Systematic Innovation for Manufacturing Quality Improvement

Shu Luing Nikalus Swee[1], Guat Guan Toh[1], Mum Wai Yip[1] and See Chew Tai[1]

[1] *Tunku Abdul Rahman University College, Malaysia*

Abstract. This paper provides a detailed analysis on the systematic innovation process in improving the quality control of latex gloves production. The systematic innovation tool such as TRIZ is applied in this case study. Function analysis, cause and effect chain analysis, physical contradiction, By-separation model and 40 Inventive Principles are applied in order to derive some feasible and low cost solutions to alleviate the problem. Findings revealed that the rejected (leaking) gloves on the production line will be manually monitored by a checker during the air blowing test and will be discarded by the same checker instantly. The main root cause is that the quality control worker is not able to concentrate all the times to detect the torn gloves, mainly is due to the fast speed production line and other distractions. The problem is solved by applying function analysis, physical contradiction, by-separation tool and Inventive Principles to generate low cost but elegant solutions within the defined scope of several constraints and without making the production line more complex. Therefore, it can be concluded that TRIZ is a systematic and innovative problem solving methodology.

1 Introduction

Manufacturing lines cover a set of serial processes. Raw materials are channeled into refining operations to produce an end-product that is suitable for consumer market [1]. It also includes inspecting, labelling, and packing the final product before the product is released. Machines, materials and workforce influence the reliability and capacity of the production operation. Therefore, every process is crucial for seamless production [2]. The production of latex gloves involves a process of coagulant dipping, in a continuous chain dipping line. High speed continuous dipping line are commonly used for surgical and examination gloves production. During the coagulant dipping process, clean porcelain formers are first dipped into a coagulant solution and then into a natural rubber latex compound. The next stage involves the bead rolling of the gloves by rotating brushes after a short drying. Then, leach the wet gel on the former in hot water. Corn starch is then applied to the outer surface of the formers via a slurry dip before the gloves are subjected to a drying and vulcanization process in an oven (tumble dryer). Subsequently, the dried gloves are manually stripped from the porcelain formers, tested and packed. [3-4] Leakage and tensile testing is part of the quality control measures. Latex glove durability is measured in tensile properties (strength and elongation) and barrier integrity (water leakage test). Leakage is identified most commonly in the finger parts of the glove [4-5].

TRIZ is a Russian acronym that is equivalent to "Theory of Inventive Problem Solving" in English. TRIZ methodology was introduced by Genrich Altshuller and his team in 1940's [6]. From 200,000 patents, he discovered and categorized his study of 40,000 patents according to innovative patterns of design and the inventive principles in these innovative solutions. Findings revealed that solutions and patterns of technical evolution were recurring across industries and sciences, and innovations used scientific effects outside the field where they were developed. Therefore, Genrich Altshuller created 40 inventive principles [6-13]. TRIZ comprises of several crucial tools such as engineering systems analysis, function analysis, cause and effect chain analysis, trimming, engineering contradiction, by-separation, substance-field model, Trends of Engineering System Evolutions, ARIZ, and etc. TRIZ uses 40 inventive principles and 39 parameters to help inventors to derive many solutions [6-13]. Besides that, there are also 4 basic concepts of TRIZ such as systems approach, contradiction, ideality and resources. Technical contradiction is the key concept in TRIZ. A problem is solved only is the technical contradiction is identified and eradicated [14-15] .

2 Problem Statement

On-site inspection revealed that the quality control worker is not able to focus all the times to detect and to discard the leaking gloves during the air blowing test which may fail the AQL, or Acceptable Quality Level. There are a few constraints to be taken into account such as the speed of the production line cannot be altered, dipping process can be altered, power of air blower cannot be toned down and there is no budget for sophisticated solutions such as robotic arms. The following are the details on how TRIZ is applied in this case study.

3 Systematic Innovation Tools (TRIZ)

TRIZ flow of processes is shown in Figure. 1. First, define the engineering system of the initial problem, and this is followed by function analysis, cause and effect chain analysis, and Physical contradiction. Finally, By-Separation model is applied to derive specific inventive principles and specific solution(s) [6-7].

