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Poka-Yoke: A simple way to Mistake Proofing

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ABSTRACT

Continuous improvement is an essential requirement for sustaining and gaining a competitive advantage . A successful continuous improvement program is one wherein the operational defects are eliminated at the root level.Defects and errors are the key concerns of Manufacturing industry. Poka-Yoke is a concept which is related to restricting errors at the source itself. It deals with "mistake-proofing". A Poka-Yoke is a mechanism developed in a Total Productive Management process that helps the operator to avoid mistakes.Total productive maintenance (TPM) methodology is a proven approach to increase overall equipment effectiveness (OEE).Mistake-proofing is one of the effective approaches that prevents inadvertent errors and helps workers to be mistake-proof and does not allow defective products to flow in to the next processes.The Poka-Yoke approach was developed in the manufacturing industry as a way of improving productivity by reducing errors using often very simple adaptations.Application of Poka-Yoke in the manufacturing process is mainly to eliminate manual errors by designing suitable means which reduces the products rejection.This concept was generated , and developed by Shigeo Shingo for the Toyota Production System.

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I. INTRODUCTION

In today's competitive world any organisation has to manufacture high quality, defect free products at optimum cost. The new culture of Total Quality Management (TQM) and Total Productive Management(TPM) in the manufacturing as well as service sector gave birth to new ways to improve quality of products and services. By using various tools of TQM like KAIZEN, 6SIGMA,JIT,JIDCO,POKA-YOKE,FMS etc. the organisations are intended to develop quality culture.

Also a huge competition in manufacturing caused a major change in the approach to quality management. Now a days, quality action included the whole product life cycle, and also in the functioning of company, they take appropriate selection of constant improvement strategies, where special emphasis is put on preventing strategy. In the present time we have techniques, tools and methods which support such approach to the quality. Once these are implemented in the organization, they results in minimization of costs, elimination of defects and thus more monitoring and improving the quality operations in processes.

Based on defect prevention(and its analysis) and monitoring of each activity in the process and implementation at each stage of the process, leads to protection against the appearance of a defect. Collection of information on emerging deficiencies(error) and prevent them is a much more efficient way of improving quality. Thus it is an effective approach to apply mechanisms to prevent the formation of errors precisely at the moment of their occurance.

Poka-Yoke method was introduced by Shigeo Shingo in 1961, when he was one of the engineers in Toyota Motor Corporation. This method is preventing the defects and errors originating from the human mistakes. Poka-Yoke technique can be applied to prevent the causes which are responsible for occurrences of errors .

Poka-Yoke allows processes to run smoothly as they are fail-safe solutions. Although the immediate result is that

defects are identified and prevented from programming, the real aim is to modify the process so that the future defects are designed out.The main objective of Poka-Yoke techniques is to obtain zero faults products, by using simple devices of fixing,assembling, warning and other related devices, which prevent the people from making the mistake,even if they wanted to do. Poka-Yoke are designed to make life easier and improve the performance of the work.It is a technique for avoiding human error at work and to avoid the defects.Generally a defect exists in either of the following two states;

a)the defect has already occurred calling for defect detection,

b)It is about to occur,calling for defect prediction

Poka-Yoke is comprised of techniques of preventing the faults, avoiding the accidental errors, eliminating the errors or self-protecting operations. The human errors come especially from tired, troubled, absent-minded or unmotivated persons. At the same time, the Poka-Yoke concept may be implemented in other activity domains, such as sales, purchase or development of new products, where the errors cost can be very high.

Poka-Yoke is not a new concept. It has been used in the safety area for many years. What is new is to apply those concepts to areas of the processes outside the safety domain.The concept of Poka-Yoke can be applied to virtually every type of project by exploring ways to present how an activity is supposed to be done,make it impossible to do it incorrectly, or make it known when it has been done incorrectly. Poka-Yoke or Mistake-proofing also releases workers from tedious and repetitive activities, while giving them an opportunity to maximize their roles in building quality, in the process, by decreasing product defects and the related cost of rework.

A Poka-Yoke device is a good solution for avoiding the errors and it has the following characteristics:

* Can be used by all the workers;
* Is easy to fit up;
* Does not require the operator's continuous attention (it would be ideally he ignores it);
* Has a low purchasing price;
* Reacts very quickly and prevents and corrects the error and intern defects.

