KES Transactions on Sustainable Design and Manufacturing II
Sustainable Design and Manufacturing 2015 : pp.159-173 : Paper sdm15-053

Continuous improvement of the effectiveness of equipment driven by the dynamics of cost reduction

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Abstract: *The purpose of this paper is to present a method of continuously targeting the improvement projects for equipment based on quantifying equipment losses in costs. The methodology for the continuous improvement of the effectiveness of equipment driven by the dynamics of cost reduction resulted by reviewing the literature and analyzing several production companies over a year and a half. Using action research, our research results show the approach of reducing costs for equipment continuously monitoring its losses. As a key academic contribution, the study provides a scientific approach to continuous improvement of costs associated with equipment losses, based on four perspectives of improvement (systemic, systematic, individual and shop floor).*

1. Introduction

In a manufacturing company, just like in any other organization, the fundamental task of any management team is to develop clear and sustainable management way. One of the major concerns of managers is to reduce costs. In this context, the strategic objectives of production companies is to increase the level of synchronization of the production system with market signals [1]. Production companies, from the perspective of increasing the efficacy and the efficiency of equipment, have a major preoccupation with respect to the constant monitoring and increase of the level of the managerial indicator named *"Factory* Overall Equipment Effectiveness" – *OEE* in connection with the level of the costs associated to the times which do not add value for each equipment [2, pp.38], against the need for constant reduction of production costs imposed by the increase of competitiveness and of the dynamics of deflation.

Even if the production companies are using different methods to reduce costs, including equipment costs, both in the production phase (kaizen costing [3, 4], value analysis [3, 5]) and especially in the research and new products development phase (target costing [3, 6], value engineering [3, 4], quality function deployment [7, 8], total productive maintenance - pillar of new product development [2, pp. 353-392, 9]), using different methods of costing (Activity Based Costing or standard costing [10]) the results are not guaranteed, especially considering the dynamics of costs.

The contribution of our research is represented by: (1) the ongoing transformation of equipment losses in costs to continuously direct kaizen projects towards achieving financial results, (2) practical collecting the performance indicators for equipment losses, (3) identifying sources of establishing the level of cost reduction, (4) development of four perspectives to approach the equipment improving (systemic, systematic, individual and shop floor).

Our research question is: ”*how to develop kaizen projects for equipment in order to reduce costs?”.* Our research question was the result of a discussion with a general manager of a company in the automotive industry (in a kaizen event for quick changeover), he asked us: ”*show me the money earned from kaizen projects for equipment”* (...) then he continued, *”when I will see financial benefits, I will allocate more resources”.*

Based on our research question, we have designed seven-step approach to continuous improving the effectiveness and efficiency of the equipment (to transform equipment losses in costs), based on four perspectives of improvement (systemic, systematic, individual and shop floor), scientifically and continuously (continuously planning kaizen projects [11] for the equipment activity improvement [12]).

After this first introductory part, we will continue in the second section with theoretical frameworks, in the third section we will describe research method used (action research - AR), in the fourth section we will briefly describe the seven steps of our methodology, in the fifth section we will give an example, and in the end to present our conclusions (in the sixth section).

2. Theoretical framework

The systematic measurement of equipment effectiveness with the purpose of maximizing outputs by minimizing entries by reducing and eliminating losses was developed by Seiichi Nakajima [3]. The purpose of OEE is to continuously increase the added value brought by the equipment and to reduce manufacturing cost [4, pp. 21-45] it is the main indicator for Total Productive Maintenance (TPM) [5, 6] . Over the time there have been numberless theoretical and practical preoccupations regarding the utility of OEE from different perspectives, such as: of detecting bottleneck [7], of classifying losses [8], of using in automatic manufacturing systems [9], of approaching continuous improvements [10], of the capability of processes [11], in time study [12], in the identification and approach of quality related problems [13] or of the operators' role in continuous improvement [14, 15]. A rather narrow approach is for Overall Line Effectiveness (OLE) [16], as it is considered that sometimes the efficacy and the efficiency of the entire line is more important than the efficacy and the efficiency of each equipment.

