Chapter 9

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OEE COEFFICIENT APPLYING IN THE CHOSEN TECHNOLOGICAL PROCESS EFFECTIVENESS ANALYSIS

Abstract: In the chapter Overall Equipment Effectiveness (OEE) was applied to evaluate the effectiveness of main processes taking part in the die-cast product manufacturing. Calculations on Equipment Availability, Performance Efficiency and Quality Rate were also made for six processes such as: die casting, clipping, drying, drilling, chamfering, packing. The coefficients level was related to the product quality level, where the correlation coefficient r was applied.

Key words: OEE, TPM, Equipment Availability (EA), Performance Efficiency (PE), Quality Rate (QE), die casting.

9.1. Introduction

To produce the final product comprises many individual processes / stages which are part of the process. The chapter uses OEE factor [BORKOWSKI S., SELEJDAK J., SALAMON S., 2006] to evaluate the effectiveness of die casting process steps.
The OEE consists of three measurable components: Availability, Performance, and Quality.

OEE = Availability x Performance x Quality [1]

A detailed analysis of OEE ratio shown in Table 9.1.

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Table 9.1. Kind of machine downtime

Coefficients of TPM	Type of loss
equipment availability,	• breakdown, • readjustments, • regulation
equipment loading,	• semi-automatic operation, • lack of stoppages
quality loss	• non-conformances, • technological trial runs

Źródło: [MĄCZYŃSKI W. 2008]

OEE is a key measure of TPM. TPM method originated in Japan as a tool to help detect and reduce losses in the process with the objective of three zeros:

- Zero accidents,
- Zero defects,
- Zero accidents at work [ELLIOT B.R., HILL G. 1999].

The goal of TPM is to enhance equipment effectiveness and maximise equipment output by [MĄCZYŃSKI W. 2008., CZAJKOWSKA A., MASZKE A., KNOP K. 2008]:

- reduce the cost breakdown,
- reduce the cost of preventive maintenance (periodic inspections and maintenance),
- reduction of losses due to the performance of the test for setting parameters,
- reducing defects caused by poor efficiency of production equipment,
- shorter production cycles (reducing downtimes device to normal operation)

- reduced inventory levels of protection in the event of machine failure.

In strong competition, a company must compete for customers, you can always find him offering high quality at a relatively low price. Lowering the cost of production of the product can be achieved through the introduction of TPM (Total Productive Maintenance) [BORKOWSKI S., JEZIORSKI L., RYCHTER A., 2004]. The figure 9.1 presents the process elements before and after the introduction of TPM

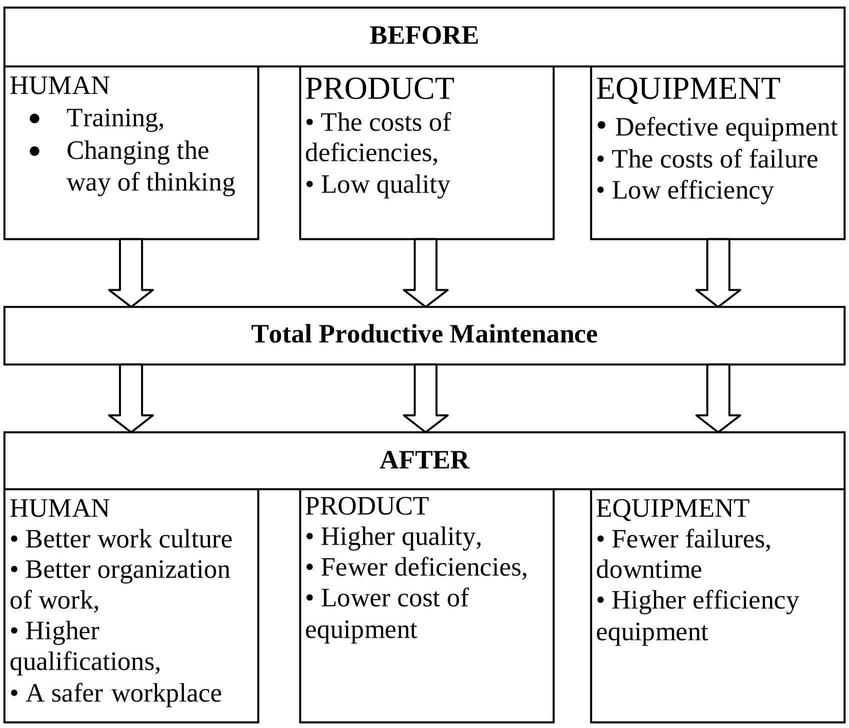


Fig. 9.1. Elements of the process before and after the introduction of TPM.