II. MEANING OF POKA-YOKE

During actual manufacturing of any product there are too many very simple and monotonous steps which are carried out by operators. These monotonous operations result in to mental fatigue and reduces the interest in work which ultimately causes silly mistakes of operators and the human is prone to such errors even though he doesn't want it. To avoid these simple mistakes Poka-Yoke concept play important role. By implementing some simple solutions of Poka-Yoke, we can avoid such mistakes. The long term success of Poka- Yoke gives output of lot of savings in time,cost and it releases the work pressure from the minds of workers.Hence we can use the creativity and special skills of workers for more creative operations and to get useful contribution. This involvement of everyone in organisation is basic need to rise roots of quality culture in the organisation.

Poka-Yoke is a Japanese improvement strategy for mistake-proofing to prevent defects arising during production processes. Poka-Yoke is a preventive action that focuses on identifying and eliminating the special causes of variation in production processes, which inevitably lead to product defects. This concept was initially called Idiot Proofing, but it was understood that this name may hurt the workers sentiment, so term Mistake Proofing was coined by Shigeo Shingo.

Poka-Yoke gives a strategy and policy for preventing defects at the source. These solutions are not only cost-effective but also easy to understand and apply. It is one of the important tools to add to any organization's Continuous improvement. The Poka-Yoke concept was generated in 1961, by Shigeo Shingo who is Japanese industrial engineer. Shingo was working for Toyota and other

Japanese companies, where he developed entire production systems focused on achieving zero defects in production and gave birth to this revolutionary work. The basic concept behind Poka-Yoke is that it is not acceptable and allowed to produce even a small amount of defective product.

To stay in market and to become a world-class competitor, an organization must go with new philosophy and technology along with side by side practice of producing zero defects. Poka-Yoke methods are the very easy and simple concepts for achieving this goal and are a key component of the continual improvement strategy in many leading Japanese companies.

A Poka-Yoke device or solution is any mechanism or idea that either avoids the mistake from being made or makes the mistake easily detected at a glance. The ability to find mistakes at a glance is important because, as Shingo states , "The causes of defects lie in worker errors, and defects are the results of neglecting those errors. It follows that mistakes will not turn into defects if worker errors are discovered and eliminated before hand"[Shingo 1986, p.50].He also adds to this that "Defects arise because errors are made; the two have a cause-and-effect relationship. ... Yet errors will not turn into defects if feedback and action take place at the error stage"[Shingo, 1986, p. 82].

Poka-Yoke is a technique for avoiding simple human error in the workplace. Also known as mistake-proofing, goof-proofing, and fail-safe work methods, Poka-Yoke is simply a system designed to prevent inadvertent errors made by workers performing a process. The idea is to take over repetitive tasks that rely on memory or vigilance

and guard against any lapses in focus. Poka-Yoke can be seen as one of the three common components of Zero Defect Quality Control performed by Japanese companies (source inspection and feedback are the other two).

A Poka-Yoke is a mechanism in a Lean Manufacturing process that helps an equipment operator avoid (Yokeru) mistakes (Poka). Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur . Poka-Yoke (pronounced "POH-kah YOH-kay) or mistake proofing was first designedby Shigeo Shingo when, as a statistical process control engineer, he became frustrated that he could not achieve zero defects in manufacturing processes. Shingo realized that there was a clear distinction to be made between a mistake and a defect. He also understood that mistakes were not always because off the operators fault,as the consequent defect becomes visible only at a later stage of the manufacturing processes .In this context, based on the above mentioned definition, a Poka-Yoke is defined as a device that prevents the defects or abnormalities, which might be detrimental either to product quality or to employees. Otherwisewe can say , it is a quality improvement methodology to prevent mistakes from happening to minimize the negative consequences.

Poka-Yoke system is important to industry because it helps people and processes work right the first time. It refers to techniques that make it impossible to make mistakes. These techniques can drive defects out of products and processes and substantially improve quality and reliability. It can also be used to fine tune improvements and process designs from six-sigma Define-Measure-Analyze-Improve-Control (DMAIC) projects. The advantage of Poka-Yoke device is simple ideas and methods, in product and process design ,can eliminate both human and mechanical errors, cheap and easy to implement within a production line, and that errors are detected either before they occur, or before they can become costly to correct .