One of the critiques of using OEE is connected to approaching the costs of losses [17], more exactly hidden costs [7] and the need for scientific quantification of the losses in production costs [18, pp. 243-263, 19-21]. The increase of the productivity of production companies, the continuous reduction of losses and of costs implicitly is a necessity imposed by the need for global competitiveness, including by deflation phenomena [22]. The reduction of the level of the prices of existing products (not of future products) and of its flexibility, further to the effects of deflation, has a major impact on the stability of economic systems, of the previously established profit plans and implicitly on the stability of production systems [22].

From the perspective of supply chain [23], the processes of production companies can be divided into three categories: (1) processes referring to entries (raw materials and materials, transport and storage); (2) processes referring to transformations and (3) processes referring to exits (warehouses, transport, distribution). In order to cope with the need for continuous reduction of the costs related to transformation processes, production companies analyze the structure of the costs in order to identify the opportunities of reducing useless consumptions of resources (losses) by especially identifying the opportunities of increasing the productivity, the quality and the deliveries. From the perspective of OEE and TPM, in order to reduce losses, with the purpose of reducing production costs [2, pp.38, 18, pp. 243-263], the following are approached: the improvement of the efficacy of equipment, of people's work, of raw materials, of consumable materials and of utilities [3]. Therefore, the continuous reduction of costs within production companies aims at approaching all costs [19].

The continuous focus on the improvement of equipment productivity by continuous identification of times without added value, of *"loss tree"* [6] respectively and of the costs related to these losses [18, pp. 243-263, 19, 24, pp. 257-270] helps to identify the *production cost reduction reserves* which may be reduced in order to cope with the continuous reduction of prices, ensuring a reasonable operational profit, including in the attenuation of the possible negative effects of deflation. Also, leads to maintaining alive the manager's wish to promote the continuous improvement culture in production companies, especially by establishing the relation cost/benefit of improvements [15].

3. The research method

The *action research (AR)* methodology as defined by Coghlan and Brannick [25, pp. 21-31], was found relevant to study the connections between equipment losses and cost reduction opportunities for existing products at the manufacturing stage.

The study was conducted in an automotive company during a year and a half and was based on three main principles: PDCA cycle [32], kaizen [2, 11, 13] and the relationship between price, profit and cost (price-profit = cost) [3]. The main requirement of the top management was to direct the kaizen projects for equipment by prioritizing them according to potentially saved costs (reduction of equipment losses) and according to avoidable costs (reduced investment). We started with target costing and kaizen costing processes related theories [3], we analyzed and improved the collection of the 8 basic equipment losses according to Total Productive Maintenance – TPM methodology [2, 9] (losses already measured and enhanced by factory) we evaluated the current kaizen project management, we evaluated the method for calculating the costs based on cost centers and we developed the quantification of equipment losses in costs, using the continuous collection of equipment losses (Table 1). In addition to analyzing and quantifying equipment losses in costs we also addressed labor yield losses and material/utilities losses.

Data were collected from the following four main sources of data and information: (1) OEE calculation for each equipment (failure losses, setup/adjustment losses, start-up losses, tool changeover losses, reduced speed losses, idling/minor stoppage losses and defect/rework losses,) [2, 3], (2) measuring losses caused by temporal acceptable shutdown (*Labour effectiveness*: time with diseases of employees (sick leave), time to count the stocks, time for training, time for short breaks, time for lack of tasks, time with injuries at work, waiting time for quality check, time to power outages (no electricity), time to return of poor quality materials and waiting for materials; *Equipment effectiveness*: allowable time for cleaning equipment, allowable time for checking and lubricating equipment, allowable time for planned maintenance of equipment), (3) consumption measurement for each process utilities (electricity, compressed air, gas and water) and (4) measuring the loss of raw materials from scrap and rework.

So, from theory and from target costing, kaizen costing [3, 9], from the practical application of OEE/TPM [2] and from costing methods based on cost centers we have reached directing the equipment effectiveness improvement projects through the need to reduce costs, and then going back to kaizen projects and OEE to achieve kaizen projects planning to continuously reduce equipment losses and by default the costs.

