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HUMAN AS AN IMPORTANT FACTOR IN PROCESS PRODUCTION CONTROL

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Abstract: *This paper discusses the importance* every human differs from the others in *of human in control of process production on* term of individual congenital *an example of electronics manufacturing. The* characteristics, such as personality, *example regarding customer complaints, points* temperament nature, behavior, and sensory *that human contribution to subjective* acquisition.
inspection is significant regarding quality of As the objective of quality control is to *final products. Although results of many* detect manufacturing faults, often in *researches in the field of productivity, and* multiple process steps, the meaning of *efficiency of process control conducted by* human factor regarding decisive part of *human have confirmed its advantage over* inspection is significant in respect of *machine with regard for human sensitivity, still* quality of final goods, as also consequently *the topic of human errors exists. Undoubtedly* against nonconforming products customer *the origin of human mistakes can be broad, not* protection.
only considered as insufficient work Client satisfaction [5] in terms of product *experience, but simply because human beings* quality, that is subject of electronics *are build to make mistakes. The conclusion of* acceptability standards[1], and in turn *the paper calls the need of further researches* contributes to automobile users safety *to human errors prevention in terms of its* plays superior aspect for manufacturing *optimization.*

Key words: *Human, subjective inspection, quality, error*

1. INTRODUCTION

The purpose of this paper is to demonstrate the importance, as also unreliability of human factor in control of electronics manufacturing process. Focusing on the most important object of quality inspection activity, that is human, awareness of its characteristics, and influence on control are essential to human errors prevention in terms of its optimization. Although the meaning of human factor is commonly known, often the term is being limited to individual job experience, trainings, motivation, and as also to related aspect as among others work place ergonomics, and a physical work conditions. Basically company's activity.

In connection with continuous technological progress, and parallel raising the customer requirements, the complexity of products becomes more and more high that impacts on manufacturing process, and finally the difficulty of visual inspection as a result of being multi-input-multi-output (MIMO) product-process system [10]. Although many researches, that has been conducted before [3] shows the weakness of human inspection system in comparison to automated, and hybrid still the human as decision-maker of uneven phenomenon, complex overlapping product parameters has considerable advantage over machine.

[1] Quality of electronics is interpreted by the standard of International Association Connecting Electronic Industries, that is IPC-A-610D, Acceptability of Electronic Assemblies, Bannockburn

2. HUMAN OBJECT IN SUBJECTIVE INSPECTION ASPECTS

Regardless of the fact, that many scientific researches, that have been conducted in various fields of studies confirmed, the human factor being the weakest object of process control undoubtedly human still has advantage over machine in key inspection aspects. Unexceptionable evidence is the fact, that human object often intuitively is misunderstood with human error, and interchangeably used. Proper interpretation of human factor and human error is needed to learn human manner in process control, and the reason of potential error occurrence. Incorrect phenomenon is ahead assumption of nonconformance appearance through human fault during every product inspection. Human performing repetitive tasks, that is product unit inspection, develops work performance learning iteratively [1] in a closed-loop feedback basing on experience, and previous committed faults.

Definition of human factor [9] comprises of environmental, organizational, and job factors, and the most important human and individual characteristics as also. Whereas human error is the consequence of actions, activities taken interacting with another system, while external, and/or internal inputs disturb their completion in desired manner. Additionally human error has been defined in complementary attributes [6] as the actions mentioned below:

- taken by human being
- deliberate, and voluntary
- occurring during men-system interaction
- exceeding tolerance limits
- negative consequences for one or both sides of interaction

2.1 Human error classification

Human errors can be simply classified in a few categories taking into consideration:

- intention/aim
- frequency
- error type
- consequences of wrong decision.

