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IMPLEMENTATION OF LEAN CONCEPTS USING QUALITY TOOLS TO REDUCE WASTE OF PRODUCT DEFECTS

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ABSTRACT
The implementation of lean concepts is to reduce or eliminate the wastes that occur during production process. One common form of waste that occurs frequently is waste caused by product defects. The object of this research is packaging process at a company that specializes in the processing of milk powder. The objective of this research is to find out the sources of defects due to sealing failure, and then develop the proposed remedial action plan to reduce these defects. Research data has been collected and analyzed quantitatively and qualitatively by quality control tools.

It was found there are 11 known causes of failed seals, and the main causes are the condition of the sealer, cutting knife, and the characteristics of semi-finished products. The study concluded 13 corrective action plans, focused on increasing skills and awareness of operators, standardization and size of packaging machinery, and machine maintenance. It is also estimated that the remedial actions will result in reduction of defective products due to failed seals by 71.5% or a savings of 10.75 tons of powdered milk per month.

Keywords: Milk powder packaging; Sealing failure; The concept of lean; Waste

1. INTRODUCTION
The duration of the global economic crisis that hit Indonesia remains unclear or how long it will last. Not only financial institutions must be aware, but also manufacturing industry should be aware. This crisis will have a considerable influence on the business climate and companies. PT. Frisian Flag Indonesia (FFI) is a consumer-goods company whose main product is milk production which is the main requirement for healthy human nutrition. FFI is also feeling the impact of the global economic crisis. In the whole world, the demand for dairy products has decreased and world market prices for dairy commodities have declined dramatically compared to prices in early 2008. To survive form these conditions FFI have to render efficiency in all areas in the production process by pressing the lowest production costs with a focus on minimizing losses and reprocess. The implementation of lean concepts is to reduce or eliminate the wastes that occur during production process (Arthur, 2007, Liker, 2004).

2. RESEARCH METHODOLOGY
Early stages in this research include exploring steps in the production problems. The data was collected previously in support of KPIs (Key Performance Indicators) such as breakdown of production machinery, machine parameter data, operational records documents, operator check sheet, and consumer complaints.

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The data was also collected from direct observations in the field. Discussions by conducting brainstorming sessions were held to identify losses due to reprocessing products, decreased productivity due to the addition of labour used to cut the bag, utility costs, and the possibility of contamination because of handling.

The next stage is to collect data on sealing failure. The recording was conducted by separating each line and each type of product. Sealing failure products from each production line was collected in plastic bags, then weighed and recorded. The total weights per shift and per type of product (preliminary data) were converted into the number of pouches or sachets. Other data was collected from the total counter in the filling machine. From all the data, it could be calculated the percentage of sealing failure in relation to the quantity of output. Product specification data and the use of semi-finished products were also collected from Online Reporting System of FFI. Filling machine breakdown data was obtained from the records on Online Reporting System.

The third stage is data processing and analysis. Data processing was conducted using quality tools (Rao, 1996) such as pie and bar charts, run charts, cause and effect diagram (Fish Bone), and flow charts. The data analysis is focused on the quantity of sealing failure, product specification data and filling machine breakdown. The analyses were conducted to determine sources of high value sealing failure.

3. RESULTS AND DISCUSSION

3.1. Data processing and quantitative analysis

Object of the research is waste of 2 ex-line value because of failed seals (sealing) and material losses. Material losses are raw material of milk powder that cannot be processed as finished goods. While ex-line of the product may be reprocessed to finished goods. Ex-line values vary. A significant increase happens in February before finally falling to 0.44%. If the two figures are compared, ex-line value is twice than of material losses. Even though milk powder will be reprocessed over again, the production cost will be doubled because of other losses such as losses of aluminum foil packing material, man hours, utility consumption, and possible contamination during the material handling (Arnold and Stepea, 2004).

For further analysis, the data will be divided into the quantity of sealing failure for each production line and for each type of product based on the passage of time during the study. The data will be analyzed by product specifications affecting sealing failure events, while research will also be carried out on the analysis of the break down of what happened in the process of filling.

3.1.1. Sealing failure of production line

There are 8 production lines as the object of this study. However, based on Production Planning and Inventory Control (PPIC) the production line will vary. There are 2 lines that serve as back up lines, such as lines of Wolf 2/3 and Tam 5. Wolf 2/3 which has the same type of machine with a Wolf 4/5 will replace the production of 120g, 200g, 300g, 400G, 450g, 600g product sizes, while the machine will replace Tam 5 sachets of product production to the size of 14g, 18g, 25G, 40G.

