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Infallibility (Poka-Yoke) Fundamentals for Improving Production Processes, Case Study: An Automotive Parts Manufacturing Company

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Abstract

In production processes, quality is defined in terms of defects and sigma level wastes. In order to achieve zero level wastes, it is required that production processes' sigma levels be increased through improvements in the processes. Utilizing Infallibility Strategy (Poka-Yoke) increases the sigma level of production processes and thus leads the process towards producing parts without fault and with zero defects.

In the present study, the researcher has implemented the Infallibility Strategy (Poka-Yoke) in an automotive parts manufacturing company. In order to achieve the objectives of the study, the researcher, using a map, first determined the areas in which defects occurred in the production process, then the significance of defects with regard to their frequency of occurrence and their scope were determined, and the proper anti-error system was chosen.

Given the number of defects and the annual production capacity, the PPM and the manufacturing process sigma level were calculated. Obtained results demonstrated the significant increase in the manufacturing process sigma level, which in turn implied the successful implementation of the Infallibility Strategy (Poka-Yoke) in the studied company.

Keywords: Infallibility Strategy (Poka-Yoke), Zero Waste, Sigma Level, Production Process, Automotive Parts Manufacturing Company.

Introduction

In today's competitive economic climate, the full commitment of organizations to improvement of their products and services is highly necessary for their (Abolalaiy, Behzad, 2012). Companies should always look for efficient and effective solutions for their products and services. The products and services should go through improvement procedures in their own production processes. This continuous improvement could be further pursued through targeting zero level defects in production processes. In order to achieve zero level defects, which represent the highest quality in production processes, production waste generation should be favorably minimized. To do so, the errors in production processes must be first determined and then the reasons of their existence be properly addressed (Grout, 2007). Despite the fact that the number of these error is high, it is undoubtedly more logical to address the most important and significant of them, and then measures be taken to minimize them effectively and efficiently.

One of the parameters, indicative of errors in manufacturing processes, is the level of sigma (Koziolek, Sebastian, Derlukiewicz, Damian, 2012; Aboelmaged, Mohamed Gamel, 2010). The higher the sigma level of production processes in organizations, the lower the error rate. Thus, the goal is to reduce the errors to at most 3/4 defects per million, under which condition 99/99966% of parts would be produced intact (Easton, George; Rosenzweig, Eve, 2012; Brun, Alessandro, 2011; Productivity institute of America, 2009).

The majority of errors in production processes of organizations are due to human error (Kamsu-Foguem, Bernard; Rigal, Fabien; Mauget, Felix, 2013). The fact is that humans are forgetful and are prone to making mistakes, in a way that we often blame one another for errors that have been committed and try to stop individuals of making such mistakes. Yet to blame, especially in the workplace, not only discourages workers or employees and reduces their motivation, but also do not help to resolve the issue (Foster, 2004). Thus, Infallibility Strategy (Poka-Yoke) is a method for the prevention and avoidance of human errors in workplace (Saurin, Duarte Ribeiro, Vidor, 2012; Bioregard, Michel, Rimond, Mac Dermot, Robin, 2005).

Today's competitive environment leaves no room for making mistakes. We shall need to follow strict and serious new strategies to prevent and avoid mistakes to obtain our customers' satisfaction (Boyer, kenneth; Gardner, John; Schweikhart, Sharon, 2012). The Infallibility Strategy (Poka-Yoke) can be converted to an integral part of the organizational culture of our country and pave the way to reach zero level defect and high level quality for Iranian companies.

Statement of Problem

Sigma level demonstrates the ability or competence of a production process to perform its duties in manufacturing without producing non-conforming items or defects (Koziolek, Sebastian; Derlukiewicz, Damian, 2012); therefore, there is a direct relationship between sigma level of production processes and the amount of non- conforming items (Chakravorty, Satya, 2009).

Since some automotive parts are critical their defects could cause irreparable damages to customers, the International Organization for Standardization, ISO, has considered high standards for production of these products (Hinckley, 2001). On the other hand, in order to have presence in international markets and to export and reduce economic costs, firms making these kinds of auto parts need to lead their production process sigma level towards sigma level of six (Kull, Thomas; Wacker, John, 2010).

