Achievements in Mechanical and Materials Engineering

COMMENT Worldwide Congress on Materials and Manufacturing Engineering and Technology
16th - 19th May 2005 Gliwice-Wisla, Poland

COMMITTEE OF MATERIALS SCIENCE OF THE POLISH ACADEMY OF SCIENCES, KATOWICE, POLAND
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, GLIWICE, POLAND
ASSOCIATION OF THE ALUMNI OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, MATERIALS ENGINEERING CIRCLE, GLIWICE, POLAND
13th INTERNATIONAL SCIENTIFIC CONFERENCE ON ACHIEVEMENTS IN MECHANICAL AND MATERIALS ENGINEERING

The attempt of evaluation of the chosen technological gear wheel process on the basis of its efficiency operation

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Abstract: The problem of efficiency seems to be more meaningful in conditions of the huge changeability of the surrounding. In industrial companies the component has the greatest influence on the efficiency of the technological process whose value marks a proper way of designing, realizing and controlling the given process [1-5].

The efficiency of the company constitutes the resultant of time, efficiency of work (the man and machines) and the existing processes like management of the quality as well. The planned effects are dependent upon the creation of suitable conditions to realize intented aims by enterprises, which should be measurable [2].

Keywords: Efficiency, Process, Operation, Efficiency of technology process

1. INTRODUCTION

According to norm (PN-EN ISO9000:2001), the efficiency of the process is the dependence between achieved results of the process – C (t), and the supplies used to this – Z (t). The value of indicator is the measure of opinion of the efficiency process - α(C, t) (1), marked on basis of the following example:

$$\alpha (C, t) = C (t) / Z (t) \quad (1)$$

where: C (t) - marks reached results,
Z (t) - marks supplies as well as expenditures.

However, the efficiency of technological processes (Et) both the existing and the projected ones, the given example (2) presents:

$$E_t = f (W_0, W) \quad (2)$$

where: W – got (gained) result ,
W_0- put (supposed) result

2. COURSE OF EVALUATION OF EFFICIENCY OF TECHNOLOGICAL PROCES

The present condition of technique, with a large variety of machines, vehicles, instruments and different mechanical constructions, demand the invention of the devices transferring

mechanical energy with the change of its parameters, including a moment, strength and angular speed. These functions are executed by teams, called generally mechanical transmissions. Toothed transmissions among mechanical transmissions are the most widespread. They can be applied both in watches, in the arrangements of driving ships, helicopters or airplanes. The gear wheel is one of the elements of toothed transmission. A very essential question is the technological gear wheel process correctly designed, which was possible to estimate it and still improve. Therefore the test of evaluation of the efficiency of technological process was undertaken on their examples [6-8].

The evaluation conducted in the research includes:

- creation of analysis pattern of efficiency of technological process,
- choice of object and appropriate technological process,
- creation of analysis pattern of efficiency for chosen technological process,
- attempt of evaluation of efficiency of the analysed technological process,

The attempt of the pattern creation of the efficiency process was undertaken in the analysis of parameters of individual operations in the optimization of technological processes. The pattern of analysis of efficiency of the technological process was created on the basis of the dependences between factors influencing efficiency and the kind of processing (fig. 1). What is more, the component values of efficiency were marked in the next kinds of processing (E_1,E_2,E_3), on basis of which it was possible to count the value of efficiency of technological process:

- efficiency of material is defined by the dependency comparing quantity of products decreased of products with defects of material dependence or its wrong selection, to quantity of produced products in the whole technological process(E_1),
- efficiency of work of machines was possible to indicate in the comparison of real time of machines' work to the planned. The value below 1 shows that the parameters were chosen mistakenly with cutting off, or the problems of technical nature were related to the machines(E_2),
- dependence between the number of products without defective products defines the efficiency of the man's work conditioned on the man's mistakes, and the number of correct products. It gives information about the mistakes made by man, which caused the defects of the product (E_3).