Sealing failure analysis on each production line aims to map out production lines with a high percentage level of sealing failure. The line will receive attention for repairs to reduce the total number of sealing failures.

Sealing failure data was classified for each production line. Total output data has been collected from the filling machine counter. By comparing both data, percentage of the sealing failure is known for each production line.

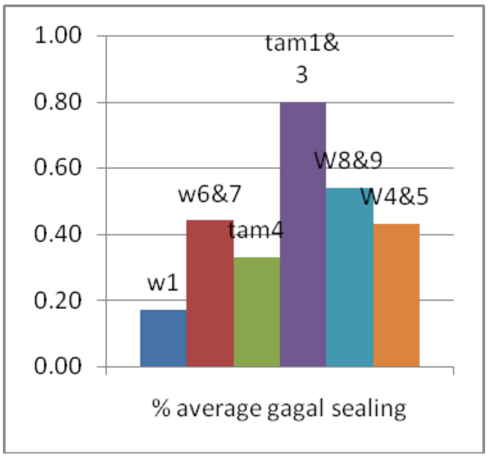

Figure 1 Average percentage of sealing failure of each production line

Percentage of sealing failure that occurred during this study of the highest order is the production line Tam 1/3 (0.80%), Wolf 8/9 (0.54%), Wolf 6/7 (0.44%), Wolf 4/5 (0.43%), Tam 4 (0.33%), and Wolf 1 (0.17%). The nominal of the first order Tam 1/3 compared with the second order Wolf 8/9 difference is nearly 40%.

3.1.2. Quantity of each type of sealing failure

Raw data of sealing failure is grouped according to product type. There are several products that can be produced in 2 or more production lines, e.g. for 450 g sizes can be produced in line 4 and line Tam Wolf 8/9. Once classified, the sum of sealing failure and output, of the total of both, and of the percentage of sealing failure was obtained for each type of product.

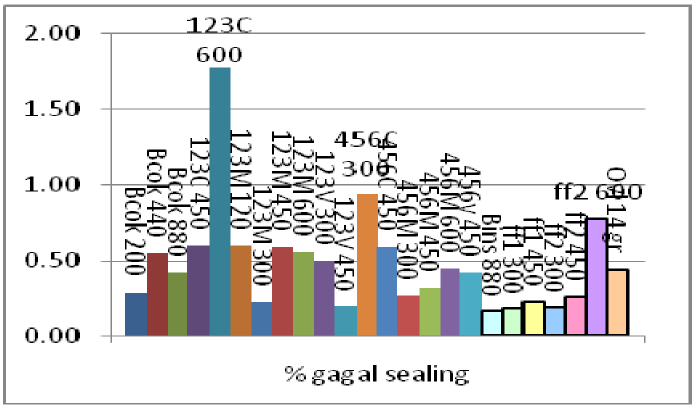

Figure 2 Percentage of sealing failure of products

The bar graph shows the 123C 600g product has the highest percentage of sealing failure. Other products which have high percentage of sealing failure are 456C 300g, FF2 600g, 123C 450g, 123M 120G, 456C 900g, 123M 450g. In nominal terms the difference between the highest 123C 600g with a second 456C 450g is almost 50%, so to 123C 600g is a very prominent value among all types of products.

It had been identified that certain factors contribute to the failure. The first factor is the type of milk powder produced. This means 123C 600g characteristic conditions of the milk powder 123 Brown, will be analyzed at the point of product specification data. The second factor is size of the product, eg 300g, 450g, 600g. The size of these products requires a certain aluminum foil size, and size will be adjusted to the foil forming tube mounted on the filling machine. Tube forming standardizes the usage of the object of this research as shown in the Table 1 below.

Table 1 Standardization of forming tube

Product	Foil dimension	Forming tube
14G	160mm x 1000m	51mm
25G	180mm x 1000m	58mm
120G; 150G; 160G; 200G	265mm x 1000m	78mm
300G; 400G; 450G; 600G	365mm x 750m	110mm
800G	410mm x 750m	125mm

Critical conditions are indicated by the number of variations on the size of the tube forming type 1. This variation is compensated by the addition for each pouch of the aluminum foil length or what is often referred to as bag length parameters. By adding the bag length means increasing the volume or the capacity to accommodate each pouch.

Table 2 Standardization of bag length

Pouch	Standard bag length [mm]
120g	185-195
200g	190-200
300g	240-250
400g	250-255
450g	260-265
500g	270-275
600g	280-290
800g	285-295

Product of 123C 600g has the highest sealing failure. Pouch volume calculation of the product was conducted using a forming tube 110mm sizes, while the proportions of the lowest and highest in 300g and 600g sizes. Bag length is taken from the range of the highest standardized measurements.