Auto parts manufacturing companies in Iran are generally in sigma level of three (Ardahay, Taghi, 2012). By improving their sigma level to four, five, and six, they would improve their production processes ten, thirty, and seventy times, respectively (Chakravorty, Satya, 2009).

Overall, improving the production processes sigma level depends on many factors, one of the most important of which is the human factors. Focusing on human errors in production processes of organizations, Infallibility Strategy (Poka-Yoke) presents ways to prevent and avoid the errors in a work environment, the results of which could be increasing the sigma level in the production processes of manufacturing companies (Nikkan Kogyo, Shimbun, 2008; Lewis, John, 2009).

In the present study, by implementing the Infallibility Strategy (Poka-Yoke) in an automotive parts manufacturing company, the effect of increasing the sigma level in manufacturing process could be delved into.

The theoretical Basis of Study

The Concept of Infallibility (Poka-Yoke)

Although the concept of Infallibility has been used in different ways in a long period of time, it was first used by a Japanese engineer, named Shigeo Shingo, as an effective method for achieving zero defects and to achieve the goal of eliminating the use of quality control inspections (Shingo, Shigeo, 1986).

Shingo's method was then made popular as infallibility. Its main goal is to attend to the intelligence and creativity of staff for removing errors (Raskin, Andy, 2003), since by eliminating repetitive tasks and duties, which require human memory and caution, it can lead the staff to direct their time and thought into creative activities that have greater value.

Infallibility is based on the idea that failure is often caused by human error (Nikkan Kogyo, Shimbun, 2008). This does not mean that errors should not arise, since errors occur due to many factors, which are the results of human error.

Infallible strategy focuses on disclaiming human factors when tasks require memory, attention, and focus for being repetitive, and of course, it does not mean that thinking must be removed, but to free the staff's time and mind with an innovative system of value adding, where tasks are done without fear of being wrong, and in a correct manner (Lewis, John, 2009).

Human errors are usually unintentional. (Abolalaiy, Behzad, 2012) Infallibility strategy for the prevention of defects also applies when defects occur unintentionally. Accordingly, infallibility reduces variables in a production process, thus creating conditions to reduce errors. For example, without infallibility, you may have five different ways to do something, one of which might be the correct procedure (Saurin, Duarte Ribeiro, Vidor, 2012). This is while using the infallible strategy, the operator does not have the freedom to choose different ways and there is just one way, e.g. the correct way, through which the procedure is to be implemented.

Zero Defects

Infallibility has the best performance when aiming for zero defects since most of the time our main objective is to improve the quality (Shingo, Shigeo, 1986). For example, reducing defects from 3% to 2% is relatively simpler than the total elimination of defects. Complete removal of defects requires the application of different methods to improve processes in which we would not rely on increased pressure on people to do the job right, but instead to implement infallibility.

Many people have the idea that the concept of zero defects is so unrealistic that it should not be treated as a target. Do safety equipment manufacturers try to achieve zero accidents or not, or do defects in the sensitive parts cause major accidents? As we focus on infallibility processes to eliminate accidents, we can also focus on infallibly to remove defects and create efficiency.