III. NEED OF POKA-YOKE

When any organization decides to implement the Lean Manufacturing then one of the objective is to reduce scrap and the aim is to achieve zero wastage, as no one is interested to compensate extra inventory on account of wastages.As Lean Manufacturing philosophy focuses on speed of production,productivity and in order to achieve this speed of manufacturing we should be careful against these defects and rework, Poka-Yoke can contribute here.Also to increase profit percentage the cost of product should always less and no management will accept continued mistakes like defect, scrap, rework,delays etc.

Also when customers buys product they rightfully expect defect free products and our conventional 100% inspection or statistical process control don't assure 100% defect-free products.Hence we have to go to the root cause of any problem(causing defect) and by avoiding it, gives us defect free product. The above discussion concludes that to get defect free products one should go with the concept of Poka-Yoke.

IV. TYPES OF POKA-YOKE:

Poka-Yoke is based on prediction and detection. That is, recognizing the the defect which is about to occur or recognizing that a defect has occurred. Consequently, there are two basic types of Poka-Yoke systems.

The first one is, control Poka-Yoke,which does not allow a process to begin or continue after an error has occurred. It takes the response to a specific type of error out of the hands of the operator.

Example1:

A fixture on a machine may be equipped with a sensing device that will not allow the process to continue unless the part is properly inserted.

2:A 3.5-inch floppy disk will not work if inserted backwards or upside down. As a matter of fact, it won't fit into the drive at all unless properly inserted.

A second type of Poka-Yoke provides some type of warning when an error occurs. This does not prevent the error, but immediately stops the process when an error is detected. This type of poka-yoke is useful for mass production industries , as the device prevents mass production of defect products.For industries with minimum loss of time or resources occure,a warning Poka-Yoke is warranted. All that needed is, a way to ensure that the error is investigated and corrected in a timely manner.

Poka-Yoke tools can be as simple as a steel pin on a fixture that keeps incorrectly placed parts from fitting properly to as complex as a fuzzy logic neural network used to automatically detect tool breakage and immediately stop the machine. Interestingly, the simple low-cost devices tend to be in the majority.

Irrespective of degree of simplicity, all Poka-Yokes fall into one of three categories:

Contact methods, Fixed-value methods, and Motion-step methods.

a) Contact methods:

Contact methods are based on some type of sensing device which detects abnormalities in the product's shape ,size or dimensions and responds accordingly. Interference pins, notches with matching locator pins, limit switches and proximity switches are used to ensure that a part is positioned correctly before work occurs. Contact methods are useful in situations which encourage mistakes. Such situations involve rapid repetition, infrequent production, or environmental problems such as poor lighting, high or low heat, excess humidity, dust,

noise, or anything which distracts a worker.The maintenance engineer should investigate at least four areas for potential problems that require contact method solutions:

1. Look for where the product will fail if parts are assembled incorrectly.
2. Look for small features critical to proper assembly.
3. Beware of relying on subtle differences to determine top from bottom or front from back, especially if the parts are painted dark colors.
4. Beware of designs so complicated that they confuse inexperienced operators.

b) Fixed-value methods:

Fixed-value methods are used in processes where the same activity is repeated several times, such as tightening of bolts. This method frequently involves very simple techniques, such as methods that allow operators to easily track how often this activity has been performed.

The example is , an operator who is responsible for tightening down nine bolts on a product. Before passing the product on, the tightening process is performed . A simple poka-yoke device would incorporate the use of a wrench dipped in paint. Since untightened bolts will not have paint on them, the operator can easily see if he or she has performed the process the required number of times.

Or the use of packaged material in the same quantities needed to complete the process. If the bolts were stored in containers of nine, the operator could easily see whether the process was still incomplete or complete as the box would still contain bolts or empty.

c) The motion-step method:

The motion-step method can be used for the processes requiring several different activities performed in a sequence by a single operator. This is similar to the fixed-value situation where the operator is responsible for multiple activities, but the difference is the operator performs different activities.