In this way, for production companies that predominantly depend of equipment (and less of direct labor) we can predict the cost reserve of the equipment which can be exploited to reduce ongoing costs of products in manufacturing processes, through a kaizen project management directed by the cost level required to be obtained in order to achieve the dynamic profit targets plan.

4. Continuous improvement of the effectiveness and efficiency for equipment

4.1 Identify processes and equipment involved

The identification and the documentation of the processes is made with the purpose of establishing the measurements necessary for the equipment and especially of causality relations between the impact of the effect of losses on equipment on other production factors (the necessary labor, materials, utilities, stocks, production methods, environment, the employee's state of mind) and the other way round. Hence, the initial documentation of the processes is made with the aid of the following measurements: the time cycles of the equipment and their correlation to takt time, the number of operators, the number of shifts, the standard level for Work In Progress (WIP), the types of equipment involved, actual production quantity, etc.

4.2. Measurement equipment losses

After identifying the processes and the equipment the losses are measured for the equipment involved in the previously identified processes [2, pp. 69] **(table 1).** The purpose of measuring losses for equipment is to identify the opportunities of improving the OEE level, depending on the emergency for the next period (the following are especially followed: the increase of the quality level, the increase of the level of synchronization to takt time and the increase of the equipment production volume, if there is demand), depending on the potentially obtained benefits (depending on the level of saved and/or avoided costs) and depending on the improvement completion term (for example: no longer than 3 months). The measurements for equipment losses take into account time-related loss - *TRL* (with an impact on reducing the exits, including reduction in output caused by defectives and rework) and physical loss - *PL* (defectives and rework, including defectives and rework - when restarting equipment).

4.3 Identification of costs for equipment losses

From the perspective of production costs related to the processes referring to the transformations inside production companies, these can be divided into two large categories namely: (1) raw materials and direct materials costs and (2) the transformation cost. In order to reduce raw materials and direct materials costs, managerial techniques can be used such as: design, alternative materials, alternative suppliers, framework contracts and successive negotiations with the suppliers, the reduction of technological losses from production processes, etc. Within the structure of the transformation cost we can identify fixed cost (especially depreciation, but also insurances, rents, guaranties) elements and floating cost (indirect materials, direct and indirect labor, fuel, power, die and jig, tool, maintenance and repair) elements [19]. In order to reduce transformation costs, especially floating transformation costs the measurements in paragraph 4.2. are used. By decreasing these times without added value of the functioning of equipment and of their associated consumptions the production cost can be reduced *consistently and continuously* [6]. In order to identify the costs related to the losses on equipment, the construction of the costs system provides that each piece of equipment be declared a cost center (place of accumulation of costs). In this way, each cost center having specific pre-established consumptions, one can establish the percentage of cost without added value by continuous measurement of the losses of the cost center, of the equipment respectively. From the perspective of losses on equipment and of the costs related to these losses, we are looking for the answer to the following question: ”*what is the level of costs for each type of loss on equipment/cost center?”*

	Category of loss	Type of loss	Name of loss	Indicators for equipment losses	Units	Manager responsible	Data collection	Frequency of the collection
1	Downtime Losses	*TRL; PL*	Breakdown	(1) Breakdown rate of equipment (1/h); (2) Repair rate of equipment (1/h); (3) Number of defects produced by the breakdown (unit);	Time (minutes); number	Maintenance	Team	Continuous
2	Downtime Losses	*TRL; PL*	Setup, settings, adjustments	(1) Number of set-ups in a period; (2) Set-up time of equipment (min); (3) Number of defectives produced during the adjustment (unit)	Time (minutes); number	Maintenance	Area	Mounthly
3	Downtime Losses	*TRL; PL*	Tool changes	(1) Number of units produced between the two tool changes of equipment (unit); (2) Tool changing time of equipment (min); (3) Number of defectives produced during the adjustment (unit)	Time (minutes); number	Maintenance	Team	Weekly
4	Downtime Losses	*TRL; PL*	Equipment start-up time	(1) Number of start-ups in a period (unit); (2) Start-up time of equipment (min); (3) Number of defectives produced during the adjustment (unit)	Time (minutes); number	Maintenance	Team	Mounthly
5	Performance Losses	*TRL*	Equipment cycle time (speed down)	(1)Theoretical cycle time of equipment; (2) Actual cycle time of equipment;	Time (minutes), number	Maintenance	Team	Quarterly
6	Performance Losses	*TRL*	Equipment minor stoppages	(1)Minor stoppages rate of equipment (1/unit); (2) Total repair time of equipment (min);	Speed, ration	Maintenance	Team	Weekly
7	Defect Losses	*PL; TRL*	Scrap and Rework	(1) Scrap rate of equipment /process (1/unit); (2) Rework rate of equipment/process (1/unit)	Quantity, time, costs	Qaulity	Team	Mounthly
8	Losses caused by temporal acceptable shutdown	*PL; TRL*	Scheduling shutdown time	(1) Total time of downtime / month	Time, quantity	Maintenance	Area	Mounthly