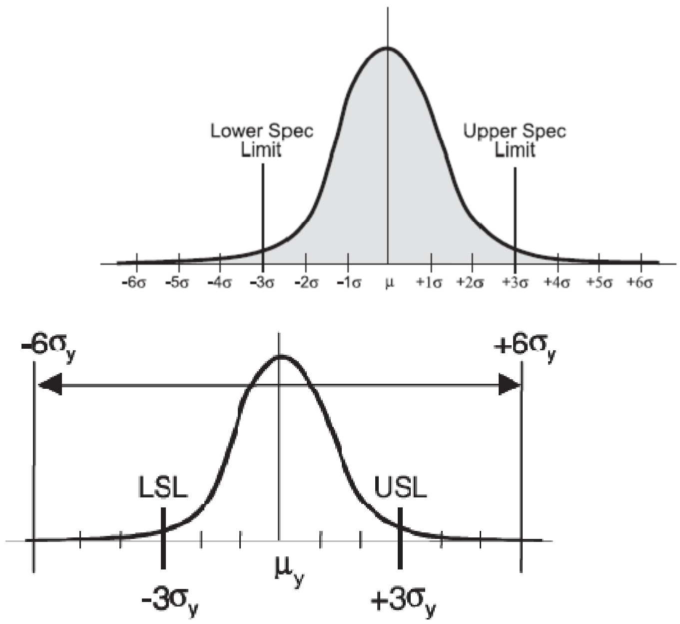

Figure 1: Sigma levels in normal distribution Chakravorty, Satya (2009)

Sigma Levels

Sigma is a Greek alphabet, which represents an important index of distribution in statistics, known as standard deviation. Sigma represents a measurement unit which determines the distribution or dispersion around the mean of a process. In trade, the amount of Sigma reflects the performance of processes and probability of error. Figure 1 demonstrates sigma levels of three and six Sigma in a statistical normal distribution (Brun, Alessandro, 2011).

Today's competitive world needs the paramount to stay in competition (Kamsu-Foguem, Bernard; Rigal, Fabien; Mauget, Felix, 2013). Accordingly, increasing the sigma levels, as a systematic program and using various quantitative strategies (including Infallibility Strategies), has been introduced. Increasing sigma levels of processes covers reduction of variation in processes (Kull, Thomas, Wacker, John, 2010), the underlying objectives of which can include reducing errors, reducing variations, reducing defects, improving efficiency, enhancing customer satisfaction, and improving financial issues (Aboelmaged, Mohamed Gamel, 2010).

Generally put, Sigma measures errors and defects as a way to increase the quality of manufacturing processes (Foster, 2004), in a way that high sigma level represents decreased level of errors and defects and low-level sigma represents more errors and defects in parts of the production processes. Thus, in connection with production processes' sigma level, the number of non-conforming parts per million (ppm) always decreases as sigma level increases (Raskin, Andy, 2003).

Table 1: The relationship between sigma levels and the number of defective parts (Easton, George, Rosenzweig, Eve, 2012; Brun, Alessandro, 2011; Productivity institute of America, 2009)

Sigma Level	Defects Per Million	Non-defective Percentage
1	697700	30.23%
2	308700	69.13%
3	66810	93.32%
4	6210	99.379%
5	233	99.9767%
6	3.4	99.9996%

Today's market requires production processes sigma levels of over three (Ardahay, Taghi, 2012). Achieving level Six Sigma is often the quality perspective of organizations and still not many companies have been able to achieve level Six Sigma levels (Bioregard, Michel et al., 2005). However, increasing Sigma levels through different qualitative methods leads to significant improvements in improving the quality and reducing the costs (Boyer, Kenneth et al., 2012). Infallibility Strategy is considered as one of the practical and qualitative methods of increasing the sigma level in manufacturing processes.

Types of Errors

Errors have several causes, but in the manufacturing processes of auto parts companies, errors and failures can be classified into five categories, which are (Razmi, Karbasian, 2012):

Failure to observe proper standards and procedures in the design process (improper temperature in heat treatments),

Deformation of the components and tools because of high usage,

Use of non-uniform or faulty materials,

Exhaustion of parts (fasteners, hoses, etc.),

Human error

By looking at the above-mentioned categorization, it could be inferred that almost all defects and wastes occur due to human errors. Thus, it can be stated that human errors are the common causes of waste and failure in manufacturing processes. Human errors are often divided into ten groups, which are referred to in Table 2 (Hinckley, 2001; Grout, 2007):

Table 2: Types of human errors and mistakes

SLOW REACTION ERRORS	FORGETTING OR IGNORING ERRORS
ERRORS DUE TO THE LACK OF STANDARDS	MISUNDERSTANDING ERRORS (UNDERSTANDING ERRORS)
UNEXPECTED ERRORS (CHANCE)	DETECTION ERRORS
ERRORS DUE TO THE FIVE SENSES	ERRORS DUE TO BEING INEXPERIENCED (NEW PERSONNEL)
INTENTIONAL ERRORS	ERRORS CAUSED WILLFULLY

Infallibility Methods

The general techniques used in infallibility strategy are as follows (Razmi, Karbasian, 2012):

Control method: measures by which the processes are corrected automatically. This method contains advanced anti-error measures and is the best way to do infallibility since it provides a fast and automated feedback and thus the processes would perform in a proper manner from the beginning (Stewart, Melnyk, 2000), such as spell checking in lexicography software.