Intention or the aim of quality inspection activities, and human errors committed during control could be considered as:

- intended – controlled
- unintended – uncontrolled

Unintended [6] errors appear randomly, surprisingly for human, and are the results of slips, lapses, blunder, mistakes, or physical or spiritual ailments as also. Errors, which occur in effect of human activity without intention its commitment, are more dangerous in point of quality product level view because of their tracking, and prediction difficulties in comparison with intended error. Knowledge of intentional human errors arising source, that can be for instance lack of praise of good work by superior, appropriate actions could be taken to error reoccurrence prevention.

Intensity of errors commitment depends on various internal, and/or external inputs that come to unforeseeable event occurrence. Errors frequency can be:

- single/random
- repetitive
- desired/planned

As single and repetitive occurrence is intuitively interpreted, the desired one concerns exclusively human actions intended to error commitment, under whole human control.

Human errors can involve performance elements, or the behavior one. Type of performance faults relates to errors occurring alternatively as a result of:

- omission
- commission

while behavior errors generally have most in common with unintended error, under influence of unexpected phenomenon.

Consequences of human faults can be distinguished between:

- reversible
- irreversible

or according to the scope of the severity for all sides taking part in interaction, and the

sequence of following actions. Human errors can also be considered in time severity consequences as:

- short-term
- long-term

Short-term faults impacts are less dangerous for whole process production then the long-term. Mostly short-term error source investigation takes relatively short time, and smaller costs born as a result of error than the second one. Long-term error often results in latent costs as they relates to subsequent prolonging faults, which appearance are not obvious at start of researches. The severity of error in long time perspective in principle results in reduction of inspection efficiency.

2.2 Subjective inspection steps issues

Without distinction of manufacturing process final product object the quality control with human participation comprises of five similar steps as follows [4]:

- visual screening/potential faults search
- fault acquisition
- fault classification
- quality decision

Control performance depends on the level of all control steps development, and for every operator should be considered independently. Human characteristics as sensory acquit, level of perception, vigilance for potential errors occurrence, signal detection, and essential cognitive processes support need to be as a matter of fact analyzed individually for every inspector. Industrial studies, that been performed during last half of century confirmed the complexity of human being researches, and its detailed influence on inspection performance. The difficulty of manual control efficiency evaluation relates not only to human performance, but also to circumstances accompanying control process with direct, and/or indirect impact on inspector as well. Visual inspection needs to be performed with proper viewing conditions, for instance optimal workplace illuminations, proper means of visual aid accessible, and ergonomics organization. Awareness of errors occurrence, and propitious faults appearance condition with high degree of visual acuity is necessary for right inspection tasks performing, that in turn reduces the risk of pass-through costs arising. Another important element of product control is the time, and the following paced inspection implementation, that does not stay in linear relation with the efficiency of control [4]. Repetitive tasks, as the inspection is, with assumed work pace, or productivity require enlarged human vigilance, and continuous high level of involvement. Avoiding high rate of product scraps occurrence in monotonous activities necessitates optimal work time organization with rest breaks, and/or variable inputs at predictable error sources prevention. Apart from factors related to work place conditions, and work time organization, the nature of the accept-reject process points out that human search, and detection capacity relates also among other to cognitive, and physical human limitations. Fault search step seems to be the most important in the result of inspection point of view; however fault classification has turned out to be problematic. Subjective inspection results could be divided into two independent decision types, as follows:

- true error
- false error

Although occurrence of true errors seems to be the most important in customer point of view, rate of false errors has also significant contribution to inspection performance. On the one hand false error appearance in subjective control could be considered as human involvement in high product quality diligence. On the other hand high rate of false alarm deteriorates efficiency of control, and commonly is unacceptable in economic point of view.

2.3 Human performance measurement

Efficiency of manufacturing process, as also quality of its products does not depend only on machines, which take considerable

bigger part of production, but also indispensable object, is human. Despite the fact that most of researches, that have been conducted over the last two decades concern man-machine interaction, and investigation methods to upgrade this relation, human factor following studies are necessary. Although results of many researches in the field of productivity, and efficiency of manual process control have confirmed its advantage over machine with regard for human sensitivity, still the topic of human errors exists.

