Journal for Technology of Plasticity, Vol. 25 (2000), Number 1-2

ENVIRONMENTAL IMPACT ASSESSMENT FOR FORMING TECHNOLOGY

Miroslav BADIDA, Milan MAJERNÍK, Alena PAULIKOVÁ, Ružena KRÁLIKOVÁ
Technical Universiny in Košice, Faculty of Mechanical Engineering,
Department of Environmental Studies and Control Processes
Park J. A. Komenského 5, 041 87 Košice, SLOVAKIA

ABSTRACT

In this contribution there are analysed the selected operation of die forming with regard to the environmental impacts and to their environmental negative influences. There are demonstrated applicable methods for complex integrated assessment of technological processes by means of technological, economical, environmental and social factors. The technologies of die forming and turning are compared using the method of synthetic indicator of technological processes with emphasis to selection of environmental technology.

Key words: *Forming technology, environmental aspect, environmental influence, negative impact, assessment factors, synthetic indicator*

1. INTRODUCTION

It is often possible to find the reserves for appropriate application of materials, technologies, functions of machine components but predominately environmental quality area in product design and production. Several products are about 25% heavier as up-to-date world class products. It is the reason for twice-greater material and energy consumption and the produced emission are several times higher in the comparison with the parameters of environmental friendly products, as well.

Comparison methodology techniques of several technological processes, which are determined to produce required products is important step connected with the environmental technology implementation in the branch of mechanical engineering from environmental impact point of view.

The comparison should lead into correct decision about preference of one of at least two technological processes with regard to its technological, economical, environmental and social characteristics.

2. FORMING TECHNOLOGY AND ITS ENVIRONMENTAL INFLUENCE

In forming technology there are distinguished two basic directions: embossing and die forming. Embossing can be divided into individual operations (shearing, bending, and cupping) and these next can be divided more in detail into sub-operations. Die forming covers operations: spinning, extrusion, punching, forging, rolling, calibration and others with many sub-operations and special techniques for example, explosion forming into liquid as well as into elastic material (rubber), etc.

Forming is used in various production areas i.e. car bodies, bathtub, pots, semi-product preparation etc. It is reasonable to explore forming environmental influences and to compare these influences with various technologies for given products. The general model of forming technology environmental influence is demonstrated in the Fig. 1.

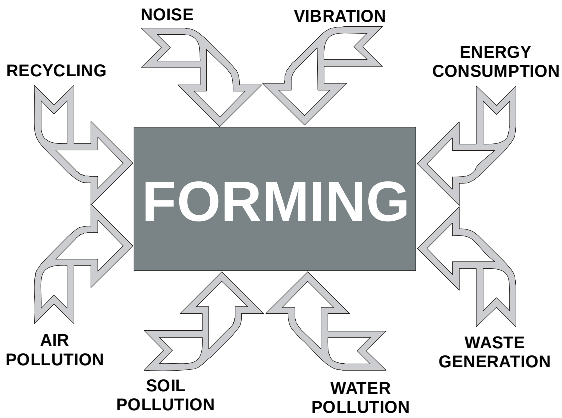

Fig. 1.

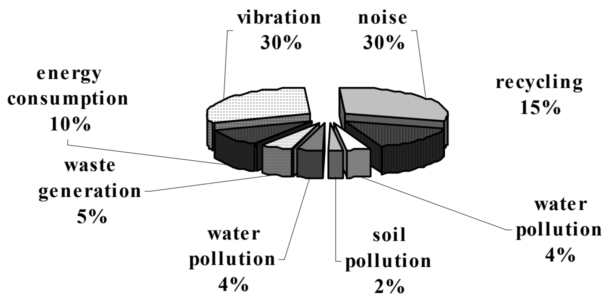

Fig. 2 **Environmental aspect percentage representation**
(professional estimation)

3. EMBOSSING INFLUENCE ON INDIVIDUAL ENVIRONMENTAL ELEMENTS

Air: technology influence is minimum and limited only to workshop microclimate, where operation devices and lubrication emulsions for forming can caused smell and related complication.