Shutdown methods: procedure or device that disables and shuts down the problem procedures. These methods include semi-advanced anti-error measures, which may reduce production capacity, but since the process is stopped quickly, mistake-making would also be prevented (Robinson, Harry, 1997). A familiar example of this method is irons would turn off automatically.

Warning Method: As its name implies, this type of equipment alarm the person to charge that something wrong is happening. An example would be the speed alarms in cars, which declare illegal speed. This method also contains semi-advanced anti-error measures.

Sensory Alert Method: This method resembles the warning method as the operator should take corrective actions after receiving a signal. This is the difference between these two methods and that is that in Warning Method, the signal is send automatically, but in Sensory Alert Method the operator should feel alert. The Sensory Alert Method has the most basic anti-error procedures, which mostly cost the least (Hinckley, 2001). An example could be using egg boxes in accurate counting of small pieces.

To choose the best method of infallibility, the mechanism of these methods, organizations' capital structure, the impact type of the manufacturing process, required fees, cost return, and other factors should be taken into consideration (Koziolek, Sebastian; Derlukiewicz, Damian, 2012). Also, attending to the table (3), which rates the relative power of infallibility from 0 to 10 is also very useful.

It is necessary to note that the choice and use of infallibility methods of control and auto-correction, shutdown, warning or sensory alarm can be combined with the power of imagination and creativity.

Infallibility Stages

Infallibility strategy is not something that should be run and created only once, rather, like other quality improvement strategies, it requires teamwork and problem solving methods (Stewart, Melnyk, 2000). To implement infallibility strategy, it is better that purposeful and planned methods be used (Saurin, Duarte Ribeiro, Vidor, 2012). Key stages of infallibility strategy are demonstrated in Figure 2.

Table 3: Relative strength of infallibility strategies methods (Nikkan Kogyo, Shimbun, 2008)

Relative strength of infallibility strategies	Method	Operation Method
10 High	Control	Automatic
9		
8		
7	Shutdown	
6		
5	Warning	
4		
3		
2	Sensory Alert	
1		
0 Low		Operator Dependent

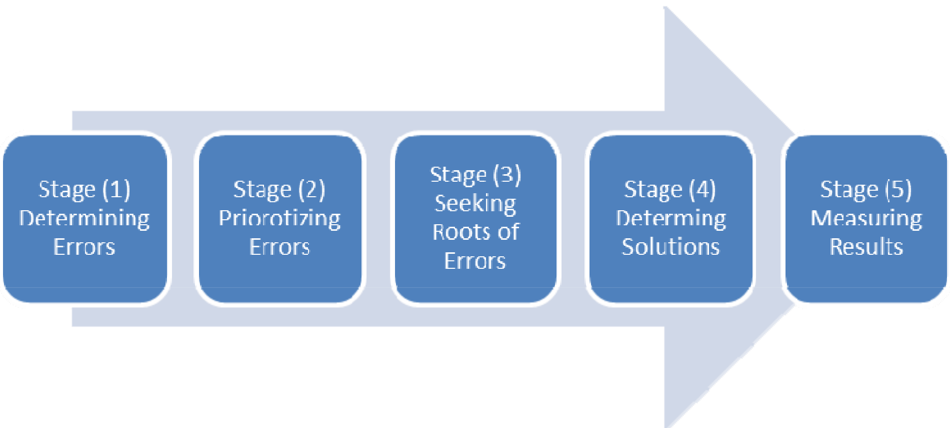

Figure 2: Key steps in infallible strategy (Nikkan Kogyo, Shimbun, 2008)

Research Methodology

According to the infallibility stages, in this study first the problems and errors in the manufacturing process are identified. In order to achieve this objective, the analysis of defective parts and waste products, returned products by customers, and errors' reports were used (Foster, 2004). In the second step, identified errors are prioritized. At this stage, factors such as frequency of occurrence of an error, loss of profits, time, and rework caused by errors, and the overall imposed costs are identified for prioritizing. In the third step, the root cause of problems and errors are determined. In the fourth phase, using brainstorming techniques discussed in infallibility, appropriate solutions for dealing with errors are presented. Finally, the results of the taken actions and solutions are measured, analyzed, and expressed in terms of sigma level of manufacturing operations.

