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A Literature Review of Optimized production using poke yoke

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Abstract
After the introduction of industrialization, Poka-Yoke (PY) has been used in a way to triumph over demanding situations which could have an effect on mistakes and defects in process. It is a broadly everyday concept- a manner of thinking, which undoubtedlycontributed to full-size outcomes in warfare towards the incidence ofmistakes in numerous paintings processes. However, despite the fact that PY appears to be wellunderstood in theory, there are a huge variety of clinical papers and books that also are trying to find to make clear and redefine PY, to be able to subsequently put into effect itssoftware at complete capacity. Many of authors, because it appears, need to emphasizeinconsistencies in cutting-edge theoretical and realistic experiences. This claim helps the truth of over 50 comparable and extraordinary PY definitions had been observed inliterature. It appears that maximum researchers did now no longer sufficiently understand everyday attitudes withinside the subject of PY, in addition to variations andinconsistencies in a number of them. Due to a feel of misunderstanding at some point of the processlayout stage, an attempt to are expecting places of viable reasserts of blunders is adirect outcome of the diffuse expertise withinside the subject, which imposes thewant to alternate that state. This paper summarizes the contemporary research anddefinitionswithinside the subject of PY programs so a complete and generally desirable definition of PY may be proposed. In order to discover a common cross-segment of the maximum vital attitudes with inside the subject of PY, a systematic literature evaluation has been used. It is essential to pick out the regions of disagreement, to apprehend any gaps that exist and description private experiences and attitudes with inside the subject. A new technique to the forms of PY supplied in this paper must be an amazing foundation for developing a improvement version and a systematic technique to the software of PY in manufacturing and carrier systems. Finally, a few conclusions and potential destiny studies guidelines are supplied.

Keywords: Lean, Poka-Yoke, literature review, process, error, inspection

INTRODUCTION

In the process of production in growingindustries, errors are inevitable. Thus to attain aggressive edge, difficulty must be progressed and errors need to be reduced to a minimal level [1]. As defined with the aid of using a superior production technologiescan have an effect on and decrease price of errors. Finding a device which can save you andstumble on reassets of abnormalities can be the toughest mission for all.Poka-Yoke helps to avoid any errors in the process of production.

Poka- Yoke (PY) has been unnoticed in educational studies and evidences of its useand implementation. It may be discovered extra from practitioners, nonetheless there are some not even aware of this term. A hole in theoretical background, definition and suggestions of PY nonetheless exists. Only papers were discoveredconcerning records and traits of PY, even as there's nonetheless no formaldefinition.

While running on one-of-a-kindprojects, authors of the prevailing paper have been striving for a solution, on severaloccasions, on the way to carry out positive obligations in order that no mistakess could get up at thestop of any interest withinside the future. By enforcing LEAN equipment and ideas on ahuge wide variety of projects, the concept got here for making use of Poke- Yoke in mistakeselimination. Reviewing journals and books on PY wasn't of amazing assist andsignificance for authors in resolving issues.

Designing the answers for thefound issues became especially primarily based totally at the designer's intuition[8]. A hugewide variety of sensible experiences, to be had from diverse journals and books inthis area, in addition to the concept of PY as a LEAN device withinside the shape of"getting rid of the purpose of mistakes" may be used as a steering forgreen layout of PY.

The preferred end at thetime became that there are various definitions of PY and they all are accurate intheir very own manner, even as a few inconsistencies nonetheless exist. It has been cited thatthere's no deep sufficient assessment article addressing this topic. Therefore, it became determined that the crew should transfer to PY studies that allows one to decide thenotunusualplace cross-phase of a huge wide variety of attitudes on this area. Thus, studies goal is toemphasize the ones thoughts and attitudes which can be coherentand extensively ordinary, which may be utilized in defining PY because of the studies that were careed out. In addition to the definition, positive conclusions of thispaper need to be useful in developing a layout version for PY, permitting fasterimprovement of answers in one-of-a-kind paintings

techniques.

Many have visible the significance towards mistakes. What may be stated with reality is that this"war", each from a systematic and sensible factor of view,gained depth in particular after theSecond World War. At the start of this period, vast backbones of thewar towards mistakess have been conventional strategies along with statistical processcontrol.

The prevalence of a mistakes leads to a final result in which very last products or services is out of formerly definedstandard. Noone remember what type of product is produced, every gadget now issearching out a method to put into effect their techniques in this type of manner that has noerrors or mistakes. Regardless of the character of merchandise and techniques, it isnormally ordinary that appropriate machines ought to be in vicinity for the realizationof producing techniques in the gadget. Machines integrate extra or lesscomplicated add-ons and equipment which affect on human- executed actionsassociated with paintings mission. This in addition influences the prevalence of materialprocessingmistakess.

METHODOLOGY

Literature assessment has been usedas one of the maximum practiced strategies for studying and reading one-of-a-kindtopics, equipment or topics in an educational environment. This paper follows thepaintings of Tranfield et al. [10] systematic literature assessment with the aid of using introducing threeone-of-a-kind stages: planning, engaging in and reporting.

Planning process

According to authors magazinearticles and convention papers have been analyzed the use of virtual databases: Scopus, IEEE Xplore, Emerald, Springer, Taylorand Francis even as engaging in theliterature assessment. Also, particular books, maximum noted with the aid of using authors and the onesto be had to authors have been analyzed. For looking criteria, key-word Poka-Yokehas been used that allows you to cowl all applicable reassets due to its particularand particular term. There became no dilemma at the yr of e-book or citationcounts, due to the fact loss of studies research withinside the area of PY.

