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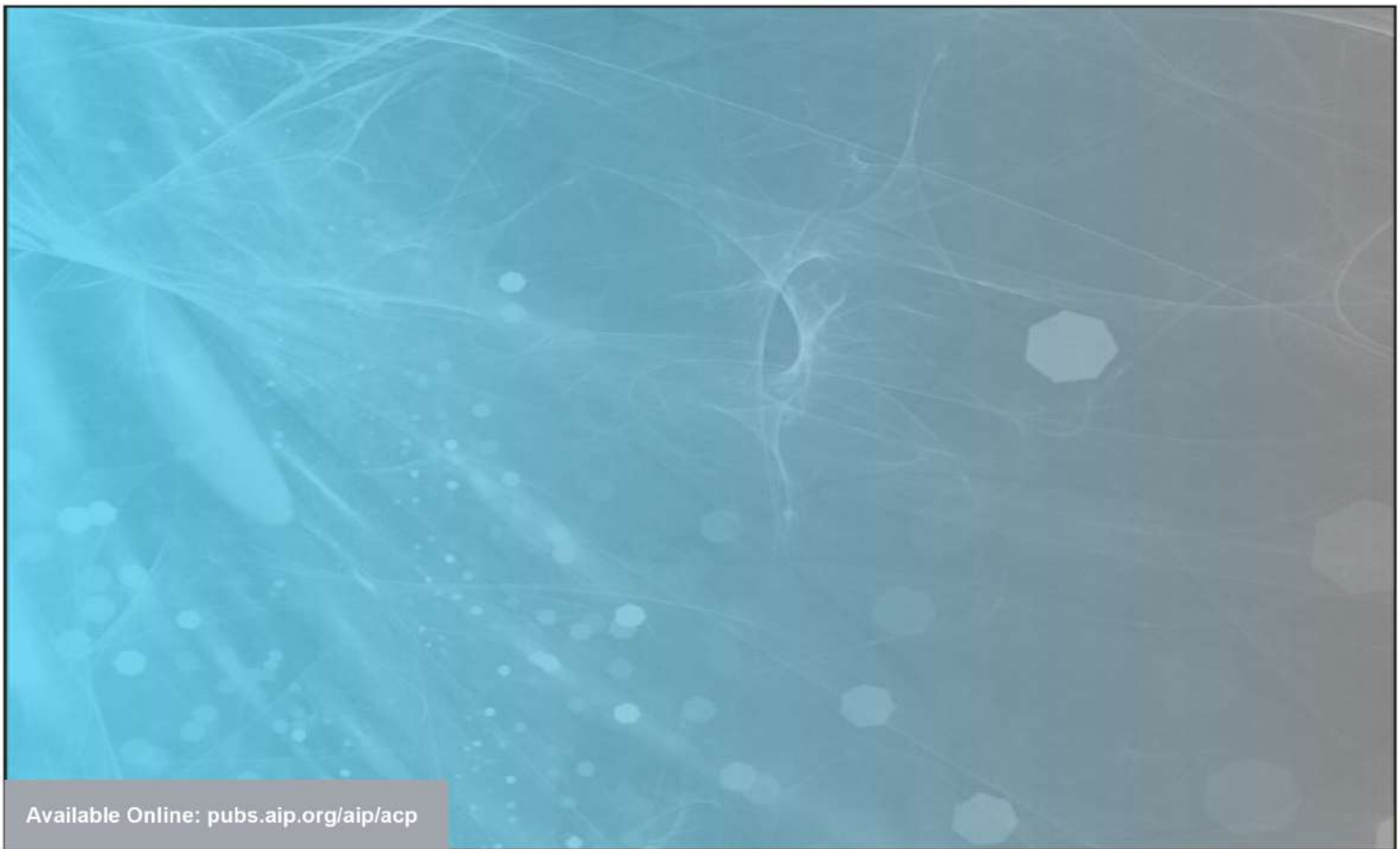

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Design thinking: Visual guidance for quality inspection case study on cosmetic packaging company