Evaluation of performance various inspection systems, such as manual, automated, and hybrid [3] with the regard to among other the rate of true failures search, false-alarm rate, overall accuracy, measurement sensitivity, and inspection time shows the pure human inspection as worse than the rest inspection systems. The conclusion of these researches is that generally the best performance of inspection system can be achieved linking human and machine, and take all advantages from that relation. Human in conjunction with computer works more efficiently assuming their whole, not partially usage. Studies confirmed that decision making part of inspection should be assign to human operator, whereas computer potential should undoubtedly be used to fault search step with its fast speed of control, acceptable hit rate, and accuracy by the agency of means of visual patterns.

3. HUMAN ERROR CONSEQUENCES

As it has been mentioned in earlier section of this paper consequences of fault commitment are investigated in the term scope and two categories can be distinguish as short-term, and long-term.

Severity of all errors occurring during manufacturing process is significant in the manufacturer, and customer point of view, as it tends among others to:

- process efficiency/ capability reduction
- rise of direct manufacturing process in terms of product reworks, or scrap
- rise of indirect quality costs of manufacturing process
- rise of outward quality cost in term of customer claims
- customer trust/satisfaction reduction
- rise of the risk of pass-through to the customer nonconformance appearance
- enlarge product sampling, and frequency of inspection

Apart from error occurrence during running manufacturing process, and corrective actions taken in real time production the more dangerous faults are these emerging, and experienced by customer. Product defects revealing outside company bring potentially higher costs, than conformances found inside factory. Indirect quality costs are understood as resources that are born in order to error source investigation, correction, improvement plan preparation, and implementation due to fault reoccurrence prevention, as also all actions effectiveness verification.

Researchers conducted in this paper focused on examination of the main cause of overall electronics manufacturing process errors appearance in the light of customer requirements. Customer satisfaction is considered by the agency of notified claims in one of company of electronic trade. Investigation of claim rate and the reason of their notification have been conducted over one economic year that is 2009 (Fig. 1). Root cause analysis of complaint error has been divided in a few problem categories as material/process/design/other.

Claims reason type that has been taken into researching consideration is process as it contains of among others machine, and human related errors. Process error category in analyzed example in turn has been distinguished in subsequent reasons that are men/machine/method/other.

Men type errors that results in customer claims often, besides trade category, are matched with training aspects, and in

sequence detailed potential human error causes are pointed out, as among others:

- improper handling/conditions of products transport between stations
- improperly made rework
- human not following the instruction
- failure not detected during human visual inspection
- misunderstanding of process/product requirements
- disregarding work rules
- misleading of visual signs

Reasons of claim notifications mentioned above suggest potential root cause (Fig. 2) of human factor indication and are the basis to effective corrective actions undertake. However the first point of claim investigation consists of potential root cause search, and check the cause of current process control failure not less important step is escape point examination. Escape point understood as prevention controls failure points out circumstances insufficiency of nonconformance occurrence protection activities (Fig. 3) as:

- insufficient training given to operator
- improper failure classification
- operator not following prescribed method
- lack of work experience
- lack of devices/gauges during control

Analysis of customer claims in on the basis of one of electronics manufacturing companies shows the majority of men related issues than the other over one year.

Most of complaints appeared as a result of human not following work instruction, and secondly law awareness of quality assurance, which directly are personal work training concern.

In turn of mainly escape points of claims the failure not detected during visual control, operator not following prescribed control method, and no sufficient work training as also should be underlined as the most important.

Conclude investigations in customer point of view of product quality; human factor role undoubtedly plays considerable part of control and has a big impact on its liability.