Conducting the assessment

First step in engaging inliterature assessment blanketed sourcing virtual databases concerning key-word PY.Results discovered 1202 magazine and convention manuscripts.

Since sourced databases mayconsist of identical magazine and convention manuscripts, outcomes have been checked andduplicates have been removed. Also to live targeted withinside the region of pleasant, mistakes,errors prevention and detection and lean thinking, any other screening of the remainingpattern has been set up concerning this remember ensuing in pattern of 323manuscripts. Many outcomes used phrase PY while quoting equipment and strategies forcasting off defects, mistakes or wastes now no longer describing any particular definition, caseexamine or traits of PY. Manuscripts in which PY has been proven or useda few times in that way have been removed, ensuing in 172 manuscripts. Thereference listing from every manuscripts became analyzed that allows you to consist of maximumnoted books and different applicable papers and articles in which the phrase PY has beenutilized in a shape of mistake proofing, mistakess proofing or idiot proofing ensuingin very last pattern of 211 manuscripts Reportingand studying outcomes

Analyzing the content material from thevery last pattern, the class approach has been carried out that specialize in fewelements and categories:

- Inspectiongadget,
- FunctionsofPoka-Yoke,
- Historyand definition of Poka-Yoke,
- StepsinPoka-Yoke implementation,
- Poka-Yokeenablers and barriers,
- Examplesand case research on Poka-Yoke.

1 SYSTEMATICLITERATURE REVIEW RESULTS

Distribution of very last pattern in line with yrofpublishing is proven in Fig. 1. Research became taken in March, 2018 and a fewarticles posted on-line were additionally blanketed on this assessment. It may bevisible from the chart, an growing hobby in PY studies because the Shingo'see-e book on Zero Quality Control has been posted in 1986.

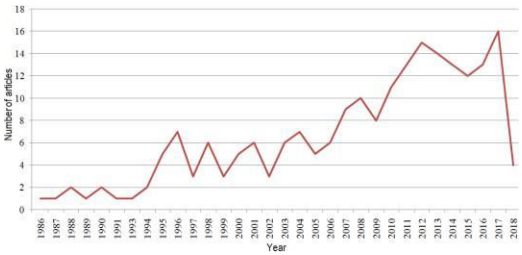


Fig. 1. Distribution of journal articles, books and conference papers on PY

Inspection system

Production is composed from thecommunity of approaches and operations [12]. Processes consist of technique of changingthe form or exceptional of the product, inspection, transportation of factors andput off in time. To enhance production technique, many exceptional manipulate methodshave been evolved counting on technique of inspection. Inspection machinetype made with the aid of using Shingo consist of: judgment, informative and supplyinspection.

Judgment inspection look intoproduct at very last degree in preference to processing degree, earlier than it reaches

thepurchaser. It best impacts inspection mistakes, it does now no longer lower disorder rate[13]. In order to perform 0 defects, detection isn't always an option.Inspection wishes to save you defects from going on and the only that impactsprocessing degree handing over remarks on exceptional troubles is referred to as informativeinspection. Once defects occur, facts is transferred to manufacturing,defects may be dealt with quicker and records reviews may be utilized in destiny forcontrolling the technique [14].

Statistical technique manipulate(SPC), successive and self-inspections are generally used and defined as a part ofinformative inspection. Using manipulate charts, version in exceptional manipulate canbe traced statistically. SPC are primarily based totally on sampling, however it isn't always 100%inspection, it can't save you defects from going on. Even Shingo becameunhappy with SPC after he found out it can't gain 0 defects [15].

Another sort of inspection isself- inspection. Operator inspects the technique and merchandise on the identical timeat the same time as he works on them. It brings speedy remarks, evaluating to SPC and helpsoperator who look into each piece to locate any uncommon behavior, to identifyand get rid of viable reasons of defects [16].

Inspecting the paintings performed with the aid of usingpreceding operator is a part of successive tests. If take a look at manner is performed with the aid of usingunbiased operator, extra dependable and fee green inspection may be [17].If the road is stopped, operator who finished preceding technique will feelaccountable for. This surroundings will have an effect on the operators to turn out to be extratargeted. Fisher [16] explains that it brings 100% inspection numerous instances anddue to the fact it's miles been performed on the identical time at the same time as operation technique, it minimizethe costs. He argues that each self and successive tests are used afterdisorder, so remodel needs to be performed. Shingo [12] explains the distinction amongself and successive tests pronouncing that it relies upon on who plays theinspection. Authors emphasize using self- take a look at evaluating to successiveone, explaining quicker facts remarks and technique improvement [14]. Inprovider zone Chase and Stewart [18] introduced new sort of inspection calling itjoint inspection so as to conquer mistakes and false impression amongpurchaser and provider provider.

Source inspection occurs earlier thanany action, on the supply [19] analyzing factors important for exceptionalmanufacturing. Authors Hinckley and Barkan [3] argue that supply inspection testsinputs which includes man, device, technique, fabric and facts so one cancast off defects at the same time as processing. Defect loose is secured with the aid of using controlling everyof those enter factors [13]. Shingo [15] explains that vertical supplyinspection tests inputs and circumstance earlier than occasion at the same time as horizontal inspectson operation. According to Hinckley [20], inspection need to be upstream of thetechnique so one can cast off wastes. Since mistakes purpose defects, the intention ofinspection needs to be targeted on putting off the ones mistakes [21].

SPC and self-tests are competingone due to the fact each are informative inspection at the same time as SPC and supply inspection arelike minded in a manner in which supply inspection may be used for putting off humanmistakes or unique reasons located with the aid of using SPC [22]. According to Fisher [16], self,successive and supply inspection are used collectively for achieving maximumresults.