Results

According to the research methodology and the stages of infallibility strategy, the major errors in the manufacturing process of Pooladin Ghate automotive parts manufacturing company are determined and prioritize as shown in Figure (3).

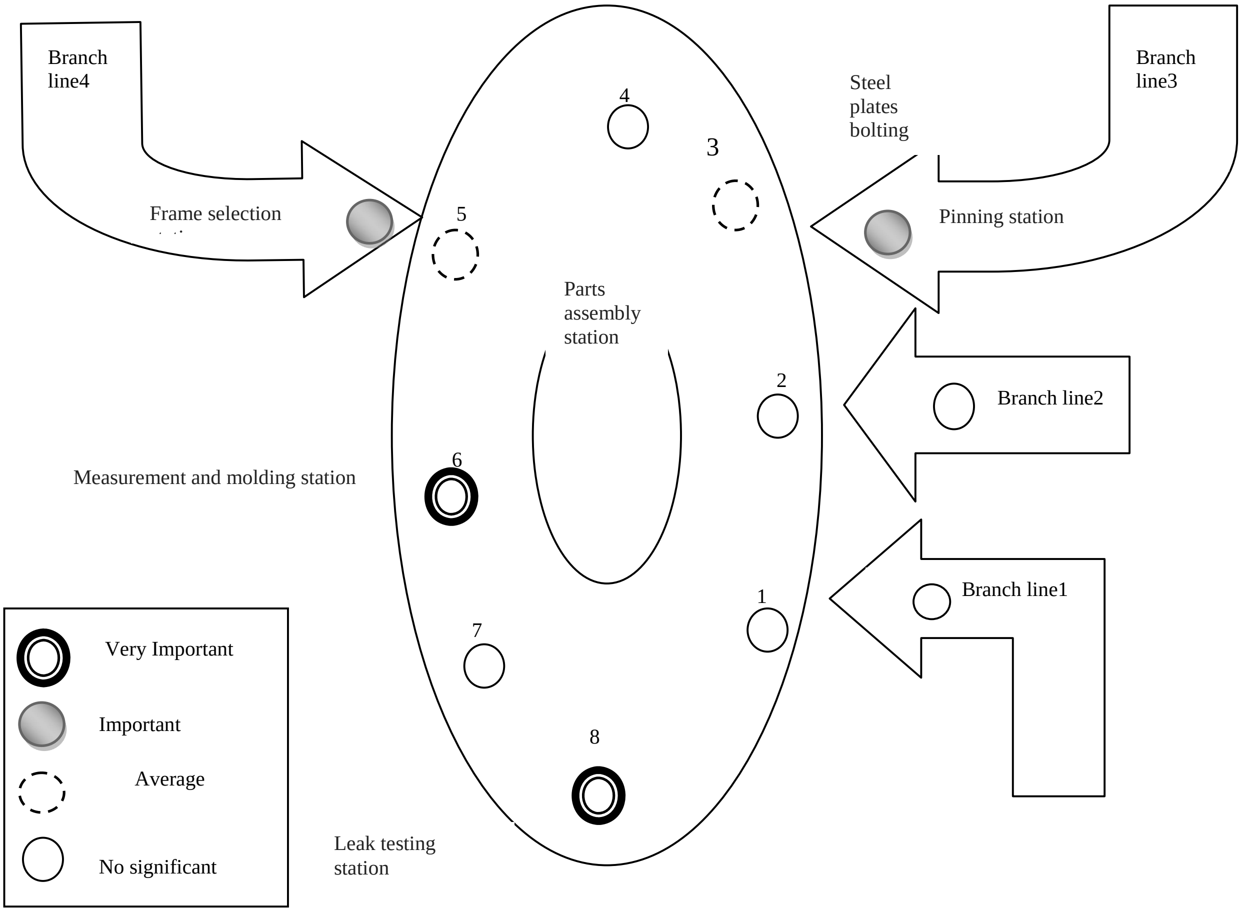

Figure 3: Map of errors in the manufacturing process of Pooladin Ghate Company

In the present study, workstations that have high, significant, important and moderate priority errors have been chosen to implement infallibility measures and procedures and low-priority errors were ignored. Therefore, six workstations were selected as follows and relevant infallibility techniques were carried out in them.

Pinning station with ‘important’ priority
Steel plates bolting station with ‘medium’ priority
Parts assembly station with ‘Medium’ priority
Frame selection station with ‘important’ priority

Measurement and molding station with 'significant' priority
Leak testing station with 'significant' priority

Workstations Infallibility Measures

Table (4): Finding of the study in pinning workstation in the manufacturing process

ERROR TYPE	INAPPROPRIATE HEIGHT BETWEEN THE FIRST AND SECOND PIN
ROOT CAUSES OF ERRORS	SECOND PIN OPERATION WITH EYES
IMPROVEMENT CRITERIA	PINS ASSEMBLY AND PRESS IN A PROPER MANNER AND HEIGHT
	REDUCTION OF WORKING TIME
INFALLIBILITY MEASURES	USE OF ASSISTIVE DEVICES (FIXTURES) FOR PINS TO BE ASSEMBLED CORRECTLY WITH PROPER CERTAIN HEIGHT
	USE OF STOPS FOR PINS TO BE PRESSED ON CRUST IN ACCURATE AND PROPER HEIGHT