Source:[ELLIOT B.R., HILL G. 1999]

9.2. Research and their analysis

The analysis included six stages of the process: die casting, clipping, drying, drilling, chamfering, packing. On the basis of data from the rated efficiency of the production process of each process step. Coefficients of EA, EP, QR and OEE is calculated according to the formula (Table 9.2).

Table 9.2. Calculation the OEE coefficient

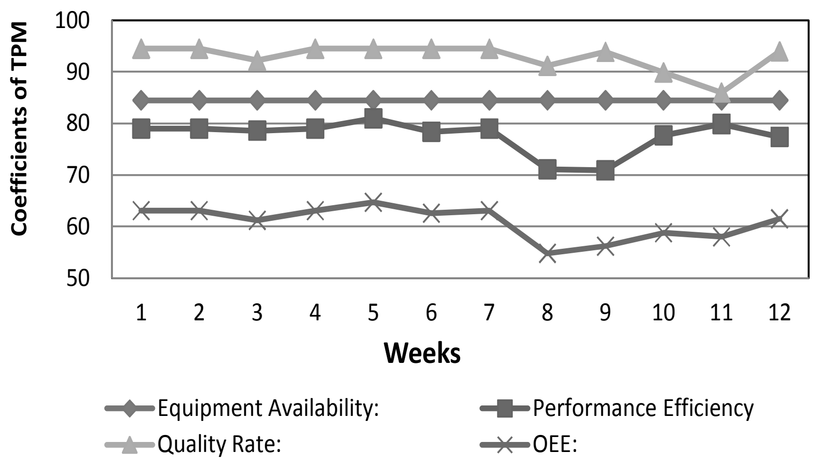
Operating pattern and machine data:		
A.	Shifts/day	
B.	Hours/shift	
C.	Minutes/shift	=B x 60
D.	Planned downtime: lunch, breaks (minutes/shift) Note: If tag relief is used, enter 0	
E.	Total planned production time/shift (minutes)	=C - D
F.	Total planned production time/day (minutes)	=A x E
G.	Days/week	
H.	Total planned production time/week (minutes)	=F x G
Sample production run data:		
I.	Total minutes run	
J.	Total breakdown time + time for minor set-ups and adjustments (minutes)	
K.	Total number of parts made (good + bad)	
L.	Total good parts (first time through only- do not include parts that were re-processed or reworked)	
M.	Total bad parts	=K - L
N.	Actual cycle time (sec/part)	=((I - J)*60) / K
Other data:		
O.	Planned cycle time-the one used for capacity planning (seconds/part)	
P.	Projected time per changeover (minutes)	
Q.	Projected changeovers per shift	

R.	Projected downtime: changeover time/shift (minutes)	=P x Q
S.	Projected downtime: (breakdown time+time for minor set-ups and adjustments)/shift (minutes)	This should agree with field J
T.	Total projected unplanned downtime/day (minutes)	= (R + S) x A
OEE calculation		
U.	Equipment Availability:	=(F-T)/F
V.	Performance Efficiency	=O / N
W.	Quality Rate:	=L / K
X.	OEE:	=U x V x W