In order to lessen techniqueerrors, Tsuda[23] identifiescomparabletype: mistake prevention as supply inspection; mistake detection as informative inspection;stopping mistake impact and mistake-proofing withinside the paintings surroundings thatmay be executed with the aid of using 5S, additionally defined with the aid of using Maurice et al. [24]. Shimbun [13]explains the significance of supply inspection and 100% inspection the usage of PY inmaintaining 0 exceptional manipulate, in which supply inspection is extra important.

Functions of PY

It is in human nature to makeerrors [12]. Mistakes made with the aid of using people are regularly the purpose of maximum defects inmanufacturing surroundings[25] and in a few providerindustries can create large poor outcome [24]. Another trouble ofdisasters can be negative control support, education and technique design [26].Blaming people will now no longer cast off defects and troubles in an surroundings [19].

The inspection structures definedin advance may be used to cast off maximum of those disasters advanced with the aid of using tool thatmechanically detects errors. Shingo [15] named this tool Poka- Yoke ormistake proofing, in which human intelligence want to be respected. He similarlyexplains unique features of PY. Regulating feature consist of manipulate andcaution kind. Control kind shuts down the technique at the same time as the caution kind bestalert operator with the aid of using mild or sound with out preventing the technique [27]. Which oneto select relies upon on defects frequency and its impact . Some authors verify that preventing the technique is favored so one can clear up the trouble,with the aid of using making use of jidoka or PY to cast off the supply of disorder that is based ondevice, in view that people could makeinadvertent errors. Even a few intentional mistakes may be removed with the aid of usingmanipulate PY tool. Saurin et al.[5] identifies manipulate kind features: flip off device, obligate operator tocarry out the paintings with the aid of using preferred manner and mechanically get rid of defects fromthe manufacturing line. PY manipulate kind is utilized in

a shape of jigs, pins, locks andsensor gadgets at the same time as caution kind PY is utilized in a shape of mild or buzzer [5].Both manipulate and caution gadgets needs to be fee powerful and clean to implement[20].

Setting feature of PY is primarily based totallyon touch, constant price and movement step technique [15]. For touch techniqueabnormalities in form, length or shadeation may be detected whether or not or now no longer thetouch among product and tool is made. Fixed price technique detects mistakesif a particular quantity of motions has now no longer been repeated. Motion step techniqueis based on preferred manner and if any step has been forgotten, it'll locateabnormalities. Fixed technique is generally utilized in locations in which the identical interest isrepeated at the same time as movement step technique is used at one area in which the operator has to technique numerous uniqueoperations.

Chase and Stewart classify putting feature as: bodily,sequencing, grouping and facts enhancement features. According to Chao there are PY approaches: Prevention primarily based totally (regulating feature) anddetection primarily based totally (putting feature) or proactive and reactive. Preventiongadgets may be similarly categorised: passive which includes visible signs activegadgets that tests for mistakes in length or form and manipulate orientated that shutsdown the technique in case of any abnormalities. Maurice et al. [24] bringforcing feature, as bodily constraint or barrier designed in a manner that nomistake may be made.

In order to cast off disorder,their supply needs to be identified [1]. According to Hinckley and Barkan [3],3 reassets of defects exist: versions as out-of tolerance circumstance;errors made with the aid of using human or device and complexity of product and technique.Defects may be categorised as isolated, which occurs ones and people occursoften as serial [19]. If there may be a complexity, the machine needs to besimplified. For version, conventional exceptional manipulate which includes SPC needs to becarried out and for errors, supply inspection and PY are the excellent solution [20].In creation enterprise due to complexity and variability of paintings,errors are well-known as inevitable. Stewart and Grout [14] defined thatcomplexity is a root purpose of errors and variability. Based on Shingo [15]regulating feature, the exceptional manipulate 3 has been evolved to conquerobstacles of different exceptional methodologies with the aid of using integrating reassets of defects andexceptional elements in a single unmarried model. Misiurek evolved PY generator sheetas preventive device for mistakes detection primarily based totally on task breakdown shape withkey factors and 5W1H approach.

As been quoted with the aid of using Shingo [12]:“PY isn't always an inspection machine, it’s a technique of detecting defects or errorsthat may be used to meet inspection feature“. In selecting the excellent exceptionalmanipulate technique, step one is to select the proper inspection machine, thenthe right feature and in the end to select the right touch, constantprice or movement step technique of PY. In a few instances the proper inspection machinemay be managed with the aid of using third-celebration inspection institutions.

Historyand definition of Poka-Yoke

The history of time period starts back in 1961while Shingo visited Yamadaelectric powered plant in Japan. The organization had a trouble of lacking spring attached to a switch. The trouble befell while the operator tried to pick up the springsfrom the huge field and wanted togather it to the switch. Forgetting to place all of the springs resulted in defects. The trouble become solved with the aid of using a smalltray located in the front of the operator in which he wishes to place best 2 springs from the huge field, so after the assemblingtechnique if not anything has left it approach that each one the springs are in area.Analyzing every book, paper and article round 50 comparable and uniquedefinitions have been identified. Many of them alternative time period PY with time period mistakeproofing, mistakess proofing or idiot proofing or describe PY in a shape of gadgets likesensors, jigs, furnishings or visible signal. Following the paintings of Shingo [12], PYhas been described as a bodily tool that plays 100% inspection andprevents defects from going on. It is a Japanese time period meaning (poka)inadvertentmistakess (yoke) avoid [13]. First time period become baka-yoke [30], which approachfool proofing or idiot proofing. While Shingo become explaining baka yoke atmanufacturing floor, ladies began out to cry as being indignant with the aid of using the time period. Everybodycould make errors, even the excellent employee so the time period has been modified to mistakeproofing [12]. PY has been utilized by unique names which includes mistakessproofing ,mistake proofing , fool proofing, idiot proofing [19]. Some definitions with the aid of usingauthors are summarized and defined in desk 1.