- 300g size:
  Volume = $\pi X\ (250mm - 24mm) = \pi X\ 226$ = 2147749.8 mm^3 = 2147.8cm^3
- 600g Size:
  Volume = $\pi X\ (290mm - 24mm) = \pi X\ 266$ = 2527882.5 mm^3 = 2527.9cm^3

where d = diameter of tube forming

- Difference in volume pouch 600g and 300g = 2527882.5mm^3 - 2147749.8mm^3 = 380132.7mm^3 = 380.1cm^3

- Percentage difference in the size of 300g = 380132.7mm^3 / 2147749.8mm^3 X 100% = 17.7%

In Pouch 1 there is an empty space that contains nitrogen gas. During the process of filling, oxygen gas levels are limited to a maximum of 1.5% (Dahle & Palmer, 1932). The magnitude of this space affects the quality of sealing, because it may increase the possibility that soft milk particles are trapped in the lower sealing area. This data is compared with the volume of empty space between 300g and 600g sizes and the volume of powder to be found in the pouch.

- Volume powder = Weight products / Bd
  Where standardization Bd min = 0:50 g/cm^3
- Volume powder 300g = 300g / 0.50g/cm^3 = 600cm^3
- Volume powder 600g = 600g / 0.50g/cm^3 = 1200cm^3

Pouch volume ratio calculation shows that the condition of 600g pouch volume is not ideal because when calculating the size of the pouch set off by the weight of the 300g powdered milk, there is as much as 100% (from 300g to 600g). This figure plus the volume of packaging results in an overload which is as much as 17.7%. This leads to a lack of empty space in the pouch. It means that 123C, 456C product will have powder traps or milk powder particles trapped in the sealing area.

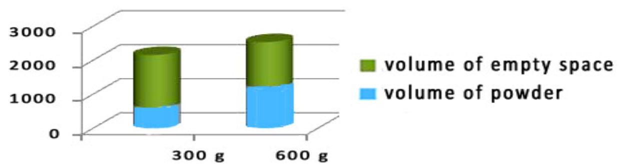

Figure 4 Comparison volume of pouch 300g and 600g

From the comparison above, to obtain long-600g pouch that has a blank space equal to 300g pouch, then an increase in the volume difference of the second pouch is required to get the additional 600g pouch length.

- Difference in volume = (Volume pouch 300g - Volume powder 300g) - (Volume pouch 600g - Volume powder 600g) = 1547.8cm^3 - 1327.9cm^3 = 219.9 cm^3

So the addition of 600g pouch length is for = 219900 mm^3 / π = *23mm*

3.1.3. Product specifications that influence sealing failure

Specifications of products vary widely so that each type of product has different characteristics. The characteristics influence the packaging because of the free flowing or easy flowing nature of materials.

High and low density value of milk powder is affected by the condition of powder particle size. If the particle is smaller or soft then *Bd* value would be increased. Dusty conditions due to particles that are too soft will greatly determine the quality of sealing, because these may be trapped in the sealing area and this reduces the strength of the sealing. There are many soft particles produced from mixing process, such as BBCOK, BBFC, BBMAD products.

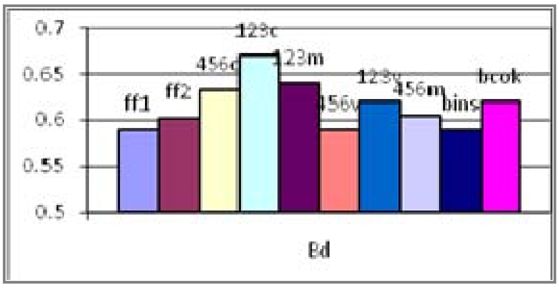

Figure 7 Average value of products bulk density

Research findings indicate that the longevity of the milk powder is strongly influenced by the condition of its constituent fat content, from the processing of milk powder incorporated into a temporary storage place (Mannus & Ashworth, 1948). Maximum age storage in a temporary storage place is 6 months. Possible degradation or quality loss occurs due to the oxidation of fat. It happens when fat in the milk powder is exposed to excess oxygen that leads to rancidity. The age of the product life becomes shorter. To avoid this, the final packaging process uses nitrogen gas to expel the oxygen in the pouch. The high fat content in milk powder will reduce the density of particles, so that the milk powder will flow more easily.

