TEKA. COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE – 2012, Vol. 12, No. 1, 331–336

Power demand in respect of environmentally friendly works carried out in motor transport facilities

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Summary. The paper presents issues related to modelling an ecological strategy by taxonomic method for motor transport facilities. It describes the methodology and justifies the purpose of the application of the said method to assess environmental issues. Based on the example of the power demanded for the execution of environmentally friendly works in a company, the method, calculation results and their interpretation in respect of the selection of a technology suitable for the application were presented.

Key words: motor transport, ecological problems, taxonomic method.

INTRODUCTION

The development of motor transport stimulated by the increase in the number of vehicles used as well as by infrastructure investments has an adverse effect on the natural environment. The environment is adversely affected by combustion gases emitted by cars and by pollutants coming from motor transport facilities [5,15,18]. The pollution of the air by combustion gases and the excessive noise level are among the most important environmental risks occurring in motor transport facilities. The management and utilization of operating fluids, such as, for instance engine and gear oils, coolants from cooling or air-conditioning systems pose a big problem, too.

In order to remedy the adverse effect of motor transport on the natural environment any kind of environmentally conscious action should be undertaken. Appropriate country-specified governmental regulations on reducing the material consumption index, energy consumption as well as the costs of production, operation and recycling of worn-out vehicles are important in the easing of the adverse effect of motor transport on the environment, too [7,8,10]. The legal regulations regarding ecological safety should also apply to the functioning of motor transport facilities that are essential for normal use of vehicles.

The use of the taxonomic method allows dendrite ordering that is better to reproduce the positions of the examined factors in the multidimensional parameter space, as opposed to all kinds of optimization method that allow only linear ordering of selected indexes for problems arising in motor transport facilities [1,6,14].

A TAXONOMIC ANALYSIS OF POWER CONSUMPTION IN RESPECT OF ENVIRONMENTALLY CONSCIOUS ACTION

The application of the taxonomic method to analyse environmental problems in motor transport facilities results from the fact that describing technological issues involves parameters that are different physical quantities by nature and are measured using different units. The structure of taxonomic models allows linear ordering for the technologies under research [12,20].

For the purpose of this paper, the power demanded to conduct environmentally conscious action was chosen to be analysed by taxonomic method. Power consumption for environmental purposes is extremely essential in any company's economic balance, especially as there is an upward trend in the energy market [4,9,13]. Power consumption related data was received from 15 companies. The unit of measure adopted for the research was kWh/mth. The selected companies have different ownership and organisational structures and offer motor transport services. Some of the companies provided us with their documents and other materials related to the logistic action taken for environmental protection on condition that their business names and affiliations were not revealed; therefore, in this paper they are called "technologies".

Since the taxonomic method requires selection of the most favourable variant on account of the criteria adopted, three additional parameters (the so called model ones) were singled out for comparison purposes. They refer to: emission of CO_2 to the environment (WP1), total amount of waste materials (WP2), overall "waste quality" in terms of toxicity (WP3). The fourth model parameter is power demand in respect of environmentally friendly works (WP4). Table 1 includes the model parameters selected for calculations and their corresponding units of measure [19].

Table 1. Parameters for pro-ecological assessment of a technical infrastructure of transport selected for analysis

No	Parameter symbol	Parameter type	Measurement unit
1.	P1	Emission of carbon dioxide (CO_2) to atmosphere	[kg/rok]
2.	P2	Total quantity of material waste	[kg/rok]
3.	P3	Overall „quality" of generated waste (toxicity)	[0-1]*
4.	P4	Energy demand with reference to pro-ecological projects	[kWh/m-c]

* 0 - lowest, 1 - highest

The collection of data related to those parameters involved sometimes considerable difficulties. The documents provided by some of the companies included insufficient data, their employees responsible for these issues were incompetent, and the like. So, the information regarding separate parameters is in many cases the result of additional analyses of the number of inspections, repairs, diagnostic testing and other services rendered within a specified time period. The data adopted for the parameters singled out were repeatedly consulted with the companies' technical inspectors and employees hired for specific jobs to ensure that credible results are obtained.

INTERPRETATION OF THE RESEARCH RESULTS

In this paper, the results obtained by taxonomic method have been additionally verified by Czekanowski's matrices. In the case of similarity of the results it can be concluded that the procedure adopted for the calculations was correct, which entitles us to explicitly interpret the results in the conclusions. The order of the connected points and the values of the mean differences between those points are of fundamental importance when analysing the results and drawing the conclusions. The closeness and the clustering of specified technologies show that the parameter concerned is similar, which allows selection of an optimal quantity [11,17].