In this workstation of the manufacturing process, Control Method in infallibility and advance anti-error methods were utilized, using mechanical equipment.

Table (5): Finding of the study in Steel plates bolting station in the manufacturing process

ERROR TYPE	INSTALLATION ERRORS AND INCORRECT ORIENTATION OF PAGES
ROOT CAUSES OF ERRORS	SIMILARITY OF PAGES AND FAILURE TO APPROPRIATELY IDENTIFY PAGES
	RELYING ON THE SKILLS AND EXPERIENCE OF THE OPERATOR
IMPROVEMENT CRITERIA	PROPERLY BOLTING STEEL PAGES
	REDUCTION OF WORKING TIME
INFALLIBILITY MEASURES	USING ASSISTIVE DEVICES (KITS AND FIXTURES) FOR PLATES TO BE SCREWED PROPERLY FROM THE BEGINNING
	USING ERROR DETECTIVE PATTERNS BEFORE PLATES LEAVE PRODUCTION STATION

In this workstation of the manufacturing process, the sensory alarm method of infallibility and moderate anti-error measures were utilized, using assistive.

Table (6): Finding of the study in Steel plate's assembly station in the manufacturing process

ERROR TYPE	SETTLING WRONG PARTS IN ASSEMBLY
ROOT CAUSES OF ERRORS	FORGOT ERROR (DISTRACTION) OR NEGLECT
	DETECTION ERROR
IMPROVEMENT CRITERIA	ENSURING INSTALLATION OF ALL COMPONENTS
	ENSURING PROPER ASSEMBLY OPERATIONS

INFALLIBILITY MEASURES	USING LARGE COMBS TO PUT PARTS WITH VARIOUS DIMENSIONS
	INITIAL PERFORMANCE TESTING TO ENSURE THE CORRECTNESS OF ASSEMBLY OPERATIONS

In this workstation of the manufacturing process, the sensory alarm method of infallibility and moderate anti-error mechanisms have been used.