Table 1 - Performance indicators for equipment losses

4.4 Establish the necessary level of cost reduction

Since the establishment of the target for reducing costs and losses is always a delicate task, just like in the case of establishing any target, for any other performance indicators, it needs a careful prioritization of the opportunities for the reduction of the identified losses, prioritization which is based on the relation between the ease of approach and the results which may possibly be obtained. The establishment of the necessary percentage reduction of the production cost for the total of production company, able to ensure the targeted profit level, has 4 influence sources (2 external and 2 internal) (**table 2**):

External influence source 1	**Internal influence source 1**
% of the decrease of the market price for the company's products (price influenced by customers, by competitors and by deflation).	% of the losses identified on equipment (% influenced by the ease of approach and by the necessary time – improvement projects for a period of maximum 3 months).
External influence source 2	**Internal influence source 2**
% of increase of the price of entries from the suppliers (price influenced especially by the increase in the raw material and utilities price).	% standard of annual reduction of the production cost, for example 10% per year [26], especially of the transformation cost based on the losses related to the equipment.

Table 2: sources of establishing % of reduction of production costs per total company

The opportunities of reducing the costs related to the losses related to *internal influence source 1* are chosen as a priority if they are higher than the other three cost reduction sources. In the case of *internal influence source 2*, the standard percentage of annual reduction of the production cost, especially of the transformation cost related to the equipment, is grounded upon the real opportunities of reducing losses (this percentage having the tendency of decreasing in time at the same time with the reduction of improvement opportunities, in the case of equipment at the same time with the increase of OEE). Usually, the percentage of reducing the costs for each cost center related to each piece of equipment is different from the percentage of reducing the costs for the entire company.

4.5 The establishment of individual targets

Starting from the percentage of necessary annual improvement and from the structure of current losses (for equipment - Table 1; for the labor, for materials and for utilities [4, pp. 12-45]) and of related costs, individual reduction targets are established for each cost center. Further on, from the perspective of equipment, for each piece of equipment we establish targets for reducing losses and the costs related to the losses. These targets for reducing the losses on equipment are established depending on the necessary resources to be allocated (people, equipping, information etc), on the complexity of improvement projects and on strategic interests The direction of improving losses on equipment must be towards zero [6].

4.6 Identify improvement techniques

The identification of the techniques for the improvement of equipment losses and implicitly of the associated costs is made for four approach perspectives: *systemic* (the strategic approach of equipment improvement), *systematic* (the approach at the level of management methods), *individual* (the approach at the level of precise improvement) and at *shop floor level* (the approach of the improvement of the equipment at the level of daily management or shop floor management) **(table 3).**

	Perspective	Directions
1	Systemic	Equipment innovation; production layout innovation (for fulfilling the principle of One Piece Flow; for shortening the lines, etc).
2	Systematic	Preventive maintenance; Predictive maintenance; Quality maintenance People skills; Utility consumption.
3	Individual	Improvement related to: breakdown, setup, settings, adjustments; tool changes, equipment start-uptime, equipment cycle time (speed down), equipment minor stoppages, scrap, rework, tool life.
4	Shop floor	Improvement of standards for cleaning, lubrication, inspection.