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Design Thinking: Visual Guidance for Quality Inspection Case Study on Cosmetic Packaging Company

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Abstract: The article discusses human error in quality inspection process at a cosmetic packaging company. Human error occurs because the visual guide of quality requirements designed by the inspector does not match the expectations and needs of the selectors as users. To improve the design of the visual guide to effectively reduce inspection errors, a design thinking approach is used. A user-centred design approach, designed jointly between users and designers, through five design stages, namely the empathize, define, ideate, prototype and test stages. The results of improving the visual guide are able to reduce inspection errors within selectors 8.3%, between selectors 36.25%, each selector vs standard 15.8%, and all selector vs standard 38.75%.

INTRODUCTION

The success of a quality control system is highly dependent on human factor, which is responsible for the system by playing a major role in the functions it performs [1]. Failure to control quality due to human error is important to be reduced or even eliminated. The role of humans in the quality control system is very important [2]. To gain insight into this important human role, a study was conducted on a company that produces cosmetic product packaging, with various sizes and with strict requirements according to customer requests. In this company, inspection errors often occur, so the quality inspection results by the selectors are validated again by the inspector, by sampling in three stages, namely during setup, in process, and at the final stage. Inspections are carried out visually with the object of inspection being the function, appearance, and color of the packaging. Inspection by the selector is carried out manually using a visual guide of quality requirements in the form of a sample image pasted in front of the selector. Furthermore, the type of visual guide of quality requirements varies according to the type of goods produced, even for the same goods by different consumers, visualization guide of quality requirements can be different.

Accuracy and durability of the selector in the quality inspection process is very important [3], where the inspected product moves on the conveyor quite quickly and inspection work is carried out in a long working time. Although the quality inspection process is quite long and strict, in reality many inspection errors are found, defective products pass quality control exceeding the acceptable quality level (AQL). Based on the company's non-conformity note in June-December 2020, 364 cases of inspection errors were found in the printing process and 134 inspection errors in the stamping process. This inspection error causes all products in the batch to be re-inspected one by one. This re-inspection takes longer and requires additional selectors.

Based on observations on the production floor, problems occurred in the visual guide of quality requirements that was used as a reference by the selector. According to the selector, the visual guide designed by the inspector could not be translated exactly according to the inspector's expectations. There are always wrong inspections, there are always defective products that pass the selection [4]. So far, inspectors have provided inspection training to selectors following the drawing guidelines several times, but inspection errors by selectors still occur frequently. In addition, inspections are carried out over a long period of time, nearly eight hours per shift, and the inspected product moves quickly on

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conveyors. Selectors get tired quickly and feel bored, moreover the visual guide used often changes according to the goods produced.

Based on this problem, how do inspectors and selectors work together to design a visual guide of quality requirements in order to obtain a design that meets the expectations and needs of the selector to significantly reduce the inspection error rate. Making joint designs between users, i.e. selector, and designer to get a visual control design that matches the selector's desire, it can best be done using a design thinking approach [5].

DESIGN THINKING AND VISUAL GUIDE OF QUALITY INSPECTION

Visual guidelines for quality inspections are often difficult for selectors to interpret accurately. According to Leavy [6], visual guidance can be understood and applied appropriately, if the user sees and feels the process of designing the guide. According to Leavy, the process of designing a visual guide needs to be demonstrated repeatedly. Demonstrating designs with users is a key element of design thinking (DT). Furthermore, according to Dobbelaer et al. [7] verbal feedback by users is very helpful in the design development process, especially direct feedback when conducting design trials in the field.

Furthermore, according to Liedtka [8] using design tools, such as mapping how each user uses the guide, will help designers and users engage with the problems encountered and work together to find opportunities. Liedtka states that the result of adopting a design thinking approach is not only in identifying solutions, but in innovating how designers and users work together to imagine and discover new possibilities. Cahyadi and Prananto [9] emphasize that communication with various interdisciplinary and cross-functional groups plays an important role in designing a visual guide. The ability of designers to collaborate with users, namely data owners or process owners will increase the effectiveness of the design process. In this sense, DT can be used as a holistic, creative and solution-oriented framework. On the other hand, problem solving with DT can increase user involvement in finding solutions [10].