Table 1. Summarized definitions of Poka-Yoke

Author	Definition of term
Shimbun	Poka-Yoke is a technique for avoiding simple human error at work
Erlandson and Sant; Hinckley and Barkan [3]; Vinod et al [6]	PY is a system that uses simple devices or work methods for error prevention in manufacturing, service or other industries. The main purpose of PY is to detect defect, stop the process and to define and eliminate the cause. It’s a technique developed to reduce physical and cognitive demands of tasks in manufacturing and assembly process that creates connection between worker and process in a form of feedback so errors can be prevented in future. A tool used in achieving the goals of zero defect and Six Sigma.
Fisher [16]; Robinson	PY is a concept, application of simple mechanisms, methodology, warning or control device that involves preventing, detecting, eliminating, and correcting errors at their source, assuring that no defect will reach the finalcustomer.
Downs [41]	PY devices are used to ensure that conditions for high quality production exist (source inspection) or to provide rapid feedback to operator on defects so cause can be eliminated (self-checks).

Stewart and Grout [14] Stewart and Melnyk [42]; Swamidass [21]	A PY is a quality improvement approach, simple device or systematic practice that prevents permanently the recurrence of the defect it is designed to eliminate. PY is used for process where desired outcomes, definedbycustomerareinevitable.Byfollowingprocessproceduresand
	steps, operators will be able to reach desired outcome without defects.
Tsou and Chen [38]	PY uses devices on process equipment to provide 100% inspection and to prevent causes that results in defects.
Al-Araidah et al.	PY is the use of process, design features or automatic devices to prevent or detect errors in process.
Pakdil et al. [43]	PY is a simple and economical device used at service and manufacturing process for mistakes prevention, which does not allow employees to fail.
Saurin et al. [5]; Vidor and Saurin [30]	PY is a system or device for prevention and detection of abnormalities that affect product quality and operators' health and safety. Being made of physical, functional or symbolic barriers it contributes to the reduction of maintenance of stability and variability processes.
Misiurek	The solutions protecting employees from making mistakes are called PY. It's a preventive Lean tool or simple mechanism that focuses on identifying and eliminating causes of variations in process, which can lead to defects.

Other authors defines PY as aphilosophy, easy and monetary jigs, furnishings, sensors, visual orcaution gadgets, cross/no-cross gauges, [22] used to redecorate a procedure withpreventing and caution feature to be able to save you abnormalities to becamedefect. Authors [14] quote that PY needs to be price effective, located closetoreassets of mistakes [18]. Shimbun [13] explains that 5 fine PY are guidepins, mistakess detection and alarms, restrict switches, counters and checklists.

StepsinPoka-Yoke implementation

In order to maintain excellent andput in force mistake proofing procedure, summarizing the paintings of Hinckley stepsfor implementation with the usage of Toyota manufacturing wheel are: apprehend theproduct or procedure so simplification may be made, pick out errors and analyzethem with the aid of using criteria: how common they're and what effect they have got on finalclients and processes, observe supply inspection and use particular managemethods. If a technique is accredited it desires to be evaluated and standardized.

Estrada et al. developedlayout for PY technique (DFPYA) carried out at early product layout degree tolower meeting excellent troubles that might be recognized latter in procedure.The technique is primarily based totally on PY layout necessities, product layout characteristicsand capacity excellent issues, which can arise later in procedure. They used a 5step technique to be able to keep away from meeting excellent issues: pick out the productexpectation and capacity issues, make priorities concerning their impact in destiny,pick out the basis purpose and use PY layout necessities to keep away from capacitytroubles. Further Estrada proposed MOKA technique thatcan be carried out to seize and shop won understanding from preceding PYanswer so it may be used for destiny designs. Customer, procedure, qualitativeor quantitative metrics, consciousness urgency and time compression (FUT) are 4constructing blocks included into an 11 step technique at the same time as growing PYprocedure proposed with the aid of using Stewart and Melnyk.

Different methodologies and stepsat the same time as imposing PY in step with authors [19] can be summarized asfollows: Problem identification; Workstation observation; Identify mostcommon mistakes; Identify reassets of mistakes; Propose PY answer; Evaluateanswer; Choose the fine answer; Design PY, Implementation; Testing;Monitoring; Maintenance and non-stop improvement. Brainstorming, FMEA andIshikawa diagram had been used to be able to find out reassets of defects orat the same time as selecting an appropriate PY strategy to the hassle. In selecting theproper PY answer, a choice criterion became primarily based totally on price, time andsimplicity.

PYenablers and obstacles

From the literature review, a fewresearch have proven enablers and obstacles at the same time as imposing PY. Rathee et al. has recognized 30 enablers of PY inIndian production industries and categorised them as very applicable enablers,in which a number of them are schooling, excellent of uncooked materials, caution gadgets,price evaluation, software program tools; applicable enabler along with shadeation coding, feedbackmechanism, automation and much less applicable enablers as complexity of aintings,synchronization. According to Vidor and Saurin, PY can fail,so a brand new PY for PY desires to be inregion to be able to maintain 0 defects. Other PY obstacles recognized in literatureare: lack of know-how and schooling on PY, excessive price of investment, commonproduct layout modification, converting the manner of thinking [4], worry from losingthe job, complexity, lack of know-how and control aid. One of theobstacles that has been stated in a few studies articles is price. TsouandChen analyzed consequences of PY on economics of a faulty manufacturing device.They have proven that the price of a faulty device is decrease with the usage ofPY, however it relies upon on inspection charges and PY investments.