Table (7): Finding of the study in Steel plates frame selection station in the manufacturing process

ERROR TYPE	CHOOSING WRONG FRAMES WITH UNSUITABLE THICKNESS
ROOT CAUSES OF ERRORS	RELIANCE ON OPERATOR SKILL AND RECOGNITION
	USING HAND TOOLS IN MEASURING
IMPROVEMENT CRITERIA	CHOOSING FRAMES WITH SUITABLE THICKNESS FOR ASSEMBLY
	REDUCTION OF WORKING TIME
INFALLIBILITY MEASURES	USING AUTOMATED DEVICES TO ENSURE THE CORRECT SELECTION
	DISPATCHING PROPER MESSAGE AND SIZES TO SELECT THE APPROPRIATE FRAME

In this workstation of the manufacturing process, the control method of infallibility and advanced anti-error mechanisms, and fully automotive devices have been used.

Table (8): Finding of the study in Steel plates measurement and molding selection station in the manufacturing process

ERROR TYPE	MEASUREMENT ERRORS AND IMPROPER MOLDING
ROOT CAUSES OF ERRORS	USING HANDHELD MEASURING INSTRUMENTS (CALIPER)
	VISUAL ERRORS IN READING MEASUREMENT
IMPROVEMENT CRITERIA	ELIMINATING MEASUREMENT ERRORS
	DECREASING WORKING TIME AND INCREASING THE OPERATION SPEED
INFALLIBILITY MEASURES	USING DIGITAL MEASUREMENT DEVICES TO PREVENT VISUAL ERRORS IN READING THE CALIPER AND INCREASING THE OPERATION SPEED AND DECREASING WORKING TIME
	INFORMING THE OPERATOR OF THE PROPER FRAME SIZE USING DIGITAL DEVICE'S GREEN LIGHT

In this workstation of the manufacturing process, the Alarm method of infallibility and semi-advanced anti-error mechanisms, and digital measurement devices, have been used.

Table (9): Finding of the study in Steel plates leak testing selection station in the manufacturing process

ERROR TYPE	PARTS LEAK DETECTION ERRORS
ROOT CAUSES OF ERRORS	MISUNDERSTANDING (SENSORY ERRORS)
	RELYING ON VISUAL AND TACTILE DETECTION
	USING OIL TO ILLUSTRATE LEAKS
IMPROVEMENT CRITERIA	ENSURING ABSENCE OF LEAKING
	REDUCING WORKING TIME AND INCREASING OPERATION SPEED
INFALLIBILITY MEASURES	USING DIGITAL AIR PUMPS TO INJECT AIR INTO THE SEGMENT CASE
	ALERTING THE OPERATOR WITH A CLEAR RED LIGHT IF THERE IS LEAKING IN THE CASE

In this workstation of the manufacturing process, the Alarm method of infallibility and semi-advanced anti-error mechanisms, and digital air pumps, have been used.

Results of infallibility actions in workstations

Depending on the type of error and its root causes in workstations and relevant infallibility measures, the following results, illustrated in tables (10) have been obtained:

Table 10: Results of infallibility actions in workstations

Workstations	PPM Before Infallibility	Sigma Before Infallibility	PPM After Infallibility	Sigma After Infallibility	Improvement Percentage
Pinning	1390	4.5	280	5	496%
Bolting and Screwing	5000	4.08	1040	4.58	479%
Assembly	8000	7.91	1670	4.48	479%
Frame Selection	4000	4.15	830	4.65	482%
Measurement and Molding	10000	3.83	1460	4.55	685%
Leak Test	30000	3.40	10000	3.84	300%

Conclusion

The infallibility strategy, which is called Poka-Yoke in Japanese, is an international innovation to produce defect-less parts, by implementing which we can prevent huge costs and wastes and even inspection-related costs. Unlike other traditional control methods, infallibility is not an after production method, rather this technique is employed during the production process to prevent errors and failure from the beginning to prevent production of any defective products. Therefore, it can be inferred that, compared to other strategies, this method has many advantages, some of which could be as mentioned:

- Ensuring the production of parts without defects and with near-zero level wastes,
- Eliminating defective parts inspection costs
- Not relying on operators and human agents (who are naturally and inherently prone to making mistakes)
- Swift feedback of mistakes, and thus their rapid elimination
- 100% parts inspection
- Simplicity and practicality of implementation of this technique, and the fact that it could be understood by everyone in the factory
- Fast profitability, which would encourage the support of officials and directors of a company

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