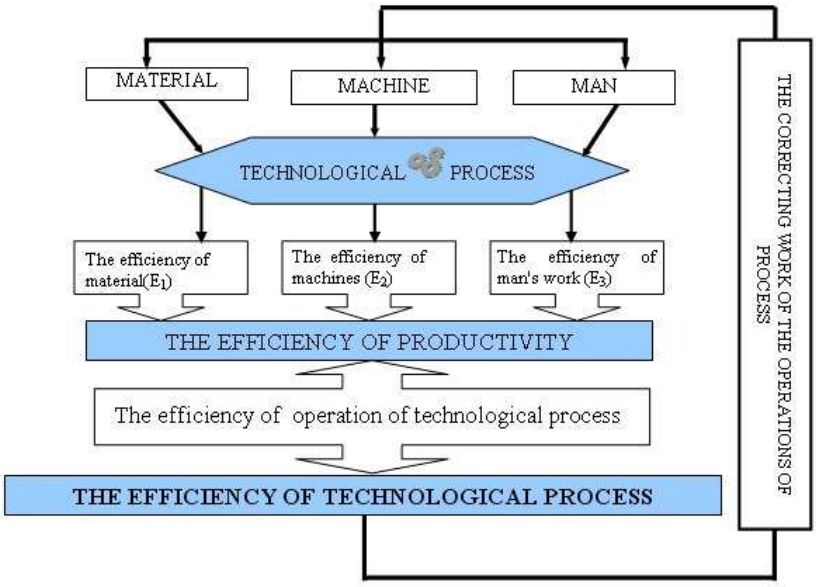
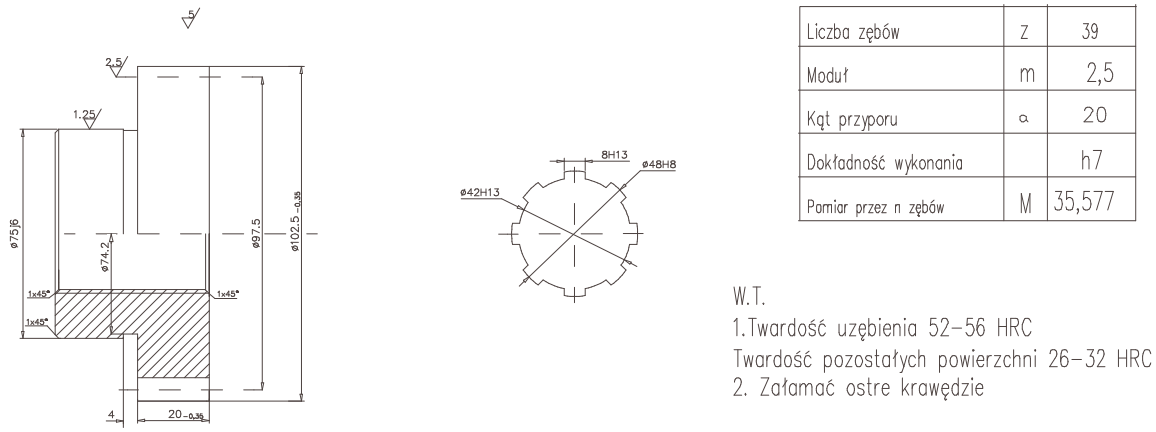


Figure 1. The diagram of analysis the of efficiency of technological process [15]

The creation of cog-wheels isn't easy, so there are the permanent tendencies of creating new ones and modernization of the methods of processing the formative as well as the thermal (the rough, formative, processing finishing off, thermal, thermal - chemical). In the planning of the processing of gear wheel one should take following criteria under into account: a kind of material as well as its structure, size of wheel, kind of dentition, size of module, required exactitude of dentition, size of production [6,8-10].

The parameters of individual operations of technological process influence its total efficiency. Analysed process is realized and controlled in view of the following criteria: Material - Machine - Man (fig.1) [7-10,13]

The gear wheel about the teeth with the straight lines was put into the test of technological process, whose the geometrical parameters and processing are not compiled (rys. 2). Steel is the material used in the production of wheel C45(PN EN 10083-2) .