Water: technology influence is minimum and limited only to the penetration possibility of sewage and cooling water and machine emulsion into surface and ground water.

Soil: soil pollution comes into consideration only in the case of waste metal material dumps. Soil contamination is possible as well as for incorrect petrol waste disposal.

Vibration, noise: they are main negative impact and their affect is important

Energy consumption: depends on kind of device.

Recycling: most waste is recycled.

There are also another specific influences in the case of non-conventional technologies.

3.1. *Specification and classification of negative environmental influences*

Material: The most used material is steel plate (up to 95%). Material has got the determined concrete properties and content necessary for extrusion, bending and so on.

Content [%]:

C	Cu	Mn	Cr	Si	Ni	P	S	N_2	0_2
0,3÷0,1	0,15	0,3÷0,45	0,03	to 0,01	0,1	to 0,03	0,035	0,002÷0,006	0,003÷0,006

Thickness:

- to 0,4 mm – very thin
- 0,4 – 2,99 mm – thin
- 3 – more mm – thick

Non-ferrous plates:

- cooper brass plates
- aluminium plate and aluminium alloy plates
- zinc plate

Plates with surface treatment:

- zinc-coated
- tinned
- aluminium-coated
- chromium-plated
- varnished
- plastic-coated (PVC, PV fluoride)

Material composition and its inefficient exploitation create negative environmental impact. Plate waste creates in processes of:

- punching
- shearing
- trimming
- cut-out
- punching

The average waste plate is about 15 – 30%. There is a problem: plates with surface treatment (zinc coated, chromium plated, etc.) and plastic coated plates because the durability of surface is higher than the plate durability.

3.2. *Technology*

Shearing, cupping, bending - negative influences are:

- energy overconsumption during shearing caused predominately with incorrect tool design and its wear. During wear there is tool damage – blunting of tool edges, creation of unevenness, creation of slackness,
- noisess during individual shearing operation,
- vibration which are created with motion and stroke of forming punch instrument.

The others technologies and processes:

- *explosion forming:* The main negative influence of this technology is noisess and vibration which create during explosion.
- *impulsive magnetic field forming:* There is unfavourable effect of magnetic field upon human body. The character of this effect is long-time.
- *electro spark bulging and punching :* spark discharge can effect unfavourable on human body and environment. Erosive effect of spark can cause injury.
- *electro-contact methods:* Excessive quantity of heat which was caused with electric arc effect, sparks and mechanical friction effect can influence unfavourable on environment.
- *anode-mechanical flow of material:* There is creation of waste heat and chemical effect of dielectric non-conductor layer. The chips contain chemical materials.
- *electro-chemical burring:* For burring operation electrolytes are used NaCl, $NaNO_3$ with concentration 15 – 20%. These materials can be dangerous for environment as well as during work and during disposal work. They are created dangerous fumes and contact with human body can cause injury.

3.3. *Tool materials*

Tools are often important waste sources because of their dimensions and frequent wear. Tools for shearing, bending, and cupping are produced from:

Steel:	*Alloys*	*The other material:*
▪ construction (10, 11,high-grade 12 – 17)		▪ aluminium alloys
▪ tool (carbonaceous,alloyed)		▪ zinc alloys
▪ for castings		▪ plastics
		▪ technical rubber

Of course, tool wear is a normal phenomenon during producing process (edge blunting, mechanical damage, etc.). Repairs in these cases are rarely possible. The waste of tools is caused for variety of production, shapes and dimensions. The tool standardisation is rare.

3.4. *Evaluation of negative environmental influences*

basic material consumption: 70-90%

secondary raw material: small cutting pieces of various materials and various surface treatments

waste heat: during heat treatment of products after cupping, during individual alternative technology

air pollution: due to application of lubricants, emulsions, and during burring in electrolytes NaCl, $NaNO_3$.

water pollution: sewage water from workshops and electrolyte disposal.

solid waste production: waste during shearing, as well as worn tools.

noise emission: device operations are one of the most environmental influences.

working conditions: during embossing there are noise, vibrations, light, heat, etc. Monotonic work is another negative working influence.