Henriksen et al. [11] suggest that designers provide access to design users when facing problems in practice. This feedback from users will help the designer think creatively to improve the design. Meanwhile, according to Bower [12] designers need to have context-sensitive design principles and knowledge, making design a reflexive practice following the context according to user needs. Lee and Lim [13] emphasized that it is difficult to understand user desires and motivations when using traditional design methods. Users expect designers to understand their hidden or unknown wants and needs. Furthermore, the designer does not just design what the user wants, but designs what the user should need, so that the design is fully desired by the user. The main reason why design thinking is a key component of innovation is that it helps to reveal complex and abstract user needs and find creative solutions for them as quickly as possible.

The essence of design thinking is aligning human needs by leveraging designer logic and methods, thereby providing better value to users and creating new opportunities. In addition, according to Bresciani [14], designing a guide with the design thinking concept can help designers make more informed decisions, guide visualization is more focused, the results are clear, have visual appeal, and can create collaboration between users and designers. According to Sandorova et al. [15], making a visual guide to quality requirements with the design thinking concept can improve creative thinking, teamwork, and communication. In addition, according to Cleckley et al. [16] designers must have empathy in the development process, namely listening to stakeholder input regarding their expectations and goals. Finally, Albay and Eisma [17] say that the application of the design thinking process can facilitate designers in creating designs that are creative, interactive, attractive, and user-centered.

DESIGN METHODOLOGY

A visual guide to the quality requirements of cosmetic product packaging to reduce inspection errors by selectors is designed using a Design Thinking (DT) approach. DT is a creative approach to creating creative and attractive solutions [18].The five stages of the DT process are the empathize, define, ideate, prototype and test stages [19]. Empathy is the foundation of the human-centred design process. Some ways to empathize are observe, engage, immerse. Observation of the behavior or habits of everyday users. Engage directly with people so that understand how users think and the values that users hold. Immerse by trying to feel the experience as a user.

If the test results are not in accordance with the inspector's standard, it is repeated again from the initial stage, namely empathize. Problem identification is done by interviewing selectors and inspectors as well as field observations by observing the flow of the production process, quality control process, and observing the types of defects that often occur. Data collection by testing MSA (Measurement System Analysis) attribute data, using feelings and eyes for visual inspection [20]. The test of selector inspection ability was carried out in three groups, namely A, B and C, with two replications. MSA results to see the ability of selectors in conducting inspections. The interpretation of the MSA results is within appraisers, each appraiser vs standard, between appraisers and all appraisers vs standard. In this research, the appraiser is a selector. Within appraisers is an analysis of the consistency of each appraisers. This analysis measures the consistency of appraisers' answers across multiple replications. Each appraiser vs standard compares each appraiser's answer with the standard answer, what is the percentage of error. Between appraisers aims to compare answers between all appraisers. All appraisers vs standard shows a comparative analysis of the answers of all appraisers with standard answers. Furthermore, the results of the selector test were analyzed using a fishbone diagram to identify variations in special causes [21].

RESULTS AND DISCUSSION

Quality Inspection by Selectors and Inspectors

In this case study, an inspection system for cosmetic packaging products in Assembly Decoration (AD) line is discussed, using a visual guide. After the product comes out of the decoration process, the selector immediately inspects each product, then weighs it and puts it in the cardboard packaging and pastes the production code. The decoration process consists of printing and stamping processes. The printing process uses ink, while the stamping process uses foil as the basic decoration material.

Quality inspections in AD are carried out by selectors and inspectors. The selector inspects the finished product when it comes out of the machine, done visually by quickly following the motion of the conveyor. Defective products are separated and placed next to the machine, while good products are packed in cardboard boxes. The selector's role is very important in determining good and defective products. Selectors in determining good and defective products follow the visual guidelines of the Defect Range Board (DRB) and Color Range Board (CRB). DRB is a visual guideline to determine the maximum limit for the product to be rejected or not. In the DRB there are examples of defective products, good products, and the maximum tolerance limit allowed. Meanwhile, CRB is a visual guide to determine color tolerance limits. DRB and CRB for each product vary according to the requirements or tolerance limits for product defects for each customer.