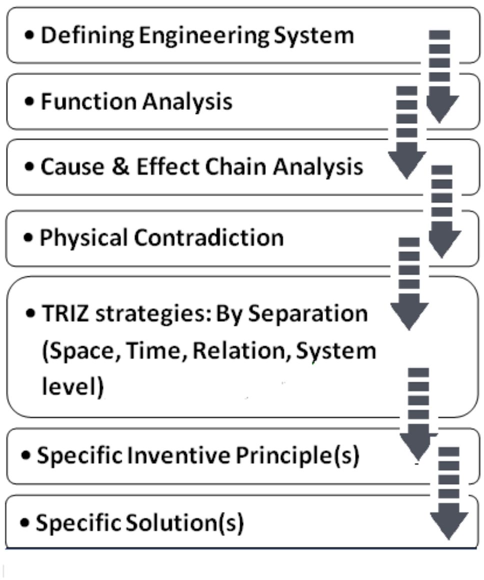

Figure 1. TRIZ Processes

3.1. Engineering System Definition

An Engineering System comprises of several components that are interacted among each other. All these components are commonly recognized as system components (subsystems) that are listed in Table 1. Along with subsystems, there are also connections between engineering system and external entities called Supersystems. Supersystems are not the members of the Engineering System; however, they can influence the Engineering System. [7-8].

Table 1. Engineering System

Sub /System Components	Formers(mold), coagulant tank, latex tank, rinser, dipping track, oven, bead roller, motor, air blower
Supersystems	air particles/dust, workers, Humidity, Thermal

3.2. Function Analysis

Function analysis analyses the contacts/interactions between two or more systems/subsystems (Engineering System components) which are listed in Figure 2. These interactions are called functions. Functions are interactions between two components, i.e., a subject and an object in which the subject acts upon and modifies a parameter(s) of the object [6]. For instance, 'a robotic arm holds a bottle. Two main types of functions are useful function and harmful function. As for useful function, it has "normal", "insufficient", and "excessive" functions. [6-7].

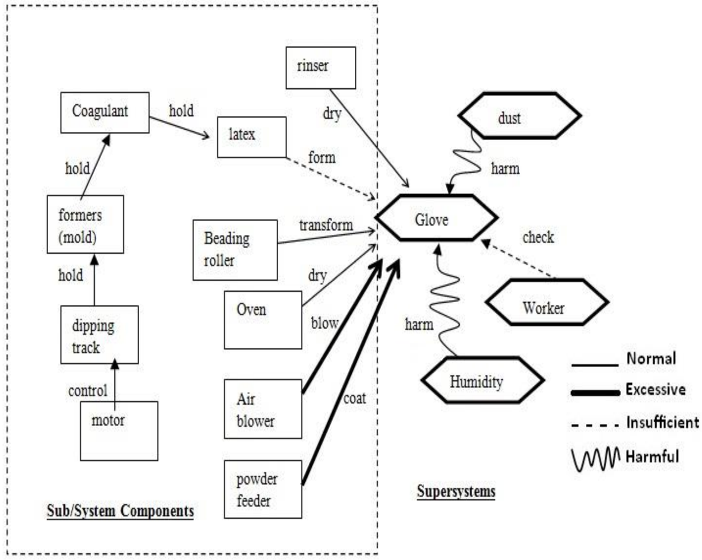

Figure 2. Function Model

3.3. Cause and Effect Chain Analysis (CECA)

Cause and Effect Chain Analysis(CECA) helps identify the right root cause(s) in relation to the problem in Figure 3. If the wrong root cause is derived, it leads to ineffective solution. We prompt for causes continuously for the problem from high level causes to low level causes by asking "the question "why?" [6]. From the CECA, the root cause identified is that checker is not able to concentrate all the times to detect and pull out the leaking gloves in the event of the high speed production line. Nevertheless, the function model shows that there exists other problems which may affect the gloves quality, but these problems are not crucial.

