ACTA TECHNICA CORVINIENSIS
– Bulletin of Engineering
Tome IX [2016], Fascicule 3 [July– September]
ISSN: 2067 – 3809

[1.]Beata HRICOVÁ, [2.]Ervin LUMNITZER, [3.]Miriama PIŇOSOVÁ, [4.]Ružena KRÁLIKOVÁ

PAIRED COMPARISON METHOD WHEN ANALYZING MACHINERY

[1-4.]Technical University of Košice, Faculty of Mechanical Engineering, Department of Environmentalistics, Park Komenského 5, Košice, SLOVAKIA

Abstract: The assessment of the eco-friendly level of machinery and equipment is currently commonplace. Eco-friendly levels of each product are defined in the pre-production stages of the product's lifecycle. Pair comparison method is one of the several ways of assessing the environmental quality of the product. The assessment is based on four factors - technological, economic, environmental and social. The article provides specific examples of assessments carried out on the impact drills with different technical parameters made by one manufacturer.
Keywords: Environmental quality, product, impact drill, paired comparison

INTRODUCTION

Short-term thinking motivated by the idea of maximum profit often had had wide-ranging consequences lasting to the present. The Earth will probably never recover from the impact of heavy industrialization. On the one hand there is a heavy consumption of non-renewable resources, and on the other hand people use substances which are harmful and contaminate Earth's closed ecosystem. Devastation of natural resources and the nature itself has led to attempts to repair or preserve natural resources through the introduction of protected areas. However, these attempts merely dealt with the consequences of the harmful human behavior.

The efforts to preserve natural sources and eliminate adverse effects on the environment are already incorporated in the process of equipment design and penetrate to the manufacture, distribution, use and disposal of particular equipment. That is why efforts to control the risk at its source should be an integral part of the design phase during the innovation or development process of equipment.

The main aim of the article is through the method of paired comparison determine the environmental quality level of selected types of impact drills.

DESCRIPTION OF EQUIPMENT

For the purposes of the assessment we used Bosch impact drills with different technical parameters. Their graphic representation is shown in Figure no. 1-4.

Figure1. BOSCH GSB 13 RE Professional [2]

Figure 2. BOSCH GSB 16 RE Professional [3]

Figure 3. BOSCH GSB 1600 RE Professional [4]

Figure 4. BOSCH PSB 750 RCE [5]

PAIRED COMPARISON METHOD

This method is used in the assessment of the impact of technological processes on the environment. However, it can be easily modified to suit the needs of the assessment of the environmental quality of the equipment and its impact on the environment.

Factors reflecting the impact of the equipment on the environment can be divided into four basic groups:

- technological factors - describe the technological process in the manufacture or use of the equipment
- economic factors - involve substantial investments and operating costs throughout the life cycle of the equipment
- environmental factors - the effect of the equipment on the environment
- social factors - an attempt to integrate social effects of the equipment use into the decision-making process. [1]

Table1. Factors describing the equipment

Technological factors	Economic factors
1. Consumption of basic material 2. Energy consumption 3. The rate of a construction-dismantling practices 4. Energy efficiency of the technological process (equipment)	5. Cost of upkeep of machinery and equipment 6. Price of the equipment on the market 7. Storage costs
Social factors	**Environmental factors**
8. Accident rates 9. Monotony of the working cycle 10. Physical demands of the process	11.Air pollution by SOx 12.Radiant heat 13.Noise 14.Vibrations 15.Dust in the workplace 16.Waste amount 17.The need for waste separation

The paired comparison method involving two or more equipment can feature as many as 80 factors. For the practical assessment, however, we have set the minimum number of environmental quality factors to 17. The number of factors should not be further reduced. [1] The complete list of factors used in the evaluation is to be found in Table 1.

After selecting the factors on the basis of Fuller triangle the frequency of the different factors is assessed. After obtaining the total frequency for each factor the factors are ranked and weighted. The frequency of the factors determines the weight of the criterion - "WJ". Then we rank the factors according to their frequency of occurrence from the highest level to lowest. The results are shown in Table 2.

The scale used for the assessment of the suitability of the equipment:

- Excellent 5b
- Good 4b
- Average 3b
- Acceptable 2b
- Unacceptable 1b

Table2. Ranking and weighting of factors

Factor no.	Weight	points	GSB 13	GSB 16	GSB 1600	PSB 750
1.	7,5	10	5	3	3	3
2.	13	10	5	3	4	3
3.	6	12	4	3	3	3
4.	9,5	6	3	4	3	3
5.	2	15	4	4	4	4
6.	9	9	5	3	3	3
7.	4,5	13	4	3	3	3
8.	7,5	10	5	5	5	5
9.	1,5	16	4	4	4	4
10.	14	1	3	2	2	1
11.	14	1	3	4	3	3
12.	9,5	6	3	3	3	3
13.	10,5	5	3	3	3	3
14.	1,5	16	4	4	4	4
15.	12,5	4	4	4	4	4
16.	4	14	3	3	3	3
17.	9,5	6	3	4	3	3

By summing weight of individual factors and their points we get the "synthetic suitability indicator of a technological process" - "Usi"Table 3. This figure clearly indicates which of the evaluated equipment should be given priority by a consumer.