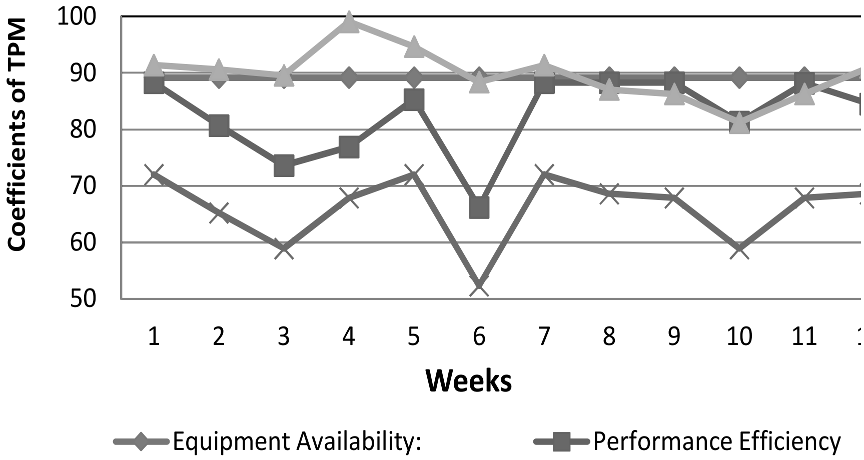
Source: [BORKOWSKI S., SELEJDAK J., SALAMON S., 2006]

The values of Equipment Availability (EA), Performance Efficiency (PE), Quality Rate (QR) and Overall equipment effectiveness (OEE) for the six processes are presented in Figures 9.1a-f.

a)



b)


100
90
80
70
60
50
Coefficients of TPM
1
2
3
4
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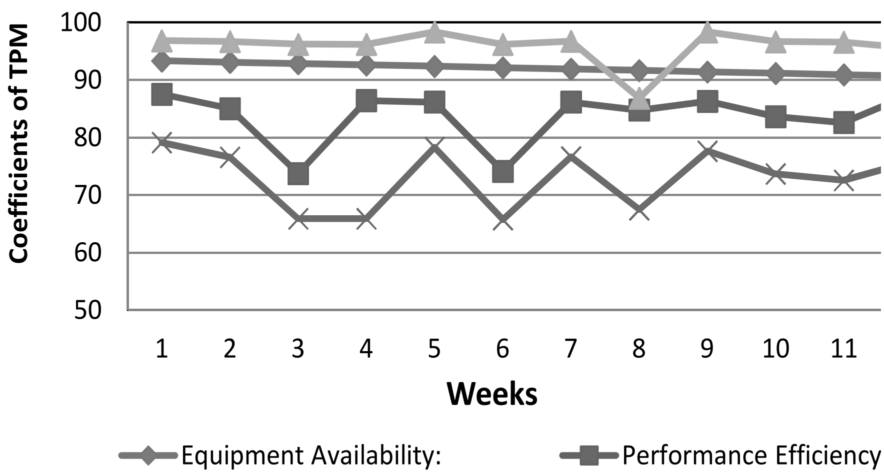
6
7
8
9
10
11
Weeks
Equipment Availability:
Performance Efficiency

c)


100
90
80
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50
Coefficients of TPM
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2
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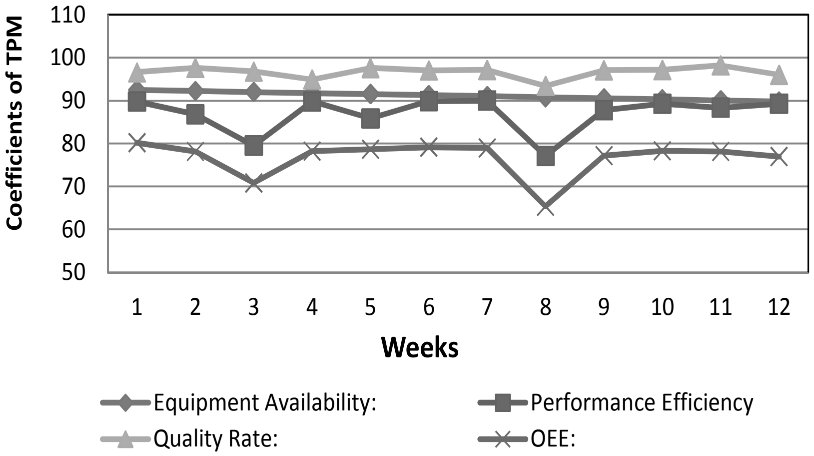
Weeks
Equipment Availability:
Performance Efficiency

d)