Examplesand case research on Poka-Yoke

Wiech and Böllhoff confirmedPYanswer for putting an item efficaciously at some stage in setup procedure of millingsystem with the aid of using introducing optical item detection device. Badiger et al. confirmed a few PY answers in a shape of restrict switches, clamps and sensors. Zhang[27] defined how wi-fi generation collectively with PY can cast off humanmistakes at logistic procedure with the aid of using the use of wi-fi scanning gadgets that may forestall theprocedure if a incorrect cargo became picked. Jadhav et al. brought PY forshaft meeting of wheeler. System makes use of good judgment controllers and sensors inorder to cast off errors made with the aid of using operator and as soon as it's far set, procedure may beexecuted routinely with alarm indicator if a hassle occurs. HedelindandJackson as compared tiers of automation in Japanese and Swedish enterprise andsaid many PY gadgets used to aid operators in meeting proceduremanaged with the aid of using programmable good judgment controller. Another take a look at of nut welding lackingcomponent became brought with the aid of using Wan Saidin et al.the use of PY jig as detectionmechanism. Kattman et al. has defined the usage of PY furnishings as visualgadgets ergonomically designed for excellent checks. PY in a shape of artificialsensors, fuzzy controllers and fan units has been used to detect, warn andmanage excellent of air, with the aid of using detecting tiers of CO and CO_2. Cooper offers examples how PY may be used for affected person safety. Pre-loaded syringes, pillcontainers with one dose only, precise affected person variety as preventive mechanism formistakes in drug management and affected person safety. Patient managementprocedure is traumatic and takes a number of ready time. One of the principle reasons ofdefects in management procedure is lacking bureaucracy as inadvertent mistakes.Using a shadeation coded publication can enhance procedure of affected person journey. Tommelein defined that PY may be carried out to architecture-engineering-constructionenterprise or at some stage in photograph processing. Errors made with the aid of using operators at cable meetingline have been traced and removed with the use of non-public RFID, so 0-defectprecept may be accomplished. Pötters et al. used 4 differentexcellent methods: 5S, Kanban, PY and Standard paintings sheet of their businesssimulation procedure for truck meeting, in which PY has proven maximum charge ofeffectiveness, influencing key overall performance indicators: rework, quickest leadtime and adherence to transport date. Selective meeting technique also can be usedto be able to enhance excellent in product meeting procedure. Other examplesand case research of PY implementation are offered withinside the tables below (Table2.-Table 7.).

Table 2. Implementation of PY in manufacturing

Author	Area of implementation - Manufacturing
Saurin et al. [5]	Authors introduced a framework to asses' safety and quality PY devices by defining attributes of PY. Framework was tested on four case studies. Quality PY were applied on the machine for polishing automobile axles, which includes a part consists of end yoke and a clamp with a sensor for hole detection. The sensor on a press machine was used to shut down the press if a worker puts a hand or any part of the body in the press area. Also green and red lights on the press machine showed safety PY. Another quality PY inspects position and dimension of brake pads before packaging. PY in this case consists from three elements: belt for carrying the parts, video camera for defect detection and monitor.

Table 3.*Implementation of PY in construction industry*

Author	Area of implementation - Construction
Saurin al. [5] ; Dos Santos and Powel[25]	The authors [5] have shown an example how PY safety device can be used for controlling elevator on a construction site preventing any defect to occur while workers are around. Other authors [35] argued that 4-5% of construction costs relates to rework and waiting times. Wastes, they explained, could be improved by using remote controller device for trolley hoist process. Dos Santos and Powel [25] on six case studies inBrazilandEnglandconfirmedthatusingofPYdevicesinconstructionsitesareofa little use for affecting variability but can be used for safety reasons.

Table 4.*Implementation of PY in automotive industry*

Author	Area of implementation - Automotive industry
Rajendra et al.	At a starter motor assembly line, a problem was identified with the assembling process between a retainer and a stop ring. The team used fixtures to eliminate the missing step of final pressing, sensors between the retainer and the stop ring in order to follow appropriate assembly steps. Laser sensors were used for detecting presents of parts and movement of pressing head. Results showed that PY can eliminate problems occurred by human errors during assembly process.
Yi and Yusof	A case study from an automotive part assembly company identified defects, mislocation and missing parts during assembly process of wires. Human errors were reported as the main cause of such errors. Automated sensor mechanism can be used to control assembly steps of operator by opening and closing the lids containing the parts from the first step to the last one. If any step is omitted by worker, sound will be a signal for error detection and won't allow the nextstep.
Che-Ani et al.	One of the main problems of an automotive assembly process was a broken plastic part connected to the sun visor of a vehicle. Color coding and designing different parts and dimensions has improved self-inspection done by worker in removing further assembly defects.

Dano et al.; Deshmukhand Mandale	This case study describes PY in a workplace for putting a rubber seal on a mechanism for car seat movement regulation mechanism in a case of an automotive manufacturer for car seat skeletons in Poland. PY was used as a laser and pressure sensor for detection of parts and their position, slots and pneumatic actuators and intelligent printersforprintingbarcodes,doublebuttonsforsafetyandwarningsignswereusedfor visual detection of finished product. PY improved quality, costs and time. Another exampleintroducedbyDeshmukhandMandaleshowsanothercarseatassemblyproblem, solved by a fencing device mounted on a conveyor for stopping defective parts, which were out of standard.
Ab Rashid et al.; Tsou and Chen [1]	Study shows wrong orientation of motorcycle bracket as being a main cause of defect in Malaysia company [70]. In order to resolve those problems caused by wrong positioning, a pin and a stopper was used to prevent workers from making a mistake during the process of molding. Tsou and Chen [1] have reported the deformation of the welding fixture in a Yazaki automotive company in Taiwan. They have also used a stopper to resolve this defect and have shown that cost of preventing activates affectsthe return of production system.