The inspections carried out by the inspectors are different from the selectors. Inspections by inspectors are more specific, by means of a sampling plan in accordance with the inspection plan. The sampling plan, inspecting the function, appearance, and color, was carried out three times, namely during setup, in process, and final. Inspection of function samples with dyne test pen, rubbing test, and tape test. Inspect the sample appearance and color by matching the DRB-CRB. The number of samples for sampling varies depending on the number of batches examined. The AQL limit is the maximum proportion of defective products allowed in each particular batch. Inspectors do sampling directly or sampling in process. Inspector inspects final samples or outgoing inspections.

Every inspection always finds defective products in the AD line, with different types of defects. The types of defects resulting from the stamping and printing processes have different characteristics. Defects in the printing process include scratches, black spots, material spots, thin printing, hair printing, jetting, printing blur, dirty ink, thick printing, gripping printing, blurry printing. Meanwhile, the type of defect in the stamping process focuses more on the foil. Almost all types of defects in this process cannot be treated because the foil cannot be removed as is the case with certain inks. The types of defects in the stamping process include slippage, hole stamps, striped stamps, jagged stamps, thick stamps, petal stamps, subordinate stamps, superior stamps, and blurry stamps.

Next, the selector's ability to perform inspections using Meaurement System Analysis (MSA) attribute data is measured. The first preparation is the selection of products as test samples. The number of product samples for each process is 20 pieces. Sample products are divided into good and defective products. The total number of sample products tested in the printing and stamping process was 40 pieces, with 20 good products and 20 defective products. Sample product selection is done when the machine is operating. The collected sample products are validated by the quality supervisor, so that the sample products used are in accordance with the product category to accept or reject. The sample product that has been categorized and validated by the quality supervisor becomes a guideline or answer key which will be asked to the selector. The answer key is divided into two categories, namely accept and reject answers. The final step is to prepare DRB-CRB, a learning tool for selectors before testing.

Testing 42 selectors in three groups, each of 14 people. The test begins by asking permission from the selector. The examiner explains the testing mechanism, where the selector inspects 40 sample products, then the selector separates the products they think are accepted in the accept product container, and the rejected product is placed in the reject product container. Before the selector performs the inspection test, it is mandatory to study the DRB to understand the acceptance limit of the product being tested. Selector test results were analyzed using MSA.

Output analysis is based on within appraisers, each appraisers vs standard, between appraisers, and all appraisers vs standard. The inspector sets a pass selector standard, for all output results, to a minimum of 85%. The first analysis is within appraisers analysis, determines the level of consistency of each selector's answers by comparing the selector's answers in the first and second replications. Based on the test results from all AD selectors, 10 out of 42 people (23.8%) are above the standard, the remaining 32 selectors (76.2%) are below the standard. Selectors below the standard need further attention, because they have the potential to make inspection errors. The second analysis is the analysis of each appraiser vs standard, aims to determine the level of truth or accuracy of each selector. In this analysis, it is not only comparing the answers between the two replications but also the standard answers that have been previously set. Based on the test results of all selectors, 41 out of 42 people (97.6%) were still below the standard. It is necessary to investigate further why many selectors make inspection errors. The third analysis is the between appraisers analysis, determining the consistency between appraisers. This analysis compares the consistency of answers between all selectors, does not compare with the standard. The results of the consistency test between appraiser are very low, the consistency of team A is 5%, team B is 10% and team C is 0%. This shows that the selectors are not consistent in conducting product inspections, the understanding of defective products and good products still varies between selector teams. The last is the analysis of all appraisers vs. standard, showing the answers of all selectors to the standard, determining the correctness of all appraisers' ratings. From the test results, the selectors in Team A got a score of 5%, Team B 10% and Team C 0%. So, the ability of the selectors to carry out inspections is still low, indicating that in one team, the selectors answered inconsistently and did not match the standard answers. That is, errors may occur, a good product is considered defective or a defective product is considered to be in good condition.