Table 3 shows the partial values for determining the synthetic suitability of the equipment. The sum of the factors gave the following total values:

» BOSCH GSB 13 RE Professional reached US_i = 510
» BOSCH GSB 16 RE Professional reached US_i = 459,5
» BOSCH GSB 1600 Professional reached US_i = 439,5
» BOSCH PSB 750 RCK reached US_i = 412,5

Table 3. Synthetic suitability indicator determination

Factor no.	GSB 13 "US_i"	GSB 16 "US_i"	GSB 1600 "US_i"	PSB 750 "US_i"
1.	37,5	22,5	22,5	22,5
2.	65	39	52	52
3.	24	18	18	18
4.	28,5	38	28,5	28,5
5.	8	8	8	8
6.	45	27	27	27
7.	18	13,5	13,5	13,5
8.	37,5	37,5	37,5	37,5
9.	6	6	6	6
10.	42	28	28	28
11.	42	56	42	42
12.	28,5	28,5	28,5	28,5
13.	31,5	31,5	31,5	31,5
14.	6	6	6	6
15.	50	50	50	50
16.	12	12	12	12
17.	28,5	38	28,5	28,5

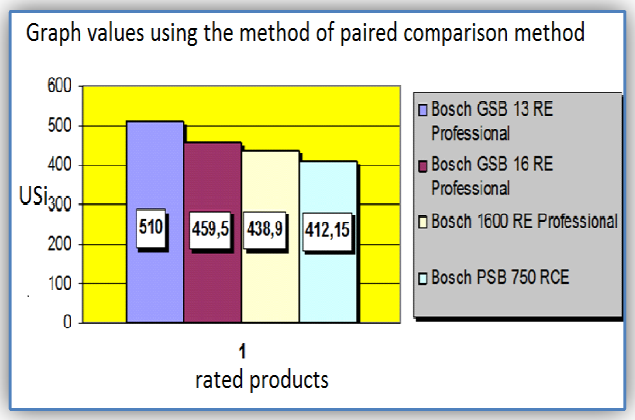

Figure 5. „US_i" values of the assessed equipment

The above results show that in terms of the suitability the best and the most environmentally friendly equipment is BOSCH GSB 13 RE Professional (Figure 1).

This ranking also confirms the environmental quality of the equipment. The graphic presentation of the results is shown in Figure 5.

Despite its easy use, the paired comparison method is not widely used. Some of its advantages and disadvantages include:

Advantages:

» 80 assessment factors,
» the possibility of replacing the existing factor with other similar factor in the case some factors cannot be assessed,
» social factors involved.

Disadvantages:

» ranking method,
» long assessment procedures,
» subjective approach,
» does not work with specific data.

CONCLUSION

The main aim of the article was to determine the level of environmental suitability of impact drills. The analysis was conducted using the paired comparison method. This method of assessment features 80 factors (environmental, technological, economic and social). Such assessment process offers a wide range of factors and choices while permitting modifications and changes to certain factors. This method also features social factors such as ergonomic criteria or the risk of damaging workers' health when operating the equipment, which means that the overall assessment may also include aspects of OSH. Clear results may convince the reader to buy the impact drill BOSCH GSB 13 RE Professional.

Special Thanks

This article was made under the project KEGA 039 TUKE-4/2015 and APVV-0432-12.

Bibliography

[1] Lumnitzer, E. – Badida, M. – Románová, M.: Hodnotenie kvality prostredia. Košice, SjF, TU, 2007., 275 s., ISBN 978-80-8073-836-5
[2] Elektrické náradie Bosch pre remeslo a priemysel: Príklepová vŕtačka GSB 13 RE Professional. [online]. Dostupné na internete: <http://www.bosch-do-it.com/sk/sk/dom%C3%A1cimajstri/n%C3%A1radie/psb-750-rce-3165140512435-199891.jsp#tab_technical>
[3] Elektrické náradie Bosch pre remeslo a priemysel: Príklepová vŕtačka GSB 16 RE Professional. [online]. Dostupné na internete: <http://www.bosch-professional.com/sk/sk/gsb-16-re-16873-ocs-p/>.
[4] Elektrické náradie Bosch pre remeslo a priemysel: Príklepová vŕtačka GSB 1600 RE

Professional. [online]. Dostupné na internete: <http://www.bosch-professional.com/sk/sk/gsb-1600-re-11363-ocs-p/>.

[5] Elektrické náradie Bosch pre remeslo a priemysel: Príklepová vŕtačka PSB 750 RCE Professional. [online]. Dostupné na internete: <http://www.bosch-do-it.com/sk/sk/dom%C3%A1cimajstri/n%C3%A1radie/psb-750-rce-3165140512435-199891.jsp#tab_technical>.

ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809