First, each step in the process is identified by the specific motions needed to complete it. Then devices are created to detect whether each motion is performed and then alert the operator when a step is skipped. An assembly process could utilize a device that senses when all required components are present at the start of the process for each unit. The devices could then detect when each component is removed from its dispenser, If a component is not removed, the sensing device alerts the assembler before worker can move on to another unit.

	Contact Type	Warning Type
Contact Method	A steel pin on a fixture keeps incorrectly placed parts from fitting properly.	A device on a drill counts the number of holes drilled in a work piece; a buzzer sounds if the work piece is removed before the correct number of holes have been drilled.
Fixed-value Type	Light sensors determine if each crayon is present in each box; if a crayon is missing, the machines will stop automatically.	Bolts are tightened with a wrench dipped in paint. Bolts with no paint on them are still untightened.
Motion-Step Method	A simple proximity switch opens after all components are loaded in the proper order.	A device detects when each component is removed from a dispenser; if a component is not removed, the device alerts the assembler before he can move on to another unit.

V. EXAMPLES OF POKA-YOKE

A number of "real world" applications are presented in the business and engineering literature. Below are a list of examples of Poka-Yoke applications.

- Color-coding a wiring template to assist the worker.
- Installing a device on a drill to count the number of holes drilled in a work piece; a buzzer sounds if the work piece is removed before the correct number of holes has been drilled.
- Cassette covers were frequently scratched when the screwdriver slipped out of the screw slot and slid against the plastic covers. The screw design was changed to prevent the screwdriver from slipping.
- A metal roller is used to laminate two surfaces bonded with hot melted glue. The glue tended to stick to the roller and cause defects in the laminate surface. An investigation showed that if the roller were dampened the glue would not stick. A secondary roller was added to dampen the steel roller during the process, preventing the glue from sticking.
- One production step at Motorola involves putting alphabetic characters on a keyboard, then checking to make sure each key is placed correctly. A group of workers designed a clear template with the letters positioned slightly off center. By holding the template over the keyboard, assemblers can quickly spot mistakes.

John Grout presented these examples in "Mistake-Proofing Production," an article written for *Production and Inventory Management Journal:*

- Trinity Industries Railcar Division workers created a layout jig to avoid having to use a tape measure and chalk to position subassemblies on each car individually. The jig has tops that allow it to be quickly positioned correctly on the car's chassis. Each component that is to be attached to the car has a corresponding cutout on the jig. The jig eliminates two modes of worker error. It eliminates incorrect measurements and inaccurate positioning of parts. It also eliminates the worker vigilance required to ensure all of the components are attached. Omitted parts are made very obvious because an empty space exists on the layout jig. Without the jig, there would be no indication that anything is missing. Once parts are spot welded in place the jig is lifted off and welding is completed. Not only is dependence on worker vigilance reduced, cost savings result from the simplified, accelerated process.
- Binney and Smith, maker of Crayola Crayons, uses light sensors to determine if each crayon is present in each box of crayons they produce. If a crayon is missing, the machines will stop automatically. Producing complete boxes of crayons right the first time is the preferred outcome.
- A mail-order computer company has designed its boxes and packing material to avoid mistakes. The inner flaps of the box bottom have a large brightly colored warning to "Stop! Open the other side." When the correct side is opened, a book titled "Setting Up Your Computer" is on top of the packing material. The sequence of the book matches the arrangement of the contents of the box. Each instruction involves the next item from the box.
- Airplane lavatory lights come on only when the door lock is engaged. This keeps customers from failing to lock the door.
- John Deere produced a gearbox that was assembled without oil, mounted on a machine, and required replacement after factor tests. A team streamlined production with a simple proximity switch that opens after all components were loaded into an assembly fixture. The switch prevents workers from using air wrenches to tighten bolts on the assembly until they cycle an oil gun into the gearbox. After filling the gearbox a solenoid releases the interlock sending air to the wrench. Then workers can tighten cover bolts and send the box to the next station.
- The electrical connectors in one machine control formerly used only three-pin connectors to join each in a series. Labels instructed assemblers which boards went where and which connectors should be joined. But in the field, assemblers connecting and disconnecting them wear or bend the pins, which meant putting on a new plug. Soon the label was gone. The simple solution involved three, four and five-pin connectors that cannot join others and demand a single assembly sequence.
- Ficarra's solution to labels that come off is to machine them into parts, especially when the function is to determine the correct orientation.
- On Varian machines, assemblers are guided by small machined-in pictures that cannot wear off.