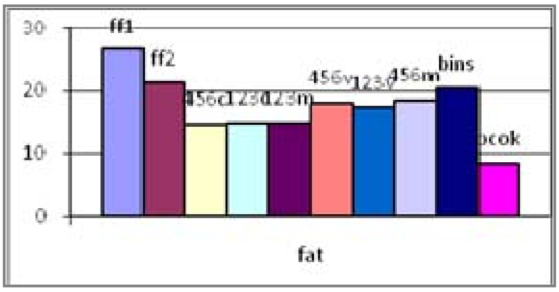

Figure 8 Average value of fat content

Sugar or sucrose is a chemical compound consisting of glucose and fructose. The sugar will provide a sweet taste in the product. There are some products that do not contain milk sugar that is formulated for infants under 1 year *(infant formula)* FF1 and FF2. This type is also the milk product for adult *full cream* milk powder (BBFC) and *instant* milk powder (bins). Sugar content in milk powder will vary in each *mix* or a mixture of 1, and each one is stored in the mix 1 tote bin that obtains an average value of the number tote bins to be used.

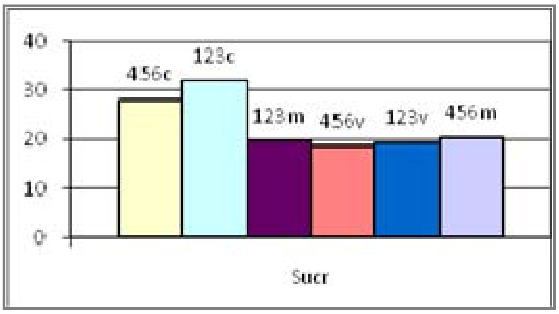

Figure 9 Average value of sugar content

The results showed above 123C product sugar levels are highest, and so on up to 456C and the lowest is 456V. The results of average value data compared with the standardization (Ziegler & Floros, 2008); show that the 123C products are the only product whose position lies between the standard value and upper limit. Overall 123C and 456C products have higher sugars, so for these two products, smooth particles and dust are going to affect all the packaging processes. For mainstream products that have a high sugar content, the product is a direct result of the spray drier without going through the process of dry mixing.

3.1.4. Technical analysis of filling machinery breakdown

Break down of filling machine may be the result of the system because there are interlocking systems between the packing machine and the filling machine. A stopped engine for a short period of time is called a 'short stop'. It happens very often.

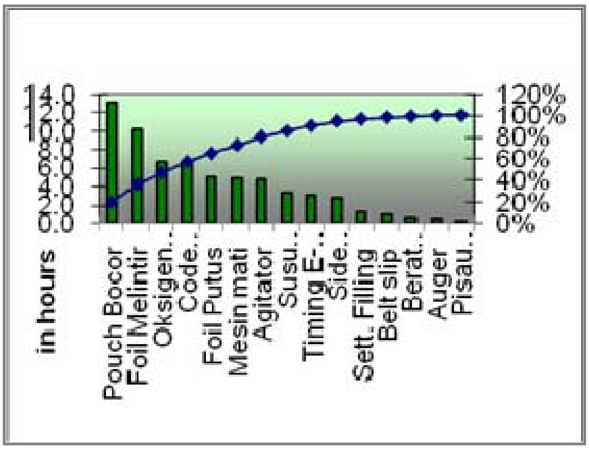

Figure 10 Pareto diagram of filling machine technical breakdown

The Pareto diagram shows that the pouch leakage is the main cause of total breakdown that causes the 'short stop' to occur frequently. The performance of the production line would be better if there are improvements aimed at reducing cases of pouch leakage. Every time there is a case of leakage, this will result in a minimum of 5 categorized failed pouch sealing incidents.

3.2. Data processing and analysis

Results from field observations and interviews with employees are among the possibilities concerning the causes of the high quantity of sealing failure. To obtain this analysis for results that are consistent with the objectives of this study, required tools are relevant to the data already collected. So as to facilitate the identification of this diagram, the causal diagram was made. The identification diagram was based on the causal relationship between the 4 categories, such as material, human, machine, and methods.

3.2.1. Materials

Materials are packaged milk powder. Variations of powder properties, although these are still for the same types of products, mainly occur in the type of product that results from the dry mixing process. There are certain moments when changing the tote bin, which means changing the service mix. This situation should require resetting the parameters for re-filling because of the nature of different powder milk than previously encountered. This is related to the smooth flow of milk powder and the nature of fine particles or dust. Another material which also largely determines the quality of material sealing is aluminum foil. There are 4 variations of aluminum foil from 4 suppliers of aluminum foil.