Number of factors	Kind of factor	Factor importance W_i	Point evaluation b_i	$W_i * b_i$
1.	Noise	0,8	1	0,8
2.	Vibration	0,6	0	0
3.	Energy consumption	0,7	2	1,4
4.	Waste generation	0,8	2	1,6
5.	Water pollution	0,6	2	1,2
6.	Soil pollution	0,5	2	1
7.	Air pollution	0,8	3	2,4
8.	Recycling	0,8	3	2,4
Sum :				**10,8**

0- unsuitable $W_i = (0,1)$

1- particularly suitable

2- suitable

3- fully suitable

4. DIE FORGING AND TURNING TECHNOLOGIES ENVIRONMENTAL INFLUENCE - COMPARISON

4.1. *Negative influence specification*

forging

- increased noise at power hammers,
- vibration due to forging – *predominately at power hammers,*
- creation of hammer scales, containing various oxides during heating and forging,
- dustiness,
- metal waste,
- energy consumption,
- heat atmospheric exhaust,
- accident danger,
- physical effort,
- expensive production of forging die,
- lubricate emulsions and oils

turning

- noise,
- vibration,
- metal waste,
- cooling emulsions, oils – *which are used in turning processes*
- chip creation,
- energy consumption,
- material consumption,
- heat atmospheric exhaust,
- contamination – *solvents,- emulsions,- oils,*
- high requirements for tool maintenance,
- time demand,
- injury – *danger from flying out chips, - danger of cut injury, - danger of scorch, - danger of interception clothing, hair, arms into chuck.*

5. EVALUATION FACTORS OF TECHNOLOGICAL PROCESSES

The basic means to evaluate technological processes from their environmental point of view is the evaluation of physical, biological, and other factors. These factors demonstrate the environmental influence of production processes. They are determined by means of process analysis as technological system. There are four basic groups of factors expressing the environmental impact of technological processes:

- **Technological factors:** describe technological method (complexity of technological process, material and energy consumption, automation level, waste and harmful substances amount)
- **Economical factors:** cover substantial investment and operation expenses of the main and supporting processes as well as other economic-organisational points of view (productivity, material efficiency, profit of the main process , the secondary raw application, environmental protection process profit)
- **Environmental factors:** cover the main interactions of environmental process evaluation (ratio of utilisable waste, environmental noise emission, waste toxicity, fauna and flora influence)
- **Social factors:** represent the test to integrate the social impact of technological process into decision process, as well as (staff structure, staff health damage hazard, education)

There is possible to define up to 80 factors from above mentioned groups during the evaluation of two technological processes. It was determined so-called minimum programme to evaluate environmental friendly factors for practical evaluation with regard to factor extension. This reduced selection consists of 17 factors and should not be reduced next. In the case that several of factors can not be evaluated it has to be replaced with similar one.

Factor specification – example

Technological factors:

1. quality of technological process
2. time losses
3. utilisation of low-waste and wasteless technologies
4. waste amount
5. machine amount
6. production quality
7. technological process time period
8. machine safety
9. machine durability
10. technological process reliability
11. marginal products of main process
12. automation level
13. energy consumption
14. material consumption
15. technological process durability

Economical factors:

1. time loss expenses
2. penalties, sanction
3. number of employees
4. machine innovation expenses
5. production costs
6. production quality increase
7. credit
8. sponsoring
9. machine repair costs
10. advertisement costs, product presentation
11. product price
12. operational expenses
13. investment expenses
14. transport expenses
15. productivity

Environmental factors:

1. air pollution
2. water pollution
3. soil pollution
4. product recycling possibility
5. influence into flora
6. influence into fauna
7. waste toxicity
8. noise emission
9. emission
10. product durability
11. simple design
12. energy consumption in production
13. material recycling application
14. production safety
15. simple dismantling
16. environmental product safety
17. waste utilisation
18. carcinogenic influence of waste
19. mutagenic influence of waste
20. device emission
21. radioactive material pollution
22. waste heating value
23. waste combustibility
24. electric field generation
25. magnetic field generation
26. hygienic parameter implementations
27. influence into ecosystems
28. adverse effect for human body
29. environmental stress for population
30. composting