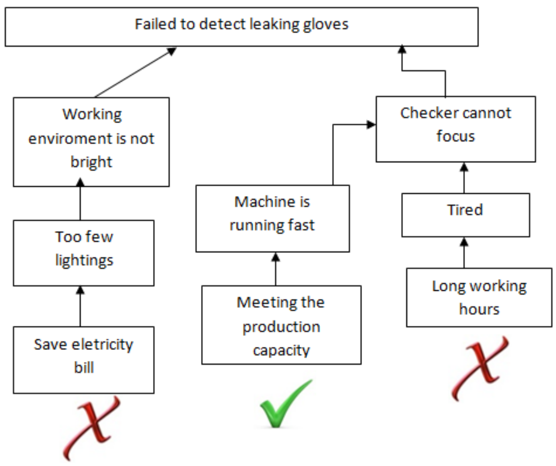

Figure 3. Cause and Effect Chain Analysis Diagram

3.4. Physical Contradiction

Physical Contradiction refers to the existence of a contradiction in an engineering system involving a single parameter (e.g. speed, weight, strength, temperature, length, volume, etc.) which has a contradiction at two different values. [6-7]. For example, Sandblasting abrasive needs to be present to remove material stuck to an object and must not be present when sandblasting operation is completed. The essence of the Physical Contradiction is to find the controlling characteristic. The Physical Contradiction can be solved through methods such By-Separation in (Space, Time, Relation, System level) and By–Satisfaction, and Bypass. In this case study, we employ By-Separation model. Based on the case study, the following Physical Contradiction is proposed.

-The speed of the production line needs to be fast for high productivity.
-The speed of the production line needs to be slow for checker to detect leaking gloves easily.

3.5. By Separation principles (Space, Time, Relation, System level)

By separation principles are used commonly to generate new ideas by resolving some key paradoxes of industrial innovations. To investigate for the type of the Separation whether in Space, in Time, or in Relation, the following scenarios should be established [6]:

- •Separation in Space – **Where** is condition Z required? **Where** is condition –Z not required?
- •Separation in Time – **When** is condition Z required? **When** is **condition** –Z not required?
- •Separation in Relation – I need condition Z **IF…** ? I need condition -Z **IF…**?
- •Separation in System level – The Physical Contradiction's controlling parameter has a value at the system level but has an opposite value at the component level or a controlling parameter exists at the system level but not at the component level.

Referring to the above scenarios, the speed of the production line needs to be fast in relation to the high productivity, and the speed of the production line needs to be slow in relation to the effectiveness of quality check. Hence, Separation in Relation model is deemed suitable to reflect the problem. There are many recommendations of Inventive principles in Separation in Relation[6], only Inventive Principle #32 Color Changes and #28 Mechanics Substitution are deemed suitable for the problem after thorough discussion with production engineers.

4 TRIZ Solutions and Discussion

Referring to the proposed inventive principles above, Inventive Principle #28 Mechanics Substitution suggests replacing a mechanical means with a sensory means such as optical, or acoustic means. #Inventive Principle #32 Color Changes suggests to change the color of an object or its external environment, or to change the transparency of the object, or to use colored additives (luminescent elements) to improve the observability of the object [6]. Based on the suggested Inventive principles, production engineers can install infrared sensors (IR) that emit and detect IR radiation to sense its ambience. IR transmitters and IR receivers are installed at the level of the finger parts of the glove in which the glove is sandwiched between the IR sensors. When the glove is tested with air blowing test, leaking finger parts will allow the IR receiver to detect the IR radiation from IR transmitters. Therefore, IR receiver can trigger color LED to light. Color LED attracts attention from the checker to discard the torn glove effectively [16-17]. In addition to that, production engineer may also consider other useful Inventive Principles even though the Inventive Principles are not recommended through the systematic approaches above. For instance, Inventive Principle #29, Pneumatic and hydraulics, suggests to use gas or liquid parts of an object instead of solid parts, e.g. transition from mechanical to pneumatic drive [6]. Therefore, the discarding of leaking glove can be automated by installing a simple vacuum suction cup to perform the task [18].