VI. POKA-YOKE IN EVERYDAY LIFE

Products that we use every day have features that make them safe and convenient. The following are a few examples of how mistake-proofing is used for everyday household products:

- **Micro-wave oven** does not work until the door is shut.
- **Washing machines** only start when the door is closed and cannot be opened until the cycle is over**.**
- USB cable can only enter facing one side
- **Electric plugs** have an earth pin that is longer than the other pins and is the first to make contact with the socket. The protective shield of the neutral and earth sockets are then opened safely.
- **Electric sockets** are shaped in a manner that only one way of plugging-in is possible. This prevents the possibility of a short-circuit occurring.
- **Child resistant tops** for medicines and household chemicals makes it difficult for childrento consume the contents.
- **Elevator doors** have a sensor that causes them to open when there is an obstruction-this prevents injury to someone trying to enter as the doors are closing.
- **Box cutters** have a retractable blade that only pops out when the handle is held.
- **Lawn mower**s have a safety bar on the handle that when released, switches off the machine.
- **Circuit breakers** in the home electrical system prevent electrical overloads.
- **Overflow outlets** in bathroom and kitchen sinks prevent flooding of the house when the drain is blocked.
- **The Door of a washing machine** or dryer makes the machine stop when it is opened, so as to prevent injury from accidents

VII. POKA-YOKE IN MANUFACTURING

In Lean Manufacturing systems, Poka-Yoke also includes a philosophy of constantly working to prevent mistakes from occurring in the first place. The internal processes in Lean Manufacturing systems are supposed to produce quality products the first time. Error-proofing in this case is a quality assurance technique that ensures quality is in-

built and results in better products.

For the final product to be of high quality, all the inter-connected process steps have to give first time quality. If an mistake or defect is allowed to move to the next step, the likelihood of it appearing in the finished product is very high. It is therefore necessary to develop ways of preventing a defective product moving to downstream process.

This is important because a finished product is considered to be the most expensive form of inventory due to the accumulated costs along the value chain. If a defect occurs in the finished product, the costs of production increase due to the effort required to correct it.

The following are some of tools of Poka-Yoke used in manufacturing.

- **Magnets** in a grain packaging plant detect and remove metal pieces before they are packed.
- **Interlock switches** which detect the position of a machine guard and switch off the machine when the guard is lifted. The machine will never operate when the guard has been lifted and this prevents accidents to the operator.
- **Light curtains** in a factory detect when someone is near very dangerous machines and switches off the machine to prevent injuries.
- **Safety mats** near machine areas that pose a danger automatically trigger stoppage when someone steps on them. This prevents injury to personnel (such are technicians) who are trying to access dangerous sections of a machine.
- **Power guard**s on high inertia machines with moving parts prevent opening until the parts have stopped completely in order to prevent accidents.
- **Machines** that must be controlled using both hands ensure that some distance is kept between the operator and dangerous machine parts.
- **In the food industry**, gloves and other small pieces of personal protective equipment must be blue in colour for ease of detection in case they fall into food. This is because blue foods are rare in nature and the color difference makes it easy to detect that a foreign object has fallen into the food.
- **Using standardized containers** at the workstation enables workers to know exact quantities without having to weigh or count the contents.
- **Use of colour coded** date labels to mark the production dates of products. This way the different batches are easily identifiable for the purpose of product rotation. The system is especially useful in the food industry where rotation of batches is very important because of hygiene considerations.