Social factors:

1. number of employees per shift-work
2. education
3. transport distance from residence
4. working team
5. situation in occupation
6. reward
7. salary
8. vacation
9. health state
10. age
11. family state
12. two or threeshift run
13. working environment good sanitary condition
14. canteen alimentation
15. health protection in work process

For minimal programme of technological process evaluation from environmental point of you there are chosen follows

4 technological factors:

1 – waste amount

2 – technological process time period

3 – production quality

4 – material consumption

4 economical factors:

5 – operational expenses

6 – product price

7 – number of employees

8 – productivity

8 environmental factors:

9 – air pollution

10 – noise emission

11 – waste utilisation

12 – waste toxicity

13 – product durability

14 – production safety

15 – influence into fauna

16 – influence into flora

1 social factor

17 – education

6. EVALUATION METHOD

It is necessary to determine the factor order with regard to their importance for the given technology. There are applied with the advantage methods of decisive analysis to reduce the risks of subjective approach in the case of evaluation for various incompatible factors each other. It is possible to apply for example the method of particular couple comparison to evaluate technological processes. This method is able to determine which of two factors is more important. All factors are configured into Fuller-triangle.

More important factor from value couple is marked appropriately:

○ - circle symbol means frequency 1., □ - rectangular symbol is used in the case of doubt, which of factor couple is more important and its frequency value is 0,5. Sum of frequencies of all factors has to be adequate to couple numbers.

Hierarchy of factors:

Factor number	Factor importance
1 – waste amount	7
2 – technological process time period	4
3 – production quality	11
4 – material consumption	6
5 – operational expenses	5
6 – product price	2,5
7 – number of employees	2
8 - productivity	7
9 – air pollution	11,5
10- noise emission	7
11- waste utilisation	10,5
12- waste toxicity	12,5
13- product durability	9
14- production safety	13,5
15- influence into fauna	13
16- influence into flora	13
17- education	1,5

According to factor assemble with regard to their final frequency in the order from the highest level to the lowest level is given the order of their importance:

Factor importance order	Factor importance
14 – production safety	13,5
15 – influence into fauna	13
16 – influence into flora	13
12 – waste toxicity	12,5
9 - air pollution	11,5
3 - production quality	11
11- waste utilisation	10,5
13- product durability	9
1 - waste amount	7
8 - productivity	7
10- noise emission	7

Factor importance order	Factor importance
4 - material consumption	6
5 - operational expenses	5
2 - technological process time period	4
6 - product price	2,5
7 - number of employees	2
17- education	1,5
n . (n-1) / 2 = 17 . 16/2 = 136	**Σ 136**

If there is the hierarchy completed, next step is the factor evaluation according to chosen point scale based on the analysis of factor level, which provides the review about the highest and the lowest achieved values. Sum of productions of factor importance and their point evaluation create the value called synthetic indicator of technological process, which is result of evaluation method. This indicator shows distinctly, which of considerate technological variants should be preferred.

Evaluation of lever according to variants: **A** – die forging **B** – turning

Number of factor	Variant A	Variant B
1 - waste amount	4	2
2 - technological process time period	4	1
3 - production quality	3	2
4 - material consumption	3	1
5 - operational expenses	3	2
6 - product price	3	2
7 - number of employees	2	2
8 - productivity	4	1
9 - air pollution	2	3
10- noise emission	1	3
11- waste utilisation	3	2
12- waste toxicity	3	3
13- product durability	3	2
14- production safety	3	1
15- influence into fauna	3	3
16- influence into flora	3	3
17- education	2	2

Evaluation scale: excellent level =4b, good level = 3b, average level = 2b, acceptable level = 1b unacceptable level = 0b

Synthetic indicator of technological process:

Number of factor	Factor importance	Variant A	Variant B
1 - waste amount	7	7x3=21	7x2=14
2 - technological process time period	4	16	4
3 - production quality	11	33	22
4 - material consumption	6	18	6
5 - operational expenses	5	15	10
6 - product price	2,5	7,5	5
7 - number of employees	2	4	4
8 - productivity	7	28	7
9 - air pollution	11,5	23	34,5
10- noise emission	7	7	21
11- waste utilisation	10,5	31,5	21
12- waste toxicity	12,5	37,5	37,5
13- product durability	9	27	18
14- production safety	13,5	40,5	13,5
15- influence into fauna	13	39	39
16- influence into flora	13	39	39
17- education	1,5	3	3
		Σ 390	Σ 298,5

According to comparison of synthetic indicators that is evident the most environmental suitable technology is die forging.

7. CONCLUSION

Evaluation method of technological processes using comparison of selecting factors was applied successfully in work places of authors. It was applied above-mentioned method of decision analysis in many tests with positive results. The most important particular task of evaluation is collection of necessary information about individual factor at all relevant levels. If there are these data at the disposal it takes only a small time period (maximum extent is several tens of hours) for evaluation, which is performed by expert group - either by individuals or by team approach.

8. REFERENCES

[1] BADIDA, M.- MAJERNÍK, M. - ŠEBO, D.: Strojárska výroba a životné prostredie. Edícia vedeckej a odbornej literatúry SjF TU v Košiciach. Vienala, 1998, Košice, ISBN 80 – 7099 – 335 – 9

[2] BEŇO, J.: Coolants and Lubricants - Survey of International Standards (in Slovak). In. Proceedings of the Int. Conf ECOFRIM, Trnava 7.9.2000, Slovakia.

[3] BOSÁK, M. : Koncept hospodárenia s odpadom, Envirautom, č. 2/1999-1/2000, roč. 5, 2000, s. 114-117, ISBN 80-7099-395-2

[4] VOKOROKOS, L: Faults diagnosis of control system using the observer, 4th IEEE International Conference on Intelligent Engineering Systems 2000, Portorož Slovenia, September 17-19, 2000, pp. 189-192.

[5] SOBOTOVÁ, L. - NOSKO, L: Analysis of Suitability of Material for Deep Drawing of the Bathtubs. In: Scientific bulletins of Rzeszow University of Technology № 179, Mechanics 54, Rzeszow Polsko, June 2000, pp. 373-376, ISBN 83 – 7199 – 137 – 1.

TEHNOLOGIJA PLASTIČNOG DEFORMISANJA I ČOVEKOVA OKOLINA

Miroslav BADIDA, Milan MAJERNÍK, Alena PAULIKOVÁ, Ružena KRÁLIKOVÁ
Tehnički Univerzitet Košice, Mašinski Fakultet

REZIME

U proizvodnji metalnih delova ne retko je utrošak materijala i energije neopravdano visok. Projektovanje i izvođenje tehnologija obrade metala mora uzeti u obzir i taj aspekt, sa ciljem da se u što većoj meri sačuvaju resursi prirode tj. čovekove okoline.

U radu su analizirane neke od tehnologija plastičnog deformisanja sa stanovišta zaštite čovekove okoline. Data je specifikacija i klasifikacija negativnih uticaja na čovekovu okolinu i vazduh, vodu, tlo (zemljište), buka i vibracija, potrošnja energije, mogućnost recikliranja. Izvršena je komparacija tehnologija skidanjem strugotine i tehnologija plastičnog deformisanja sa stanovišta uticaja na čovekovu okolinu.

Ustanovljeno je da postoje četiri osnovne grupe faktora koji izražavaju uticaj tehnologija na čovekovu okolinu:

1. *Tehnološki faktor*
2. *Ekonomski faktor*
3. *Faktor čovekove okoline*
4. *Socijalni faktor*

U svakoj od ovih grupa sadržan je veći broj pojedinačnih uticajnih faktora. U radu je definisana metodologija ocene važnosti pojedinih faktora. Najvažniji preduslov za takvu ocenu je sakupljanje brojnih informacija u vezi pojedinačnih faktora na svim relevantnim nivoima. Ako takve informacije postoje ocena se može relativno brzo i efikasno sprovesti.