Furthermore, the potential root causes of defective products that pass inspection are analyzed using a fishbone diagram (Apendix 1). Based on in-depth discussions with all selectors and inspectors, it was found that the main causes were human factors and methods. Method factors include difficulty in identifying defective products according to DRB-CRB guidelines, different specifications for defective products according to DRB-CRB, and different inspection methods for each selector. The human factor occurs due to several reasons, the selector is tired, especially eye fatigue, does not know the product specifications, the selector is less focused, and the selector pays less attention to defects, especially material parts.

Redesign Visual Inspection Guide with Design Thinking

Improvement efforts to reduce defective products pass inspection by selectors, by redesigning the DRB-CRB visual inspection guides to help selectors identify product defects more accurately. The redesign of DRB-CRB was carried out using a design thinking approach [18] through 5 stages, namely the empathize, define, ideate, prototype and test stages.

Empathize Stage. This stage aims to fully understand the DRB-CRB guidelines from the user's point of view [16]. The approach taken by the designer of the DRB-CRB guidelines is discussion and observation, by observing and asking various questions to all selectors and examiners as users, to properly understand the DRB-CRB guidelines they want. At this stage, various information about the DRB-CRB was collected. How often is the DRB-CRB seen to be used as a guide to inspect the quality of the packaging in one shift. Is the location and position of the DRB-CRB easy to see. Whether the DRB-CRB guide can help identify the types of defects. Also, it asks for the current appearence of the DRB-CRB, its size, and the distance between the image and the description in the DRB-CRB. What do users want about the appearance of the DRB-CRB? What is the user's understanding of the current CRB-DRB description, where should the description be placed, are there any suggestions for additional descriptions. How often users encounter types of defects that are not indicated in the DRB-CRB, and types of defects that are difficult to determine. Do users often doubt and ask about defects to other departments.

Define Stage. At this stage, users' needs regarding the DRB-CRB guidelines, which have been identified in the empathy stage above, are analyzed for clarity. Based on observations and questions to users, it is known that users, selectors, see or pay attention to the DRB-CRB guide on average only 1-3 to 3-5 times in each shift. It turns out that the DRB-CRB guide is rarely used by users. It was also identified that the DRB-CRB guidelines for some products were found to be less helpful or less useful. In general, users propose improvements to the DRB-CRB to maximize the function of guiding inspections. Among the suggested improvements, is the change in the layout of the DRB-CRB guidelines, not overlapping to make it easier to distinguish the types of defects. It is also recommended that the description of the guide be made more detailed and clear, and in Indonesian, so that users can understand more accurately the types of defects. Also, consider a more precise location of the guide description to make it easier for users to see and read.

Ideate Stage. This stage aims to collect and develop various solution ideas based on the suggestions or inputs given by users in the Define Stage above. Ideas for solutions to various DRB-CRB guidelines that are more in line with the wishes and needs of users, by brainstorming with all quality control stakeholders, namely all selectors, inspectors, and quality managers. They all share ideas or suggestions for solutions to improve the DRB-CRB design [9]. A total of 50 proposed DRB-CRB designs were obtained. All of the DRB-CRB design solution ideas were evaluated and some of the best were selected. Next, the selected DRB-CRB guide solutions ideas (Appendix 2) were prototyped. The design of the selected DRB-CRB guide is clearer and more organized, contains additional information on each type of defect, the types of defects are separated by columns to make it easier to see, the position of images and their descriptions do not overlap. Writing with different colors and with maximum tolerance, for example the word reject is distinguished by color, red means reject and black means it is still within tolerance/acceptable limits.