Liczba zębów	z	39
Moduł	m	2,5
Kąt przyporu	α	20
Dokładność wykonania		h7
Pomiar przez n zębów	M	35,577

Figure 2. Executive drawing of analysed cylindrical gear wheel about teeth of straight lines - A32.120.3

Analysed technological process consists of individual operations, which was divided with regard to the kind of processing. The devices in the technological card were introduced due to which there was processing of the operation and parameters of the operations made in order (tab.3).

The scale of efficiency of the process (Et) was created with regard to the rule which was based on the evaluation of efficiency of the technological process, namely [14]:

- if Et = 1, process is effective,
- if Et < 1, process is ineffective.
- if Et > 1, the process is ineffective, (However, sometimes its realization is necessary in view of technological requirements. Therefore when larger value than unity is gained it is valid to remember about analysing the efficiency with regard to requirements.

Using the dependence that the value of efficiency aims to 1, in the analysis of process the scale of efficiency was worked out, which was the result of the dependence (2) and it makes it possible to define the level of efficiency, namely:

- Et = 1 ideal level of efficiency,
- Et = 0,99 - 0,97 - very good level,
- Et = 0,96 - 0,95 - good level
- Et = 0,94-0,93 - sufficient level
- Et = 0,93 - level which cannot be accepted

The evaluation of efficiency of individual operations of the technological process was conducted according to the created pattern of analysis of efficiency for the chosen process of processing cylindrical gear wheel (fig. 3) based on the general pattern of the analysis of efficiency technological process.