Table5.*ImplementationofPYinsoftwareandservicesector*

Author	Area of implementation - Software and service sector
Robinson	The author has described that applying specific PY solutions could improve software development processes. Using a specific computer language and unit test as a source method can prevent wrong coding or detect errors before they become defects. Mistake proofing can be applied to prevent application menu defects by writing a program or scripts with alarm option for generating and resolving errors.
Shahin and Ghasemaghaei	The authors have proposed a framework for classification of elements in service PY and recovery solutions. The framework can help service managers for errors detection, in a stage before or during a service process. They have shown some examples of service PY: slot parts for paying a service on a vending machine, which are designed to refuse any coin; bus station benches designed to prevent sleeping; usingpaperstripsinhotelsasavisualanddetectionmechanismforhousekeeping personnel.
Chase and Stewart [18]	A classification of errors and steps for fail-safe implementation in service process has been introduced by the authors. A case study from a car dealer showed some of the most frequent process errors: forgetting appointment time, unnoticed customer presence by operator, too long waiting time, high work load, misunderstanding, operator wrong diagnosis, inventory problems. The solutions for these problems can be solved by bell signals, color coding, car tags, joint inspection methods, checklists, computer diagnosis systems, limit switches, motion step PY for alarming vehicle retriever specialist.

Table6.*ImplementationofPYforindividualswithdisabilities*

Author	Area of implementation - Individuals with disabilities
ErlandsonandSant	PY controller was designed to improve weighting and counting process for persons with cognitive impairments. PY controller consists of software with scale weight, count and sensor mode. The authors have shown how PYC was applied in case studies, one in Michigan packaging process providing voice control to the operator who was unable to perform the task. Process was improved from 5 pound boxes per hour to 152 boxes. PYC was used for counting crashed cans controlled by sensor and light beams.
Treurnicht et al.	The authors have described the use of PY workstation in order to eliminate errors made by individuals with cognitive disabilities working on a ribbon cable assembly process in South Africa. Some of the possible errors were wrong socket alignment, wrong angle, length error, crimping and cutting errors. A specially designed box header, pins and jigs, color coding and checklists, lights and test device were used and resulted in high level of productivity.

Table 7.*Implementation of PY in healthcare*

Author	Area of implementation - Healthcare
Grout and Toussaint	A blood-lock, a single use plastic lock allowing usage only by the code placedonpatient wristband,andautomaticwheelchairbrakesareexamplesofmistakeproofingdevicesinthehealthcare process.
Kovach et al.	Providing knowledge on error proofing strategies to healthcare managers can improve and prevent occurrence of errors in hospitals. Most of the strategies are used to prevent medication, pre-surgery and child errors by box labeling for special medications, different color coding, pillbox, sponge counter bags, and protective electric plugs.

DISCUSSION

By reading formerly proven research associated with PY, it has beenconcluded that there are unique procedures to developing a PY answer. Somephrases and procedures to the hassle have encouraged the manner of wondering provenbelow. It has been determined that there aren't anyt any usually generic kinds of PY,nor fashions for fixing troubles associated with casting off the mistake. The contextin their use and alertness is to a positive volume unique, a good way to beclearer from the similarly contents of the studies presented. Significantemphasis is positioned on the character of the approach for the prevention or eliminationof the mistake, in addition to the instant and way in their application.

This dialogue on PY shall start from the overall description of thepaintings manner, proven in Fig. 2, which illustrates a simplified paintings manner. Asmay be seen, the paintings manner, in essence, includes some of operations,i.e., activities, which have to be found out with the intention to create a completed productor service. The manner starts offevolved with the primary operation, and ends withoperation (activity) m. In order to meet great requirements, everyoperation have to be done in step with the predefined layout answer. Thatsaid, every of the operations (activities) represents a capacity supply ofproduct failure. In every of the operations (activities), feasible aberrationsfrom layout answer can arise, which introduces mistakes. Error prevalence leadsto a product (service) which isn't compliant with the unique requirements.

The subsequent essential query is while the mistake is possibly to arise. Basedon Fig. 2, it could be stated that mistakes are possibly to arise at numerous timefactors. Area marked with letter A represents set of factors interior operation,wherein mistakes can arise. The first capacity blunders supply is the start ofoperation (activity) execution, which is marked via way of means of factor A1 withinside the graph (Fig.2). Another blunders supply is everywhere in among or on the cease ofoperation (activity) execution, marked with A1 to An.

According to Fig. 2, blundersprevalence and suitable response thru PY, can take area at followingtime factors:

- Itis feasible to save you mistakes from taking place throughout complete operation - i.e.,preventive react;
- Establishthat the mistake befell at factor An, i.e., on the cease of the operation, andtake movement to get rid of its consequences. This shape of response to blundersprevalence is detection;
- Theblunders may be detected via way of means of inspection at another time factor alongside the operationexecution, which once more represents detection. Some harm has alreadytranspired, however the advantage is that it'll now no longer attain the buyer.