Coefficients of TPM
110
100
90
80
70
60
50
1
2
3
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6
7
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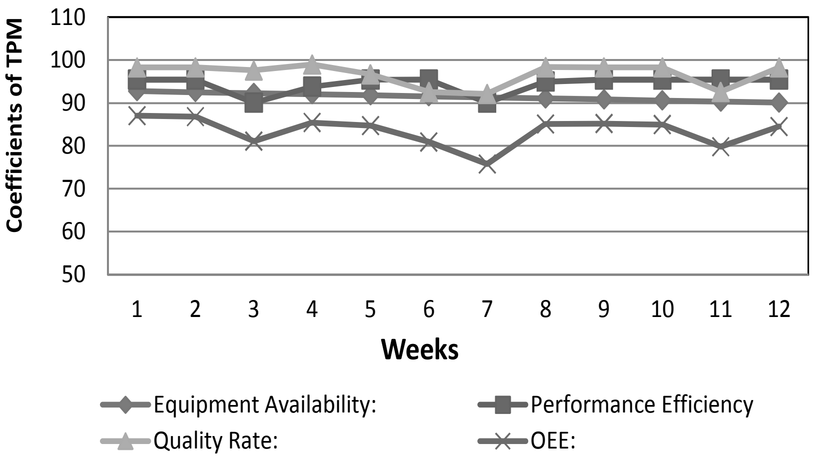
9
10
11
12
Weeks
Equipment Availability:
Performance Efficiency
Quality Rate:
OEE:

e)



Coefficients of TPM
110
100
90
80
70
60
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1
2
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Weeks
Equipment Availability:
Performance Efficiency
Quality Rate:
OEE:

f)

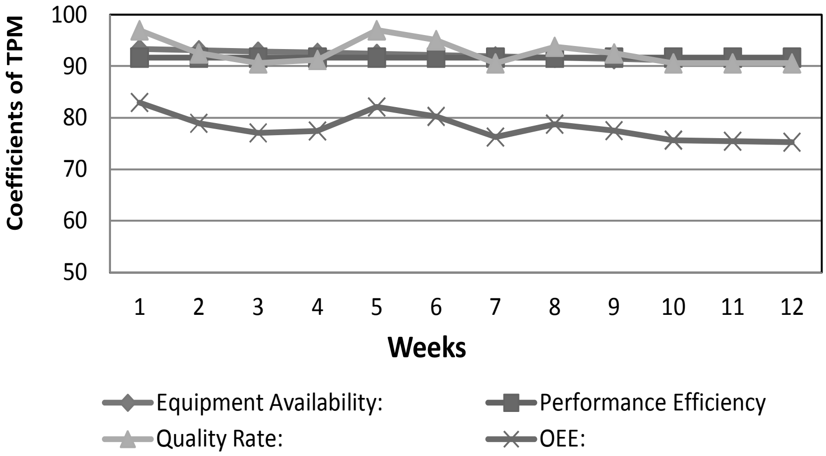


Fig. 9.2. The values of EA, EP, QR and OEE for a) Die casting, b) Clipping, c) Drying, d) Drilling, e) Chamfering, f) Packing.

Source: own elaboration

The analysis of the study shows that all processes have similar coefficients of availability remaining at a level 90-93,33%. The highest efficiency is the process associated with the chamfer and packing (more than 90%). The lowest efficiency was observed in the case of two processes: die casting and clipping. The lowest level of quality can be observed in the case of three processes: Tapping (69,43%), Clipping (74,7%), Trimming (75,71%).

The table 9.2 shows the average values of Equipment Availability (EA), Performance Efficiency (PE), Quality Rate (QR), Overall Equipment Effectiveness (OEE).