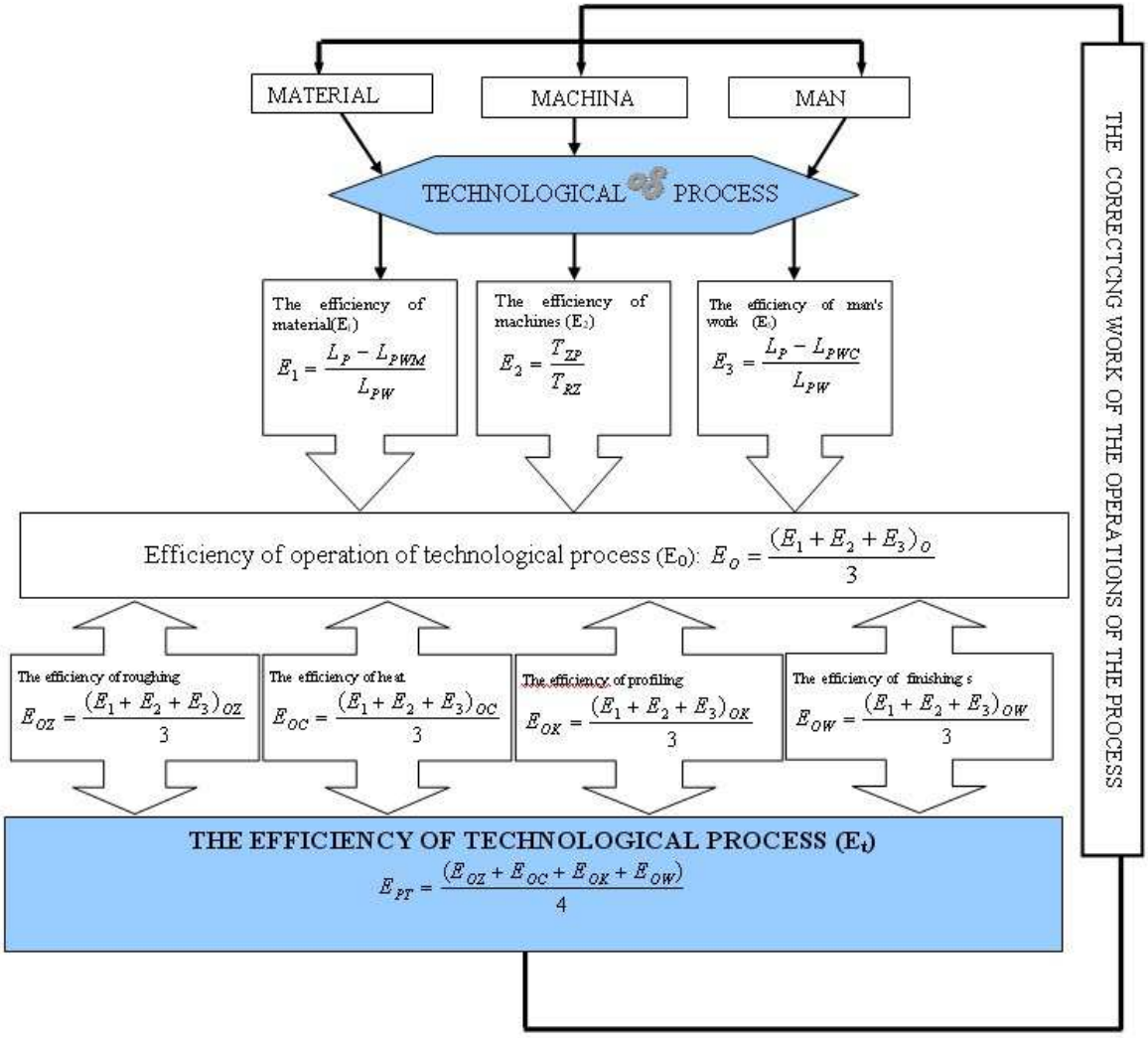


Figure 3. The detailed pattern of the analysis of efficiency technological gear wheel process - L_p - the number of products , L_{PWM} - the number of defective products because of the defects of material, L_{PW} - the number of made products, L_{PWC} - the defective products caused by the man's mistake, T_{ZP} - the planned time of machine work in indicated time, T_{RZ} - real time of work of machines in indicated time, the E_{PT} - the efficiency of technological process on the basis of the efficiency of individual operations .

Studying the efficiency of technological process apart from delimitation of the efficiency of individual processing by delimitation of the efficiency of individual components one should determine the whole technological process efficiency of these components.

In view of dependences (E_1,E_2,E_3) it was possible to mark the efficiency of the applied kinds of processing in technological process of cog-wheel:

- the efficiency of rough (E_{OZ}) – informs if the operations of rough processing were executed in the expected way and intended time,
- the efficiency of profiling (E_{OK}) - informs how far the operations of formative processing differ from the intended result,
- the efficiency of heat (E_{OC}) - the degree of regularity of realization defines the thermal processing,
- the efficiency of finishing (E_{OW}) - the degree of regularity of realization processing defines execution.

Indication of the proper way to achieve the intended quality of the product defined by dependences (the E_{PT}) enables the analysis of technological process and delimitation of the efficiency of individual operations.

To indicate the efficiency of the material and man's work, the data achieved during technical controls was used (tab. 1 and 2)

To define the efficiency of technological process the efficiency of machines is necessary. Subsequently, the data necessary to indicate it was provided in (tab. 2). One may find here data related to:

- planned work time (T_{ZC}) - how much time, according to the time standard, was designed for the realization of this kind of processing
- real time of realization (the T_{RZ}) - the of realization, estimated after finishing the production, including all the standstills which were not planned.

Table 1.

The result of technical control of technological process

Product: gear teeth		**Material:** C45		**Symbol:** A 32.120.33				**Amount:** 1000	
ROUGHING									
Operation 25: PRODUCTION CONTROL									
Dimensional control 76,2mm		Dimensional control of front Ø76,2 and Ø103,4		Dimensional control of hole Ø41,6		Dimensional control 48,7mm		Dimensional control 21mm	
Lack amount	Cause	Lack amount	Cause	Lack amount	Cause	Lack amount	Cause	Lack amount	Cause
2	Wrong set-up of machining parameters	1	defect of material	0	-	0	-	0	-
PROFILING									
Operation 60: PRODUCTION CONTROL									
Dimensional control of hole Ø102,5and Ø75,35			Dimensional control 48 mm			Dimensional control gear teeth			
Lack amount	Cause		Lack amount		Cause	Lack amount	Cause		
1	The man's mistake		0		-	2	The man's mistake		
FINISHING									
Operation 85: PRODUCTION CONTROL									
Control of surface roughness Ø 75,6				Control of surface roughness of gear teeth					
Lack amount	Cause			Lack amount	Cause				
2	defect of material			0	-				
HEAT									
Operations 10 and 70 CONTROL OF HARDNESS									
Control of hardness				Control of hardness of teeth					
1	defect of material			1	The man's				