The research results have been collated in tables and presented graphically in the form of dendrites and Czekanowski's matrices, namely:

- **Table 2** – collation of the analysed parameters for all the companies under research,
- **Table 3** – the parameter values determined by taxonomic method for the lowest power consumption for environmentally friendly works, in 5 of the companies under research,
- **Table 4** – mean differences between the technologies under research (according to Table 3),
- **Table 5** – Czekanowski's diagonal matrix (verification Fig. 2),
- **Table 6** – the parameter values determined by taxonomic method for the mean power consumption for environmentally friendly works, in 5 of the companies under research,
- **Table 7** – mean differences between the technologies under research (according to Table 6),
- **Table 8** – Czekanowski's diagonal matrix (verification Fig. 3),
- **Table 9** – the parameter values determined by taxonomic method for the higher power consumption for environmentally friendly works, in 5 of the companies under research,
- **Table 10** – mean differences between the technologies under research (according to Table 9),
- **Table 11** – Czekanowski's diagonal matrix (verification Fig. 4),
- **Fig. 1** – dendritic differentiation of technologies according to power consumption for the 5 lowest values,
- **Fig. 2** – dendritic differentiation of technologies according to power consumption for the 5 mean values,
- **Fig. 3** – dendritic differentiation of technologies according to power consumption for the 5 highest values.

Table 2. Analysed parameters for the 15 companies under research (including the model parameters)

Technology \ Parameters	P1	P2	P3	P4
1	929	58 518	0,35	800
2	1 328	63 372	0,72	900
3	1 679	55 846	0,27	950
4	1 000	31 982	0,26	600
5	2 647	113 516	0,13	975
6	1 221	48 288	0,49	740
7	3 017	106 424	0,31	250
8	1 921	84 961	0,87	1000
9	1 395	62 282	0,59	430
10	896	55 423	0,70	740
11	1 093	63 230	0,18	800
12	4 329	161 326	0,19	940
13	2 247	57 013	0,64	800
14	1 444	65 510	0,25	850
15	2 309	124 893	0,13	900

WP1	672	41 568	1	555
WP2	750	23 987	1	450
WP3	1 441	63 721	1	750
WP4	2 262	79 818	1	187,5

Table 3. Parameters according to power consumption for the 5 lowest values from among 15 companies

Technology \ Parameters	P1	P2	P3	P4
7	3 017	106 424	0,31	250
9	1 395	62 282	0,59	430
4	1 000	31 982	0,26	600
6	1 221	48 288	0,49	740
10	896	55 423	0,70	740
WP1	672	41 568	1,00	555
WP2	750	23 987	1,00	450
WP3	1 441	63 721	1,00	750
WP4	2 262	79 818	1,00	188

Table 4. Mean differences between the technologies under research (according to Table 3)

Technology	7	9	4	6	10	WP1	WP2	WP3	WP4
7		4301,99	7215,07	5704,15	5079,70	6315,27	7981,52	4214,46	2577,86
9	4301,99		2918,23	1812,08	1044,95	2121,03	3682,79	550,84	1883,30
4	7215,07	2918,23		1572,25	2252,50	1009,37	783,42	3058,33	4645,56
6	5704,15	1812,08	1572,25		1145,92	970,27	2352,95	1677,59	3221,37
10	5079,70	1044,95	2252,50	1145,92		1342,40	3019,58	893,54	2626,04
WP1	6315,27	2121,03	1009,37	970,27	1342,40		1689,32	2163,82	3809,71
WP2	7981,52	3682,79	783,42	2352,95	3019,58	1689,32		3837,11	5411,25
WP3	4214,46	550,84	3058,33	1677,59	893,54	2163,82	3837,11		2001,91
WP4	2577,86	1883,30	4645,56	3221,37	2626,04	3809,71	5411,25	2001,91	

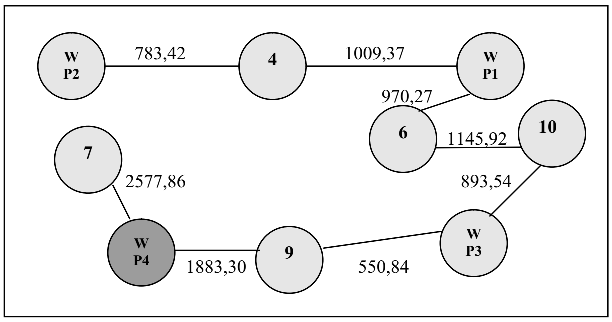


Fig. 1. Dendritic differentiation of technologies according to power consumption for the 5 lowest values

Table 5. Czekanowski's diagonal matrix (dendrite verification according to Fig. 1)