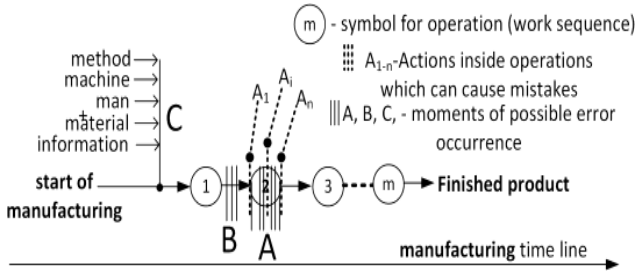


Fig. 2. Process with operations

It need to be mentioned that thefeasible supply of blunders can arise outdoor factors vicinity A, i.e., at factors B,(among paintings operations), and C (on the very starting of system). It canadditionally transpire all through insufficient delivery or product handling, among paintingsoperations. This means that PY answers also are relevant to qualitycontrol outdoor paintings operations, in addition to on the very starting of thesystem.

The dialogue supplied so far,may be based via established order of ok sorts of Poka-Yoke gadgets:

- Passivegadgets PY - PPY;
- Activepreventive PY - APPY;
- Active,for detection PY - ADPY;
- Hybridactive, preventive - HAPPY;
- Hybridactive, detection - HADPY.

PassivePoka-Yoke - PPY

Passive PY method that gadgetsare used for caution approximately possibilitiesof blunders all through thesystem. The gadgets used forthat reason may be mild indicators, sound indicators or numerous modes of visualcontrol (utility of various kinds and colors). The deficiency of thissort of Poka-Yoke is that it can not save you blunders (Fig. 3). However, actionsare taken to sign its prevalence (Fig. 4). Fig. 3, five and seven indicates an operationwith moments of feasible errors, actions (A1 to An) which could purpose mistake andwhite arrow, supplying operation output without or with defects. It is notfeasible to save you the prevalence of an blunders through utilization of audio-visualindicators, however they could sign which steps are incorrect and need to consequently beavoided. As implied through the word, passive PY has no ability of electro-mechanical response inside system control.

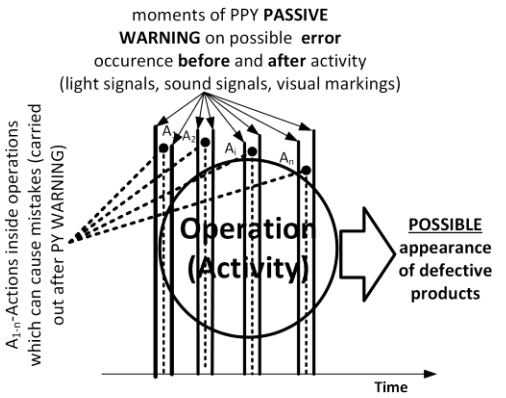
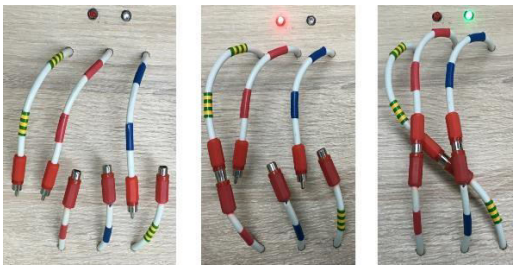


Fig. 3. Passive Poka-Yoke - PPY



Three activities (A1, A2 and A3) are needed in orderto complete the assembly operation. Visual signals are colored tapes and led lights.	A1- action 1 is cause of error. Passive signal red light and marks on cables indicate where and when errors occurs.	A3 – last action 3 is completed, operation is performed, green light confirms correct operation without error.

Fig. 4. Example of Passive Poka-Yoke - PPY

Poka-Yoke Effective Preventative-APPY

Effective preventive Poka-Yoke seeks to avoid the occurrence of errors. This form of PY is active from the very beginning of the activity and springs into action before the activities which cause error occur. When the job procedure is complete, faulty goods will not occur. There is therefore no need to re-work the product, because PY prevented errors (Fig . 5).

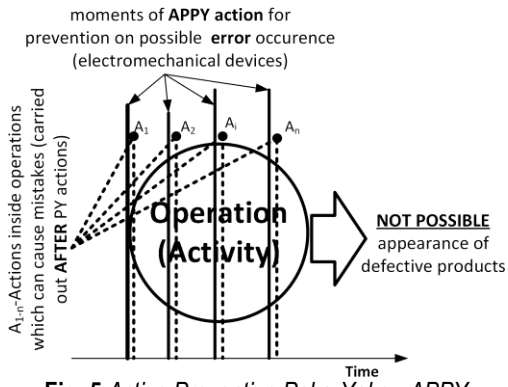


Fig. 5.*Active Preventive Poka-Yoke - APPY*

It is important to note that if a specific procedure needs several activities to be conducted, many APPYs may be set up within that operation prior to any activity leading to a potential error (Fig . 6).

In order to prevent errors, in the example, the mechanical characteristics of the elements for preventing the occurrence of the error are used in the illustration. Three activities (A1, A2 and A3) are needed in order to complete the assemblyoperation.	There is no possibility to perform any of the three activities (A1, A2 and A3) from the operation that will make the error. Mechanical construction of elements will not allow any error in the finalproduct.

Fig. 6. Example of Active Preventive Poka-Yoke - APPY

Active Detection Poka-Yoke -ADPY

Active PY detection requires the use of a suitable electro-mechanical tool to detect product defects (Fig . 7). Hence the PY system responds by detecting defective goods. A faulty product is the outcome of previous activities being carried out.