Table 2.
Control of hardness of gear wheel

Product: gear wheel	**Material:** C45	**Symbol:** A 32.120.33	**Amount:** 1000
THEROUGHING			
TIME OF WORK OF MACHINES [min]			
PLANNED		REAL	
4270		4283	
PROFILING			
TIME OF WORK OF MACHINES [min]			
PLANNED		REAL	
2592		2630	
FINISHING TREAMENT			
TIME OF WORK OF MACHINES [min]			
PLANNED		REAL	
7840		7870	
HEAT TREATMENT			
TIME OF WORK [min]			
PLANNED		REAL	
4400		4450	

Table 3.Operation sheet of technological *gear wheel* process [11]

The product A32		*The* name of the part *of gear wheel*	Symbol, No. the outline A 32.120.33		Number order *1300.108/95*	
The material: *C45*		Dimensions of initial material: *Foring*	Amount/product 2	kg/1szt netto 1,65	Amount on order *1000*	
Nr op.	*Department* / *Position of:*	*Description of operation*			T_{pz} / t_j	$T = T_{pz} + n * t_j$
05	thermal processing / Heat	Hardening and temper to hardness 26-32 HRC				
10	thermal processing / Technical Control	The control of hardness				
15	formative processing / Turret lathe	Turn the outer face Ø76,2 and forehead, roughly Ø76,2 and Ø106 reboring Ø40,0 chambering hole Ø41,6			48 / 3,32	3368
20	formative processing / Manufacturing lathe	Turn the forehead and outer face Ø103,4 roughly			30 / 1,95	1980
25	formative processing / Technical Control	Production control				
30	formative processing / Broaching machine	Hole broaching			28 / 0,91	938
35	formative processing / shaping	Rectifying of burr, refraction sharply edges			3	
40	formative processing / Multicut lathe	Turn the outer forehead and outer,			45 / 0,57	615
45	formative processing / Manufacturing lathe	Turn the outer face			27 / 1,40	1427
50	of processing formative / Fellows slotter	Chiseling teeth			43 / 4,22	4263
55	processing formative / shaping	refraction sharply edges on the side of tooth			2,5	
60	formative processing / Technical Control	Control production of gear teeth				
65	thermal processing / Heat	Surface hardening				
70	of thermal processing / Heat	The control of hardness gear teeth				
75	formative processing / Cylindrical grinder	Grinding Ø 75,6			30 / 1,87	1900
80	formative processing / grinder	Grinding gear teeth			30 / 5,91	5940
85	formative processing	Final control				

Table 4.
Results of analysis of efficiency

PROCESSING	EFFICIENCY			
	Machines $\Sigma E_2 = 0,99$	**Man's work** $\Sigma E_3 = 0,994$	**Material** $\Sigma E_1 = 0,996$	**Processing**
Rough(E_{OZ})	0,99	0,98	0,99	0,986
Formative(E_{OK})	0,98	0,99	0,98	0,983
Finishing (E_{OW})	0,99	1	0,99	0,999
Heat(E_{OC})	0,99	0,99	0,99	0,999
	EFFICIENCY OF TECHNOLOGICAL PROCESS E_{PT}			0,987

CONCLUSION

Applying the proposed pattern of approach to the evaluation of efficiency of technological process of cog-wheel about straight lines teeth tempered on the surface, one may notice that in the technological process the most effective is the finishing processing - E_{OW} = 0,999 and thermal one - E_{OC} = 0,999, but the least efficient is the formative one - E_{OK} = 0,983 (consequently, in first order the correcting work should be fixed with regard to the last one, aiming at the rise of efficiency).

Analysing the efficiency of factors influencing the technological process (Material - Machine - Man) the results seem to be in the following order: Machine - E_2 = 0,99, Material - E_1 = 0,996, Man's work - E_3 = 0,994.

The efficiency of the whole technological process - E_{PT} = 0,987 is on a very good level.

With reference to the data mentioned above, one may assume that the proposed pattern can be used to determine the efficiency of individual operations and the efficiency of the technological process as well.

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