Table 9.3. Average values of EA, PE, QR, OEE

Symbol	**Nazwa operacji**	Equipment Availability [%]	Performance Efficiency [%]	Quality Rate [%]	OEE [%]
$\mathbf{P_1}$	Die casting	84,5	77,58	92,85	60,85
$\mathbf{P_2}$	Clipping	89,2	82,49	89,76	66,02
$\mathbf{P_3}$	Drying	92,01	83,68	95,94	72,94
$\mathbf{P_4}$	Drilling	91,16	86,96	91,61	76,69
$\mathbf{P_5}$	Chamfering	91,44	94,36	96,68	83,44
$\mathbf{P_6}$	Packing	92,02	91,65	96,00	80,64

Source: own elaboration

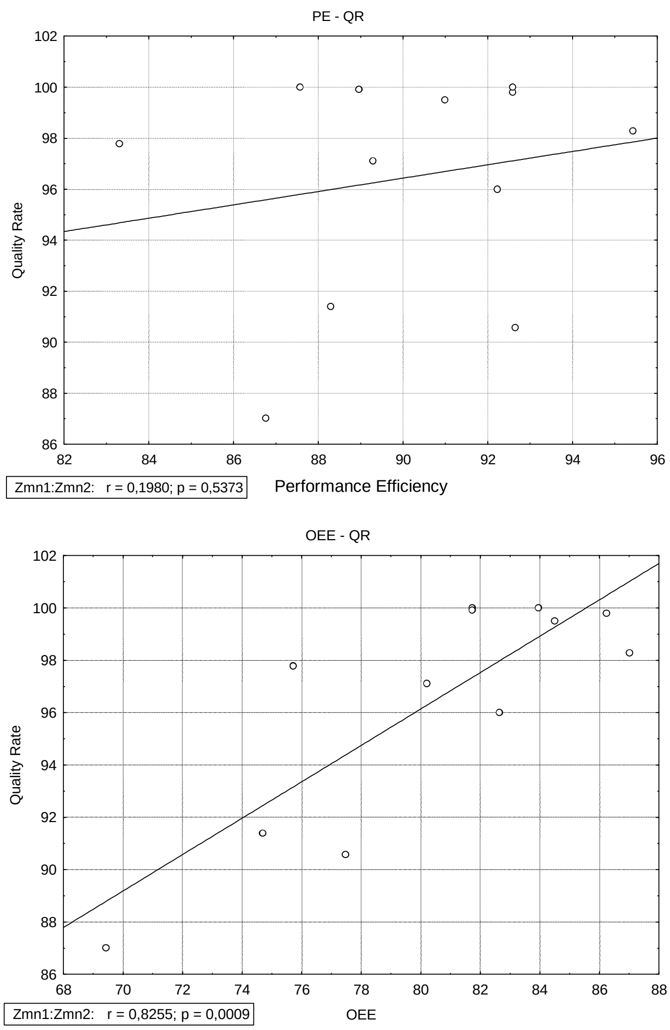
In order to determine if EA, PE and OEE impact on the quality of casting, correlation coefficient *r* was used [MIELCZAREK K., BORKOWSKI S. 2008., BORKOWSKI S. 1999., BORKOWSKI S., CZAJKOWSKA A 2010.]. Correlation coefficient was calculated from the formula [JÓŹWIAK J., PODGÓRSKI J. 1994., OSTASIEWICZ S., RUSNAK Z., SIEDLECKA U. 1998]:

$$r = \frac{\operatorname{cov}(x, y)}{\delta x * \delta y} \qquad (1)$$

δx - standard deviation of *x* variable,
δy - standard deviation of *y* variable,

Scatter plots the relationship between Performance Efficiency (PE) and Quality Rate (QR) as well as Overall Equipment Effectiveness (OEE) and Quality Rate (QR) is presented in Figure 9.3.

The analysis of the study shows that there is a poor correlation between the EP and QR. The analysis of the figure also shows that there is a very strong relationship between OEE and QR (r = 0.83)



a)

b)

Fig. 9.3. Scatter plots the relationship between a) Performance Efficiency (PE) and Quality Rate (QR), b) Overall Equipment Effectiveness (OEE) and Quality Rate (QR).

Source: own elaboration

9.3. Summary

There was a higher overall efficiency in the packaging process, chamfering and drilling (average 80-90%) than the first three (below 65%).

Performance Efficiency was lower in the die casting process, clipping and drying.

Equipment Availability followed a similar pattern in all processes.

The lowest level of quality can be observed in the case of die casting.

The analysis of the study shows that the coefficient of OEE is an excellent tool for evaluating the effectiveness of each process involved in the production of die-cast product.

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