data for calculations are taken from the driving cards made by drivers at SMAK-Górno meat processing works. The calculations were performed applying the software that used dependencies presented in previous chapter describing methodology of calculations of transportation means work efficiency. Tab. 5 presents average values of work efficiencies for analyzed vehicles.

Tab. 5. Work effectiveness results for all studied vehicles

Registration number	Load [kg]	Ti [h]	T0[h]	Tz	Tw	Wi	W02	Nrbh [wh]	Lo [km]	Li [km]	B [%]	C [%]
RZE 82JY	573.6	1.78	7.58	2.40	2.40	0.32	0.07	12.4	50.0	88.7	63.7	21.6
RZE 3G95	439.3	1.29	6.43	2.26	2.26	0.35	0.07	11.0	30.8	64.4	66.2	70.7
RZE 80JY	464.7	1.10	5.56	1.93	1.93	0.43	0.08	9.4	30.0	54.9	64.6	47.1
Mean	492.53	1.39	6.52	2.20	2.20	0.37	0.07	10.9	36.9	69.3	64.8	46.5

## 5. Conclusions

The work efficiency of discussed vehicles can be univocally determined on a base of calculated indicators. Performed study revealed that mean amount of carriages under analyzed conditions was 0.492 t, average effective work time 1.39 h, average operative work time 6.5 h, mean uploading and unloading time 2.2 h. Average efficiency of transportation means during the effective time was 0.37 t/h, while during operative time 0.07 t/h, mean labour inputs 10.9 working hours, mean distance covered with no load 36.9 km, whereas with a load 69.3 km. The route and load capacity utilization are the most important calculated indicators. They reached up the following values: 64.8% and 46.5%, respectively.

These values would be more beneficial in the case of better planning the subsequent route stages and better utilization of applied vehicles load capacity. A proper selecting of transportation means to the works' needs is also crucial. It reflects in lower exploitation costs, i.e. sum spent on a transport of goods in an enterprise during the long-term utilization of a vehicle.

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