Table 3: Perspectives for equipment improvement

4.7 Planning, implementation and monitoring of kaizen projects for equipment

The planning in time of improvement projects must be in full accordance with the company's annual objectives and with reaching the targets of key performance indicators and with the allocation of the necessary resources in order to obtain the strategic improvements for equipment (the losses from **table 1**).The planning of improvements is approved by the company's top management. The planning for each improvement project must contain the following elements: project code, the department which proposed the project, the name of the improvement, the manager beneficiary of the improvement, the managers' responsibilities, the step in the process in which the improvement shall be made, project definition, target for improving the loss; target for improving the cost; project sponsor, project leader and project team. The coordination of improvement projects must take into account the proposed intermediary and final solutions, the necessary resources and investments, the estimated benefit at the level of times, etc. Actually, *the analysis cost/benefit* is made by estimating the benefits which may be obtained, including from the horizontal multiplication of the chosen solution and by estimating the costs necessary to be allocated to the project for the sustainable implementation of the chosen solution. The proposed solutions must be consistent in time, at least as it was planned in the cost-benefit analysis.

5. Example of an application

Our proposed methodology was applied in an automotive company in order to assess the viability of the approach, during a year and a half. Using performance indicators for equipment losses **(table 1),** in order to reduce the transformation costs by increasing the OEE in the plastics processing, the management decided to analyze the current transformation costs and losses for plastic injection equipment **(figure 1).** Our approach and the traditional approach of OEE (**Table 4)**, led to a scientific coordination of the equipment continuous improvement projects in order to achieve cost reduction targets.

Application of the methodology steps:

a) identifying processes and equipment involved (Figure 1):

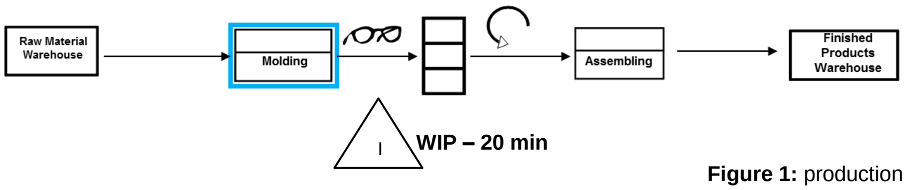

Figure 1: production flow

b) equipment losses measurement

Initial information (measurements and calculations for 6 months - 3 shifts, 8 hours per shift; equipment dedicated to the realization of two relatively similar products - **Table 4)**: Working Hours [WH] – 14.400 available min. maximum per month; the total number of parts produced [N]: 8.050 pieces; total pieces of scrap [S] (pieces): 130 pieces; standard cycle time [Sct] (seconds /piece): 60 seconds per piece; real time cycle [Rct] (seconds /piece): 65 seconds per piece.

	Calculation of loss of effectiveness of equipment	monthly average (min.)	no. of events/month	average time/ event min.	scrap
1	**Monthly working hours** (30 days * 8 hours * 60 minutes)	14.400			
2	**Scheduled downtime** (a+b+c+d+e+f)	**1.640**			
a	Short breaks (5-10 minutes/break)	180	30	6	0
b	Lunch break (maximum 30 minutes)	900	30	30	0
c	Planned maintenance activities	80	2	40	0
d	Cleaning Time	300	100	3	0
e	Electricity Interruption Time	60	30	2	2
f	Time for training	120	2	60	0
3	**Loading time [LT]** (1)-(2)	**12.760**			
4	Breakdown time (g+h+i)	255			
g	Mechanical failure	90	9	10	56
h	Electrical failure	45	5	9	30
i	Waiting for repairs	120	6	20	0
5	Set-up & adjustment time	551	19	29	0
6	Cutting tool replacement time	380	20	19	0
7	Start-up & yield	200	50	4	42
8	**Operating time [OT]** (3) - (4) - (5) - (6) - (7)	**11.374**			
9	Loss of speed [Ls] (*)	671			
10	Minor stops and idling [MSI] (**)	2.623			
11	**Net Operating Time [NOT]** (Sct * N)	**8.050**			
12	Rework time	30	30	1	
13	Total loss with scrap [TLS] (***)	130			
14	**Value-adding operating time [VAOT]** (****)	**7.920**			