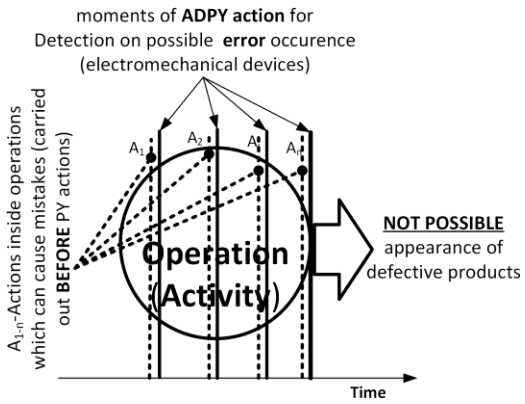
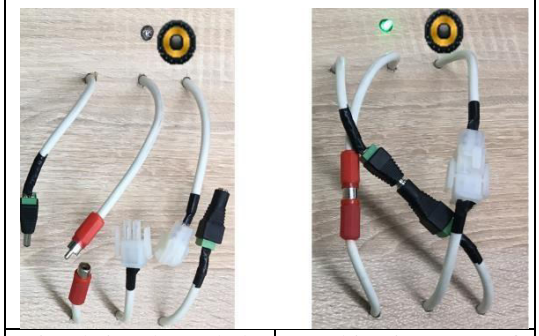


Fig. 7.*Active Detection Poka-Yoke - ADPY*

In that respect, ADPY tool prevents the faulty product to reachbuyers. However, the mistake and the ensuing faulty product or servicerequire ok response and alertness of corrective measures at themerchandise which do now no longer observe great standards. That slows down theprocess, inflicting losses, which predominantly mirror in expenditure of extratime, materials, device paintings, and labor, at the re-paintings required. Similar toAPPY, have to execution of a specific operation require numerous activities, itis feasible to installation numerous ADPYs, practically, previous to any hobby whichis susceptible to cause errors.
Generally speaking, it's also feasible to mix APPY with ADPYinside an operation, relying on a specific operation and paintings process.

Hybrid - HAPPY andHADPY
Hybrid Poka-Yoke represent a combination of the discussedvariants.
Thus, with the aid of using combining Passive PY (PPY) and Active prevention (APPY), onederives a Hybrid Active Preventive Poka-Yoke (HAPPY). This is the nice variantof the Poka-Yoke gadget for mistakess inspection. The improvement andimplementation fees of HAPPY are barely better in phrases of passive andactive. On the only aspect it prevents errors, at the same time as on the opposite aspect itwill increase employee performance at some point of execution of guide operations, through utilization of audio-visual signals. It is crucial to emphasisethatworkers trainings are a good deal simpler andfaster. This is why HAPPY gadgets are maximum efficient, despite the fact that their layout istruly extra complex.
Hybrid **A**ctive **D**etection **PY** (HADPY) evolved as a combination of ADPY and PPY.
Hybrid PY are, in any case, most desirable in the work processes (Fig.8).



Visual signals are led light and color of connectors on cables. Audio signals are from beeper speaker. These are passive PY elements. Connectors are also mechanical enablers (means) for error prevention. This is active preventive PY.	Combination of audio-visual (passive) PY and active preventive (mechanical) PY. Basic characteristics are higher eficiency in certain activities execution, without the possibility of an error and training is moresimplified.

Fig. 8.*Example of Hybrid Active Preventive Poka-Yoke HAPPY*

3CONCLUSIONS

Conducted analyses have proventhat the overall concepts and factors of view are essentially coherent, and arepredominantly primarily based totally at the works of Shigeo Shingo. Theoretical foundation hasappreciably advanced on this region of expertise.Careful evaluation additionally revealssure contradictions and inconsistencies withinside the positions of a fewresearchers, which offers sufficient area for one of a kind interpretations ofspecific issues.

Implementation of PY inmanufacturing techniques has thus far given extremely good effects, whilst PY has come to be asynonym for blunders prevention. However, thru verbal exchange with eminentprofessionalswithinside the region of productexcellent manipulate, one regularly has the influence that the theoretical method tothis subject matter is simply too extensively described, which the to be had literature corroborates.As the end result of this situation, developing PY inspection answers nevertheless takesintuition, whilst the very last final results relies upon at the excellent of engineeringmethod.

Understanding of the previouslymentioned category appreciably allows software of PY inpractice. According to that category, PY also can be described as themanipulate machine wherein the emergence of mistakes and their proliferation as much as theconsumer may be averted passively or actively. The passive machine offersdecrease

reliability and lets in mistakes to attain buyers. Design of lively PYs calls for a few PY gadgets to be usedif you want to save you execution of terrible moves with the aid of using the people or the detection ofterrible merchandise which can be the effects of mistakes. In this way, mistakes are avertedfrom attaining customers. As proven withinside the preceding figures, the instant of thefeasible incidence of blunders atsome stage in paintingstechnique may be very vital for the expertise of the essence of PY. Moreover,the connection among PY and technique blunders is without delay linked to the timeflow, i.e., the time factor wherein the mistake is reacted to. Another vitalcomponent is the method closer to treating mistakes, which may be categorized into3 categories: passive method, lively prevention of mistakes, and livelydetection of faulty merchandise.

This research changed into centered ona complete evaluate of the achievements withinside the PY domain, in addition to at themodern theoretical processes to PY and the war in opposition to mistakes at some stage inpaintings technique. This will permit wider software of PY as a LEAN device in varioustechniques. Furthermore, the mentioned method to PY category have to additionallyfacilitate the introduction of a version for the improvement of PY systems. Finally,this research have to permit identity of vital regions which can benevertheless insufficiently researched, together with a way to expand PY to hold PY runningand save you PY from failure, that is thrilling in its personal way.

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