5 Conclusion

The manufacturers should be able to process faster, reliable with lower cost for any types of products [19-20]. In this case study, the problem was confined by applying TRIZ tools particularly the Physical Contradiction and By-Separation tools. TRIZ helps engineers generate more practicable ideas which may derive multiple low cost and elegant solutions. TRIZ needs field specialists and TRIZ consultant to work together to derive effective solutions. It can be concluded that TRIZ is a systematic and an innovative problem solving methodology.

References

1. Sarder, MD Baniamin, Liles, Don H, Ali M Yousuf 2005 Design & Implementation of production line

inapparel manufacturing industry *IIE*, Annual Conference. Proceedings, pp. 1-6 (2005)
2. U. Michael, G. Van and U. Elisabeth, Improving production line performance, IIE Solutions; 32, 11 ProQuest, p. 36 (2000)
3. Jose Paul Meleth, *An Introduction to Latex Gloves*, Lap Lambert Academic Publishing (2012)
4. Ploytip Jirasukprasert, Jose Arturo Garza-Reyes, Horacio Soriano-Meier, Luis Rocha-Lona, A Case Study of Defects Reduction in a Rubber Gloves Manufacturing Process by Applying Six Sigma Principles and DMAIC Problem Solving Methodology, Proceedings of the International Conference on Industrial Engineering and Operation Management Istanbul, Turkey, July 3 – 6, (2012)
5. A. Douglas, T. R. Simon and M. Goddard, Barrier durability of latex and vinyl medical gloves in clinical settings, American Industrial Hygiene Association Journal, 58, 9; ProQuestp. 672 (1997)
6. T.S. Yeoh, T.J. Yeoh, and C.L. Song, *TRIZ-Systematic Innovation in Manufacturing*, Selangor: Firstfruits (2009)
7. A.A. Guin, A.V. Kudryavtsev, V. Yu. Boubentsov and A. Seredinsky, *Theory of Inventive Problem Solving*, First Fruits (2009)
8. D. Mann, *Hands-On Systematic Innovation*. Belgium: CREAX Press (2003)
9. D. Mann, *Hands-On Systematic Innovation for Business and Management*, Devon: Lazarus Press (2007)
10. E. M. Smith, From Russia with TRIZ, Mechanical Engineering, 125, 3; Academic Research Library, p. D18 (2003)
11. G.S. Altshuller, *The Innovation Algorithm, TRIZ Systematic Innovation and Technical Creativity*, Worcester, MA: Technical Innovation Centre (2000)
12. G.S. Altshuller, *40 Principles*, *TRIZ Keys to Technical Innovation,* Worcester, MA: Technical Innovation Centre (2002)
13. J. Terninko, A. Zusman, and B. Zlotin, Systematic Innovation: An Introduction to TRIZ, New York, NY: CRC Press (2010)
14. Bowyer, D., Evaluation of the effectiveness of TRIZ concepts in non-technical problem-solving utilizing a problem solving guide. ProQuest (2008)
15. Ilevbare, I. M., Probert, D., & Phaal, R., A review of TRIZ, and its benefits and challenges in practice. Technovation, 33, pp. 30–37 (2013)
16. M.Gordon, Collison avoidance and detection: Part 1, Poptronics; 1, 12; ProQuest, p. 53 (2000)
17. S. Piet 2003 Electro-optical sensors: How good are they?, Naval Forces*;* 24, 1, Research Library, p. 13 (2003)
18. Zalud, Todd, Using suction cups to design a vacuum system, Machine Design, 70, 22 p. *114 (1998)*
19. Andy Longford, Chip packaging challenges …a roadmap based overview, Microelectronics International, 22/2, pp. 17–20 (2005)
20. Lagner, P., Advantest Handling challenges of small & fine pitch devices, Advantest Technical Forum (2004)