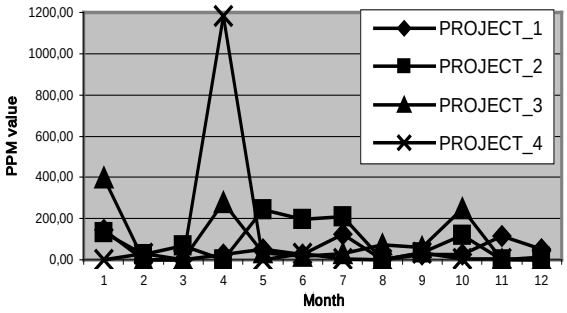

Fig.1 Claims of circuits amount over 2009

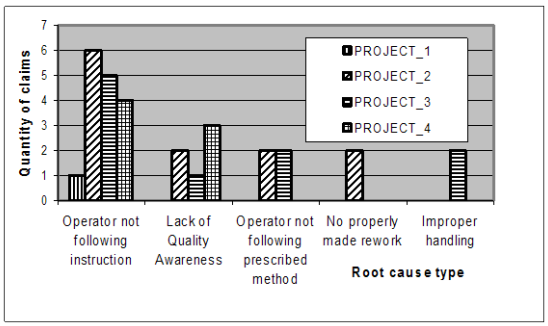

Fig 2. Identified root cause of claims

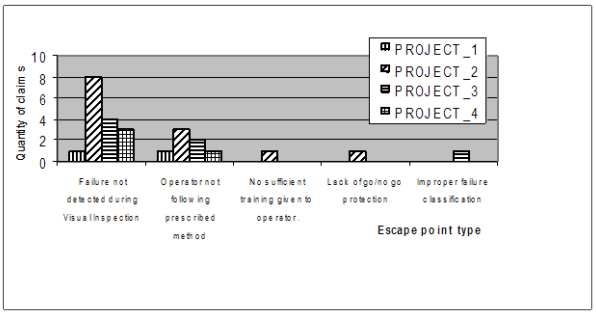

Fig 3. Identified root cause of claims

Taking into consideration the fact about human complexity, and multiplicity of factors, that have considerable influence of inspection results, and in sequence quality of products deep analysis of major impacted human characteristics and/or parameters has to be performed. Most of scientific investigations, that have been held in a last few decades based on human experience researches, and its influence by iterative learning [1] on control process performance. The results have confirmed the hypothesis, that human modify control actions recalling committed error, and errors rate in each iteration aiming better inspection performance. The ability of products control rises in time, and as at the start particular errors mostly emphasize on work behavior and control manner, so after

some iterations general error rate becomes the most desired input information.

4. ANALYTICAL PREDICTIONS OF HUMAN CAPABILITY

Manufacturing process capability evaluated by process step (C_p, C_{pk}) and/or machines (C_m, C_{mk}) capabilities, should also be featured equivalently by human inspector detection performance indexes with consideration of major parameters of human subject. Representing human being as non-linear function:

$$H = f(x_{inborn}, x_{learnt}, x_{outward}) \quad (1)$$

where H is human inspection performance, and respectively x_{inborn}, are personality type, behavior manner, physical abilities, and limitations x_{learnt}, are characteristics describing the level of experience, education, motivation, acquired standard, and rules, and finally $x_{outward}$ are work place and/or work time organization, gratification, praises and punishment system. Broad insight into human subject of control shows the complexity and multiplicity of factors related to human being influencing on control performance, and in result the quality of products. Introduction the hypothesis of impact of variables of Eq. (1) needs to enrich all parameters with weight assigned to particular characteristics independently for every human operator taking part in the research, that will the topic of next paper.

5. CONCLUSIONS

Human factor in manual subjective inspection plays undoubtedly major role as decision maker. Although its perceptual system, sensory acuity stand for considerable advantage over machines working in pattern system still human error exists that worsens control performance. Complexity of human being in terms of personality, behavior, experience, education level, as also work place, work time organization contribute to deep research need, not limited to only part of parameters such as experience and learning iteratively in loop compensatory systems, but reaching inborn characteristics, behavior manners, and motivation.

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