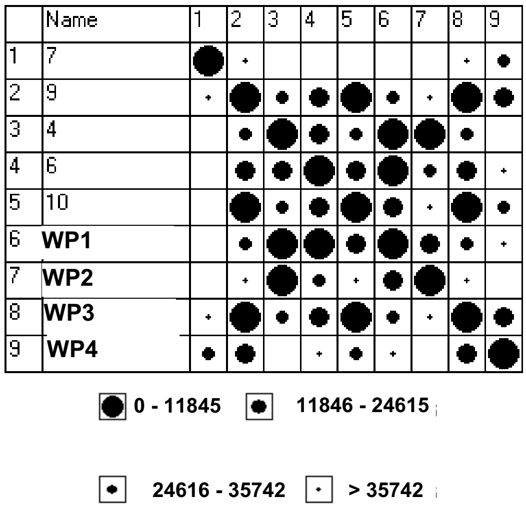


Table 6. Parameters according to power consumption for the 5 mean values from among the companies under research

Technology \ Parameters	P1	P2	P3	P4
13	2 247	57 013	0,64	800
1	929	58 518	0,35	800
11	1 093	63 230	0,18	800
14	1 444	65 510	0,25	850
2	1 328	63 372	0,72	900
WP1	672	41 568	1,00	555
WP2	750	23 987	1,00	450
WP3	1 441	63 721	1,00	750
WP4	2 262	79 818	1,00	188

Table 7. Mean differences between the technologies under research (according to Table 6)

Technology	13	1	11	14	2	WP1	WP2	WP3	WP4
13		839,54	1221,75	1207,25	931,81	1623,59	3238,84	802,90	2539,55
1	839,54		1567,27	966,97	886,19	1707,93	3320,58	1080,33	2371,91
11	1221,75	1567,27		1264,60	851,67	2251,43	3776,22	912,86	1757,25
14	1207,25	966,97	1264,60		479,62	2335,36	4011,45	745,66	1824,96
2	931,81	886,19	851,67	479,62		2127,11	3803,37	357,72	1812,33
WP1	1623,59	1707,93	2251,43	2335,36	2127,11		1689,32	2163,82	3809,71
WP2	3238,84	3320,58	3776,22	4011,45	3803,37	1689,32		3837,11	5411,25
WP3	802,90	1080,33	912,86	745,66	357,72	2163,82	3837,11		2001,91
WP4	2539,55	2371,91	1757,25	1824,96	1812,33	3809,71	5411,25	2001,91	

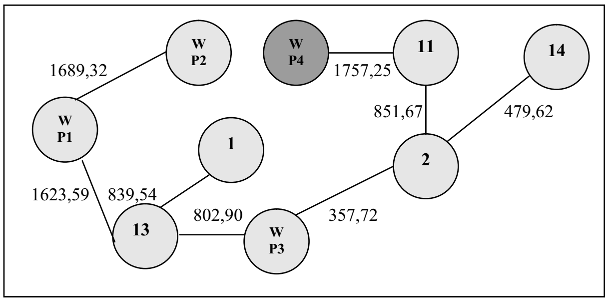
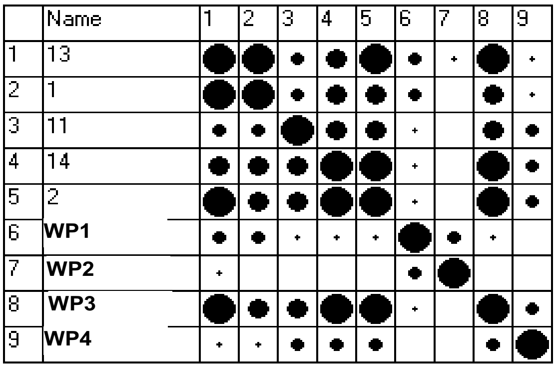


Fig. 2. Dendritic differentiation of technologies according to power consumption for the 5 mean values

Table 8. Czekanowski's diagonal matrix (dendrite verification according to Fig. 2)



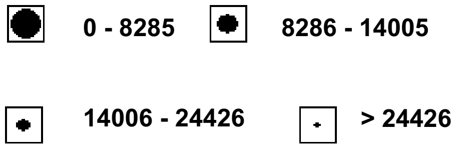


Table 9. Parameters according to power consumption for the 5 highest values from among 15 companies

Technology \ Parameters	P1	P2	P3	P4
15	2 309	124 893	0,13	900
12	4 329	161 326	0,19	940
3	1 679	55 846	0,27	950
5	2 647	113 516	0,13	975
8	1 921	84 961	0,87	1000
WP1	672	41 568	1,00	555
WP2	750	23 987	1,00	450
WP3	1 441	63 721	1,00	750
WP4	2 262	79 818	1,00	188

Table 10. Mean differences between the technologies under research (according to Table 9)