Prototype Stage. Based on the ideas of the DRB-CRB guide design solutions selected in the Ideate Stage above, a prototype DRB-CRB was made to guide the inspection of a product. The DRB-CRB prototype was made as closely as possible to the chosen design idea. Next, the DRB-CRB prototype was tested, using it as a guide by several selectors to inspect products that were known to be defective/non-defective. Products that have been inspected by each inspector, are checked again for validation, whether the selector as a user has made the right decision according to the design idea. This prototype is for testing purposes only, not for use on the production floor.

Test Stage. At this stage, the new DRB-CRB design is tested, used by several selectors to guide the quality inspection of a product. The test results of attribute data were analyzed using Measurement System Analysis, to find out whether the new DRB-CRB design affected the appraiser's answer or the user's response. Before testing, all users/selectors, studied the new design of the DRB-CRB. Six users were taken as samples, randomly selected from Team A and Team B. The test was replicated twice, on different days. As a result, the new design of the DRB-CRB affects user response. User test results using the old and new designs are presented in Appendix 3. Based on the analysis of each appraisers vs. standard, the selectors as appraisers have improved quite well, only two of the six selectors have not reached the company standard. The error rate made by the user is quite low, compared to the previous test results. The results of improving the visual guide are able to increase in correct checking accuracy or reduce inspection errors within selectors 8.3%, between selectors 36.25%, and each selector vs standard 15.8%. In addition, the analysis of all appraisers vs the standard shows an increase in correct checking accuracy reaching 45% for Team A and 32.5% for Team B, so in average the visual guide are able to reduce inspection errors for all selector vs standard is 38.75%. However, this increase in accuracy is not optimal as expected by the company, which is an increase of 85%.

The improvement of the DRB-CRB design needs to be done again with five stages of design thinking, starting from the initial stage, empathize. In the second cycle of design thinking, it is proposed to improve the training method. In addition to improving inspection skills, this training aims to find out how selectors use the guide. What are the limitations or shortcomings of the guide design. How does the selector feedback when using the guide. All of these are inputs for improving the design, which can improve selector performance in performing inspections. During the training case studies are given so that the selectors actively participate in training activities [6]. Due to the limited time of the study, the proposed training has not yet been fully implemented. The new DRB-CRB design, designed with training using case studies, is expected to help selectors improve their skills during inspections.

The updated DRB-CRB design needs to be continuously monitored and evaluated for its effectiveness. Monitoring can be done using the checklist form (Appendix 4).