Table 4: Overall Equipment Effectiveness calculation

(*) Ls = N * Rct-Sct = 8.050 pieces * (65 sec. – 60 sec.) = 8.050 * 5 sec. = 40.250 sec. = 670,83 min.
(**) MSI = WH - (2+4+5+6+7+9+12+13) - VAOT = 14.400 – 3.857 – 7.920 = 2.623 min.
(***) TLS = Sct * S = 60 sec./piece * 130 pieces = 7.800 sec. = 130 min.
(****) VAOT = [Sct*(N-S)] = 60 sec./piece * (8.050 pieces – 130 pieces) = 7.920 min.
OEE = Availability x Performance x Quality = OT/LT x NOT/OT x VAOT/NOT = 11.374/12.760 x 8.050/11.374 x 7.920/8.050 = 0,891 x 0,708 x 0,984 = **0,621** or
OEE = VAOT/LT = 7.920 / 12.760 = **0,621.**

c) Identification of costs for equipment losses

Initial information about costs:

- ✓ the total manufacturing cost structure is: 65% of the raw material; 12% administrative and sales; 23% transformation cost (budgeted expenses allocated to cost centers);
- ✓ the transformation cost structure for cost center of injection equipment is: variable transformation cost ratio *(vtcr)* is 2,57 €/min. (auxiliary materials, utilities, repairs and maintenance, rent, insurance, services, travel, fees, commissions, salary costs etc); monthly fixed transformation cost budget is 8,68 €/minute (depreciation of equipment is 125,000 € per month; therefore, 125.000 € / 14,400 minutes with monthly working hours), fixed transformation cost ratio *(ftcr)* = monthly fixed transformation cost budget / loading time = 8,68 €/min. / 12.760 min. = 0,00068 €/min.
- ✓ planned manufacturing cost for a product: *vtcr* (2,57 €/min.) + *ftcr* (0,00068 €/min.) = 2,571 €/ piece;

Transformation of losses in costs:

a) Breakdown losses variance = *ftcr* x breakdown time = 0,00068 €/min. * 255 min. = 0,1734 €/month;
b) Set-up & adjustment losses variance = *ftcr* x set-up & adjustment time = 0,00068 €/min. * 551 min. = 0,374 €/ month;
c) Cutting tool replacement losses variance = *ftcr* x cutting tool replacement time = 0,00068 €/min. * 380 min. = 0,258 €/ month;
d) Start-up & yield losses variance = *ftcr* x start-up & yield time = 0,00068 €/min. * 200 min.= 0,136 €/ month;
e) Speed losses variance = (*vtcr* + *ftcr*) x loss of speed = (2,57 €/min. + 0,00068 €/min.) x 671 min.= 1.724,92 €/ month;
f) Idling & minor stoppage losses variance = (*vtcr* + *ftcr*) x minor stops and idling losses = (2,57 €/min. + 0,00068 €/min.) x 2.623 min. = 6,742,89 €/ month;
g) Capacity utilization losses variance = (d) + (e) = 8,467,81 €/ month;
h) Rework losses variance = (*vtcr* + *ftcr)* x Rework time = (2,57 €/min. + 0,00068 €/min.) x 30 min. = 77,12 €/ month;
i) Scrap losses variance = (*vtcr* + *ftcr)* x Total loss with scrap = (2,57 €/min. + 0,00068 €/min.) x 130 min. = 334,18 €/ month;
j) Loss of scrap (material) = 130 pieces x 2,571 €/ product = 334,18 €/ month;
k) Operation variance: (a) + (b) + (c) + (d) = 0,1734 + 0,374 + 0,258 + 0,136 = 0,9414 €/ month;
l) Efficiency variance : (e) + (f) + (h) + (i) + (j) = 1.724,92 + 6.742,89 + 77,12 + 334,18 + 334,18 = 9.213,29 €/ month;

d) Establish the necessary level of cost reduction

From the calculations we have the following data:

- ✓ Unit cost = 2,571 € /piece and
- ✓ Total cost = 20.696,55 € (€ 2,571/piece * 8.050 pieces);
- ✓ Average monthly cost of total losses = 9.214, 23 € (operation variance 0,9414 € + efficiency variance 9.213,29 €) for 8.050 pieces;
- ✓ Average monthly cost of total losses per unit = 1,14 € /unit (9.214, 23€ / 8.050 pieces);

Cost reduction targets in dynamic (of losses identified on equipment): 1st year, down 7%; 2nd year, down 6%; 3rd year, down 5%. Setting targets to reduce costs was made considering the evolution of the market price **(table 2 - *external influence source 1*).**

e) The establishment of individual targets

So, for the first year, the target of reducing unit costs by 7% is 0.18 € /unit (2,571 € /unit * 7%) and for the total cost is 1.448,76 €. Following the discussions between the people involved in the area of plastic injection equipment we set the improvement targets (*annual improvement plan for equipment*) coordinated in particular by the cost of each loss type, by the need to increase the capacity of the equipment and by the need to increase flexibility improvement for small batches. One individual goal was to reduce the *set-up & adjustment losses variance*, taking into account the need for future growth in the volume of orders (hence the need for capacity to molding) and the need to increase flexibility for small batches. The annual equipment improvement plan established two successive targets to reduce set-up and adjustment losses: from 29 minutes to 14,5 minutes (first target for the first 6 months of the year) and from 14,5 minutes to 9,5 (second target for the last 6 months of the year). Therefore, individual cost reduction target for set-up & adjustment losses is 0,187 €/ month (*ftcr* x set-up & new adjustment time = 0,00068 €/min. * 19 events * 14,4 min.).

f) Identify improvement techniques

The improvement technique chosen for setup and adjustment losses variance was: *Single-Minute Exchange was of Die (SMED)* [2, 4, 6].

g) Planning, implementing and monitoring kaizen projects for equipment

After a kaizen project which aimed to reduce set-up time and adjustment losses by applying SMED technique, over six months, with a team of 7 people, the time for set-up and adjustment was reduced to 9,2 minutes. Using two video analysis and identifying internal and external activities of set-up and adjustment we identified the time-consuming activities. The longest time was consumed by heating the mold for future product - in injection equipment. The solution chosen was preheated mold with warm water using an external device. The new monthly cost for set-up and adjustment is 0.119 € / month (ftcr x set-up & new adjustment time = 0.00068 € / min. * 19 events * 9,2 min.). Therefore, the annual target of 9,5 minutes was reached and exceeded by the first improvement project. The solution was applied to 14 similar equipment. The main improvements obtained from the four perspectives (**Table 3)** were: a new layout for preheating system (*systemic level)*, training for new people skills - new standard for set-up and adjustment (*systematic level)*, using the technique SMED (*individual level)* and a new standard for reducing cleaning time/5S (*shop floor level)*.

6. Conclusions

Reviewing the literature and analyzing the principles and phenomena of the company in which the research was conducted, the need to deepen the continuous reduction of costs of equipment losses was revealed. The literature reviewed shows the need to continuously reduce costs for equipment losses, but does not present a clear and scientific approach. Based on our research question, the approach presented in this article significantly contributes to understanding the path of continuous improvement of the effectiveness of the equipment. Besides, the measurable advantages of our approach presented in the application above, during our research we have identified a number of intangible benefits (directions for future research) such as: improving team work (both in the planned events and in their absence), increasing motivation and involvement of all people (especially senior managers), increasing job satisfaction to operators (results are measured in costs), increased involvement of operators in setting targets for improvement (achievable targets), acceptance of systematical improvement as a normal way of life in the company, increasing knowledge of operators about equipment problems, increasing confidence in the workplace, etc.

Note: This work was partially supported by the strategic grant POSDRU/159/1.5/S/137070 (2014) and POSDRU/159/1.5/S/134197 of the Ministry of National Education, Romania, co-financed by the European Social Fund - Investing in People, within the Sectoral Operational Programme Human Resources Development 2007-2013.

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