Technology	15	12	3	5	8	WP1	WP2	WP3	WP4
15		3703,76	6617,01	2029,78	4225,07	8037,54	9714,72	5919,93	4383,47
12	3703,76		10182,73	4645,04	7466,31	11609,48	13285,65	9450,61	7901,15
3	6617,01	10182,73		5562,80	2813,09	1568,22	3105,89	989,99	2590,46
5	2029,78	4645,04	5562,80		3767,05	7041,35	8650,23	5360,95	3710,97
8	4225,07	7466,31	2813,09	3767,05		4220,54	5896,81	2060,95	1091,67
WP1	8037,54	11609,48	1568,22	7041,35	4220,54		1689,32	2163,82	3809,71
WP2	9714,72	13285,65	3105,89	8650,23	5896,81	1689,32		3837,11	5411,25
WP3	5919,93	9450,61	989,99	5360,95	2060,95	2163,82	3837,11		2001,91
WP4	4383,47	7901,15	2590,46	3710,97	1091,67	3809,71	5411,25	2001,91	

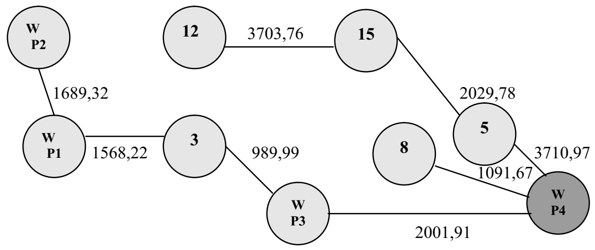


Fig. 3. Dendritic differentiation of technologies according to power consumption for the 5 highest values

Tabela 11. Czekanowski's diagonal matrix (dendrite verification according to Fig. 3)

	Name	1	2	3	4	5	6	7	8	9
1	15	⬤	●	+	⬤	•			+	•
2	12	●	⬤		•	+				+
3	3	+		⬤	+	●	⬤	●	⬤	●
4	5	⬤	•	+	⬤	•	+		+	•
5	8	•	+	●	•	⬤	•	•	⬤	⬤
6	**WP1**			⬤	+	•	⬤	⬤	●	●
7	**WP2**			●		•	⬤	⬤	●	•
8	**WP3**	+		⬤	+	⬤	●	●	⬤	⬤
9	**WP4**	•	+	●	•	⬤	●	•	⬤	⬤

⬤ **0 - 24835** ● **24836 - 48398**

• **48399 - 68685** + **> 68685**

CONCLUSIONS

Ordering environmentally friendly technologies in motor transport facilities with the use of the taxonomic method is an effective way to find the point determined using the defined criteria in the space of selected parameters. The taxonomic method can be used to effectively select logistic systems for environmental problems occurring in the motor transport sector [2,3,16]. It is also possible to verify the results of differentiation of environmentally friendly technologies with the use of Czekanowski's diagonal matrix.

The analysis of the results described in this paper allows their interpretation with respect to the usefulness of the technologies in question. Among the technologies with the lowest power consumed to carry out environmentally conscious action, the least energy-consuming is No. 7. It is close to the model technology WP4 but the gap between them is relatively wide. Within this group, technology No. 9 that is very close to the model technology WP3 and at the same time closer to the model technology WP4 than technology No. 7 is, looks best. It should be also emphasized that the dendritic differentiation made for the technologies of this group is linear, which makes it difficult to draw explicit conclusions.

Within the group of companies grouped according to the mean power consumption values, technologies 1, 11 and 13 are marked by the lowest values. However, the technology closest to the model one, WP4, is marked No. 11.

Within the group of companies with the highest power consumption for environmentally friendly works, among the 15 companies considered there is technology No. 8 that ranks closest to the model technology WP4. Attention should be also paid to technology No. 3 that is not the best in this company group but is close to the two model technologies WP1 and WP3 which may make one take it into consideration when designing motor transport facilities.

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ZAPOTRZEBOWANIE NA ENERGIĘ W ODNIESIENIU DO PRAC PROEKOLOGICZNYCH REALIZOWANYCH W ZAPLECZU TECHNICZNYM MOTORYZACJI

Streszczenie. W artykule przedstawiono zagadnienia dotyczące modelowania strategii ekologicznej w obiektach zaplecza transportu samochodowego metodą taksonomiczną. Opisano metodykę i uzasadniono cel wykorzystania tej metody do oceny zagadnień ekologicznych. Na przykładzie zapotrzebowania na zużycie energii potrzebnej do prowadzenia działań proekologicznych zaprezentowano metodę, wyniki obliczeń oraz ich interpretację odnośnie wyboru odpowiedniej technologii do aplikacji.

Słowa kluczowe: transport samochodowy, problemy ekologiczne, metoda taksonomiczna.