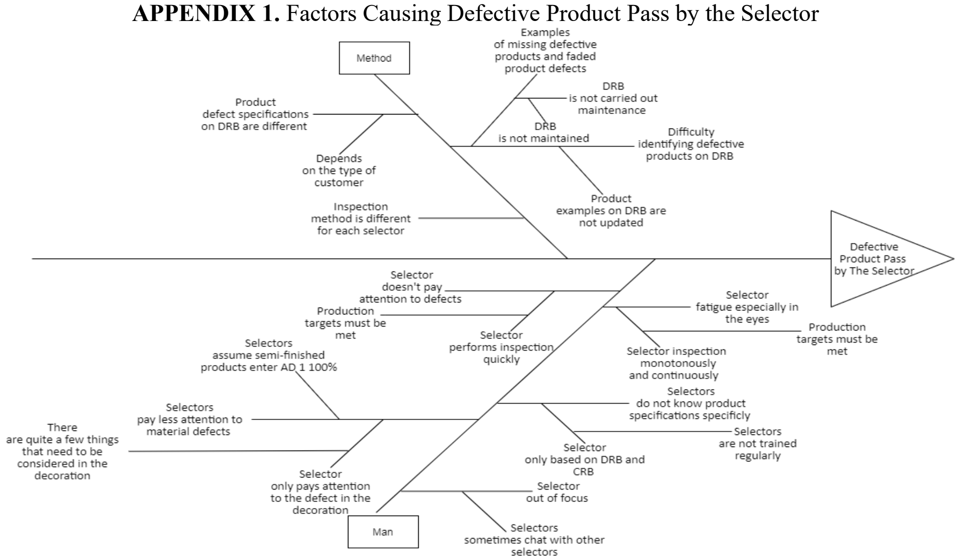
CONCLUSION

Based on observations on the production floor, many defective products pass inspection, due to the inability of DRB-CRB to accurately visualize quality control limits and human error or selector incompetence. Improvement efforts by redesigning the DRB-CRB according to the wishes and needs of users. The redesign process is carried out collaboratively between designers and users with a Design Thinking approach. Based on the measurement system analysis, the new DRB-CRB design helps reduce selector error, although it is not optimal as expected by the company. The results of improving the visual guide are able to reduce inspection errors within selectors 8.3%, between selectors 36.25%, each selector vs standard 15.8%, and all selector vs standard 38.75%. The ability of selectors to apply different guidelines according to the products ordered by customers, needs to be further improved with more interesting training, different from the usual training carried out so far. Training using presentation methods and case studies is a proposed option. The goal is to find out what kind of DRB-CRB guidelines the selectors really need, so that they are happy and excited to implement the guidelines.

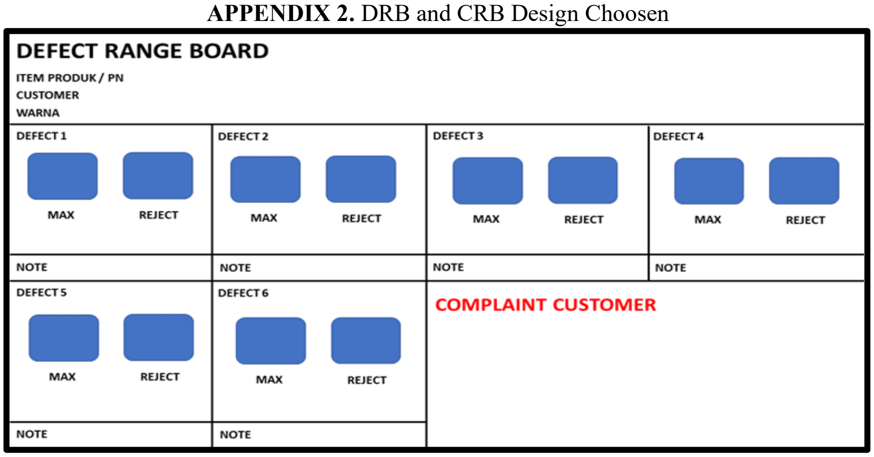
The design of the DRB-CRB visual guide with one DT cycle still has many weaknesses, the selector error has not been reduced much according to the company's expectations. Another weakness has not been observing the work behavior and habits of each selector. It is necessary to improve the DRB-CRB design by applying DT cycles repeatedly. For the development of a more attractive and effective DRB-CRB in reducing inspection errors, in the future it is necessary to research the use of other media, such as audio-visual which can provide more detailed explanations, communicative, and more interesting.

APPENDIX

APPENDIX 1. Factors Causing Defective Product Pass by the Selector



APPENDIX 2. DRB and CRB Design Choosen



APPENDIX 3. MSA Analysis for Attribute Data Before and After Improvement

Selector	Within Appraiser (%)		Each Appraiser VS Standard (%)		Between Appraiser (%)		All Apraiser VS Standard (%)	
	Before	After	Before	After	Before	After	Before	After
Team A	85.0	100.0	77.5	90.0	35	77.5	32.5	77.5
	87.5	87.5	72.5	80.0				
	80.0	92.5	55.0	87.5				
Team B	80.0	92.5	70.0	87.5	35	65.0	33.5	65.0
	87.5	90.0	75.0	85.0				
	72.5	80.0	55.0	70.0				

APPENDIX 4. Checklist Form Example for Monitoring the DRB-CRB Effectivity

DRB-CRB Checklist										
Company Logo					**Ref no: XXXX** **Items: Product X**				***Confirmed by***	***QC Approval***
Name	Loaning Borrow Date	Loaning Return Date	Cleanli-ness	Evaluation Appropriateness	Evaluation Product Condition	Evaluation Writing Condition	Need Repair?	Description	Corrective Action	

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