VIII. POKA-YOKE, THE OTHER EXAMPLES

There are many other examples of products that have fool-proofing ranging from USB cables to child proof sockets. Here are a few examples:

- **Glow-in-the-dark strips** around the toilet bowl prevent users from urinating on the sides.
- **Mop slippers** save time for the busy person as they prepare to go to work or school.
- **Scrap collecting bowl** has a ledge that is attached to the table top to collect vegetable scraps before they fall on the ground.
- **Oven rack guard** prevents accidental burns as one is removing food from the oven chamber.
- **Locator stickers** that are put on commonly lost items such as keys and can be traced using the phone.
- **Upside-down** tomato sauce bottles enable the consumer to use up all the tomato sauce and also lets the water that collects at the bottom come out first.
- **Mobile phones** are designed in such a way that when they fall, the cover separates so as to minimise the shock that would damage them.
- **Color-coding** of electrical wires is meant to prevent short circuiting that can occur if they are not matched properly.
- **Ice blocks** that prevent someone from drinking too much.
- A company invented a fork that tells you when you have eaten too much thus preventing you from getting over-weight

A practical case study of how a Poka-Yoke is implimented and its results are summerised in the following table.

Table showing Poka - yoke implemented for shot peening machine.

Problem definition	Solution to problem	Key impro-vement	Before Improve-ment	After Improvement
If the bottom mesh tray is opened machine can still be on.	Limited switch & toggle clamp provided at the opening of tray.	Prevent damage to machine parts	If the mesh tray is open, m/c can still run. Occasionally small springs can escape to hooper and damage the parts. Also shots come out from the opening.	Limit switch & toggle closing provided to the tray If the tray is open by mistake the entire electrical system shutdown. No damage to the machine parts No leakage

Even after completion of peening cycle the rotor & shots will still be on.	Indicator and hooter is connected to output of time	Quality improved.	If the mesh tray is open, m/c can still run. Occasionally small springs can escape to hooter and damage the parts. Also shots come outfrom the opening.	A timer, hooter & indicator provided. Rotor and shots will be off immediately after the completion of peening cycle. No over shot-peening. No scrap.
If the door is open ,blast motor / shots still can be on.	Limited switch is provided to door.	Safety to operator No shots leakage	Independent control By mistake if the door is opened blast /shots can still be on. Risk to personnel (unsafe) Shots leakage.	Auto mode Limit switch provided at door hat is connected to control circuit. If door is opened, blast motors / shots will stop automatically.
If shots level is low, blast motor / shots can still be on.	Proximity sensor provided at minimum shots Level in Hopper	No rework	Even if shots level is low, peening still takes place.Poor quality of peening Rework.	Proximity sensor provided at minimum shots level on hopper gives indication to control circuit and the blast motor / shots will be automatically shut off Peening quality good.

IX. BARRIERS FOR THE IMPLEMENTATION OF POKA-YOKE

There are many number of barriers a firm has to face while implementing Poka-Yoke within their system. These may include:

- Difficulty in accepting the change by workers as well as management.
- Justification of the investment.
- Using inappropriate and ineffective methods for its implimentation.
- Time requirements.
- Difficulty encountered as a result of continuous process.

Stewart and Grout, in an article entitled "The Human Side of Mistake-Proofing," make the following recommendations for the implementation of Poka-Yoke devices:

1. The outcome of the process must be known in advance so as to have a standard for comparison.
2. The process must be stable(i.e., outcomes should not change.)
3. There must be an ability to create a break between cause and effect in the process so as to provide an opportunity to insert a Poka-Yoke.
4. Environments requiring substantial operator skill are prime locations for Poka-Yoke devices.
5. Environments where training or turnover cost is high are prime locations for Poka-Yoke devices.
6. Environments with frequent interruptions and distractions are prime locations for Poka-Yoke devices.
7. Environments with a consistent set of mixed products are prime locations for Poka-Yoke devices.
8. The beginning of any process where there are multiple other possible processes that could be initiated are a prime location for Poka-Yoke devices.
9. Locations in the process with similarly positioned or configured parts, controls or tools are prime locations for Poka-Yoke devices.
10. Any point in the process requiring replacement or orientation of parts in order to prevent mispositioning is a prime location for Poka-Yoke devices.
11. Any point in the process where adjustments are made for machine or process setups is a prime location for Poka-Yoke devices.

John Grout attributed defects to three sources: variance, mistakes, and complexity. Complexity requires techniques which simplify the process while managing variance can be accomplished by utilizing statistical process control (SPC). However, if quality problems are the result of mistakes, Poka-Yoke devices are the appropriate technique to use. In this case, Poka-Yoke provide an even more effective quality improvement tool than SPC. Other Poka-Yoke benefits include reduced training costs and the advantage of freeing workers' time and minds for more creative and value-adding activities.

Circumstances where Poka-Yoke is not the appropriate response are situations involving high speed production, situations where X-bar ($\overline{X}$) & R charts are effective, and use in destructive testing. Other situations, however, provide opportunities for simple, inexpensive, and fail-safe devices to improve performance. Grout relates the example of Lucent Technologies, which reported that half of their 3,300 mistake-proof devices cost less than $100. However, they estimate a net savings of $8.4 million or about $2,545 per device.

X. BENEFITS OF POKA YOKE IMPLEMENTATION

A typical feature of Poka-Yoke solutions is that they don't let an error in a process happen. But that is just one of their advantages. The other advantages are:

- Less time spent on training workers;
- Elimination of many operations related to quality control;
- Unburdening of operators from repetitive works;
- Promotion of the work improvement-oriented approach and actions;
- A reduced number of rejects;
- Immediate action when a problem occurs;
- 100% built-in quality control;

- elimination of set-up errors and improved quality;
- decreased set-up times with associated reduction in production time and improved production capacity;
- simplified and improved housekeeping;
- increased safety;
- lower costs;
- lower skill requirements;
- increased production flexibility;
- improved operator attitudes.

XI. CONCLUSION

From the above comprehensive list of examples, it becomes obvious that there are certain characteristics of Poka-Yoke devices that help in achieving the aims of mistake-proofing. These characteristics include:

- **Simplicity,** which means that the solutions are not complex and unambiguously resolve the problem of error occurrence.
- **Automatic Nature,** they do not require any further intervention from the person using the device.
- **Safety,** is a key characteristic of Poka-Yoke devices in that they also prevent the users from injuries.
- **Feedback** is immediate in the case of failure when the conditions go out of specification.
- **Quality** is ingrained in the process and the solutions encourage the right methods to be used by operators of the devices. It is a way of standardizing the correct methods of performing a process.
- **Location at the source** of a potential problem within a process.
- **Reduction in the number of process steps** required to complete a process as the inspection aspect is minimized or completely eliminated.

REFERENCES

1.Implementation of poka-yoke in Indian manufacturing industry by: enablers, barriers and questionnaire based survey. Niranjan 1 , Yogesh Sharma 2

2)Review Paper On “Poka Yoke: The Revolutionary Idea in Total Productive Management. 1,Mr. Parikshit S. Patil,2,Mr. Sangappa P. Parit,3,Mr. Y.N. Burali

3)The Management and Control of Quality: By James R. Evans and William M. Lindsay.

4)https://www.referenceforbusiness.

5)https://toughnickel.com

6)Implimentation of Kaizen and Poka-Yoke to enhance overall
Equipment Performance - A case study
by Anil S. Badiger, R. Gandhinathan, V. N. Gaitonde, Rajesh S. Jangaler

7)REVIEW ON “POKA-YOKE: TECHNIQUE TO PREVENT DEFECTS” Aishwarya J. Kurhade Department of Mechanical Engineering, KIT’s College of Engineering, Kolhapur.

8) M. Dudek-Burlikowska*, D. Szewieczek, “The Poka-Yoke method as an improving quality tool of operations in the process”; Journal of Achievements in Materials and Manufacturing Engineering VOLUME 36 ISSUE 1

9)Stewart Anderson,“Poka-Yoke: Mistake-Proofing as a Preventive Action”;THE INFORMED Outlook Reprint: March 2002Volume 7, Number 3

10]PAULDVORAK Senior Editor;“Poka-yoke designs make assemblies mistake proof”; http://www.penton.com/md MARCH 10, 1998 MACHINE DESIGN

11)John R. Grout, and Brian T. Downs; “A Brief Tutorial on Mistake-proofing, Poka-Yoke, and ZQC”;
Lean Business Solutions United States.

12)“Lean Six Sigma Operational-Delegate Workbook”;Mistake Proofing techniques; The British StandardsInstitution; SSG06101ENUK-MP/Issue 1.1/ September 2008