3.2.2. Humans

Operators vary in age and educational background. This affects the ability and skill level of these operators. From observation, there is no sharing of experience and knowledge between them. Employee awareness levels are also low maybe because of the age factor. The level of awareness is very influential for keeping the area of production clean, since cleaning the work area is related to sealing. There is also no standard way of working that is in accordance with proper procedures in the Code of Practice (COP). During the field observations there were departments that already had a COP document but either had not installed them or had not made them available in the field.

3.2.3. Machine

Machines are the production assets to produce goods and services. Machines should be maintained in good condition so as not to lose the ability or the capacity to produce. Improvements made in machinery are often less thorough at times because of spare parts that must be taken from parts of an operating machine, which as a consequence will create new problems for the other machine to operate.

Preventive maintenance has been done is not considered optimal because the technician operates only on the basis of a work order from maintenance planner. Each technician who performs preventive maintenance or planner should also look at the machine's operational history.

3.2.4. Method

To provide guidelines for operators in performing their duties begins first of all with a checklist. But the observations do not always function optimally, so a checklist provides only guidance. The contents of the points are sometimes just pointless repetition. Frequently checking occurs too often. It is found in a checklist manual that the points are not yet integrated or related to one another, consisting of 4 pieces of content there are overlapping. These points should be integrated in a single sheet so it is much easier to see the arrangements and inter-relationships.

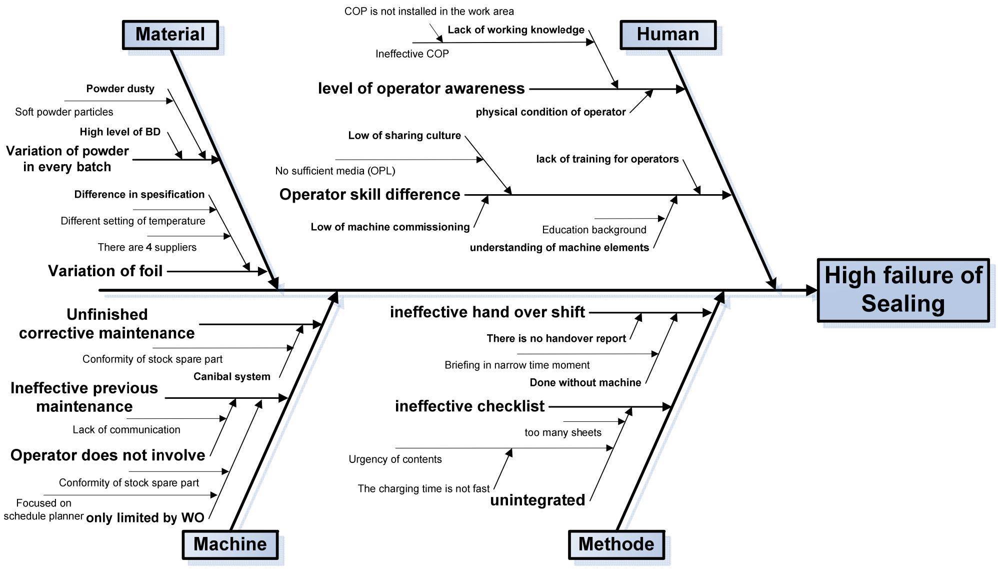

Figure 11 Cause Effect Diagram of Sealing Failure

3.3. Action plan to reduce sealing failure

To reduce the sealing failure needs continuous improvement and further efforts. The following action plan is submitted as a way to reduce waste due to defective products for sealing failure. An experiment was conducted to see the result.

The *chart* below shows *the Run* on July 15th that points out for almost all the production lines except Wolf 4/5 there was decreased sealing failure. According to previous observations on

July 14, a general demolition and cleaning of the 'clean-sealer' and the cutter knife *(knife)* was carried out. Replacement of some knives occurred because the knife was dull or dirty. The knife affects the quality of sealing. Otherwise at the time of sealing the foil position may have slipped accidentally so the sealing failure was not because of the knife.

When calculated, the average percentage of sealing failure during the study was 0.513%, while the lowest percentage after general cleaning was done is 0.146%. It can be determined that the decrease in sealing failure was due to sealer cleaning and replacement of the dull knife with a sharp one as follows:

- Average during the study of sealing failure = 0.513%
- Value of sealing failure after general cleaning = 0.146%
- Difference = 0.513 – 0.146 = 0.367
- Percentage decrease = (0.367/0.513) x 100% = 71.5%

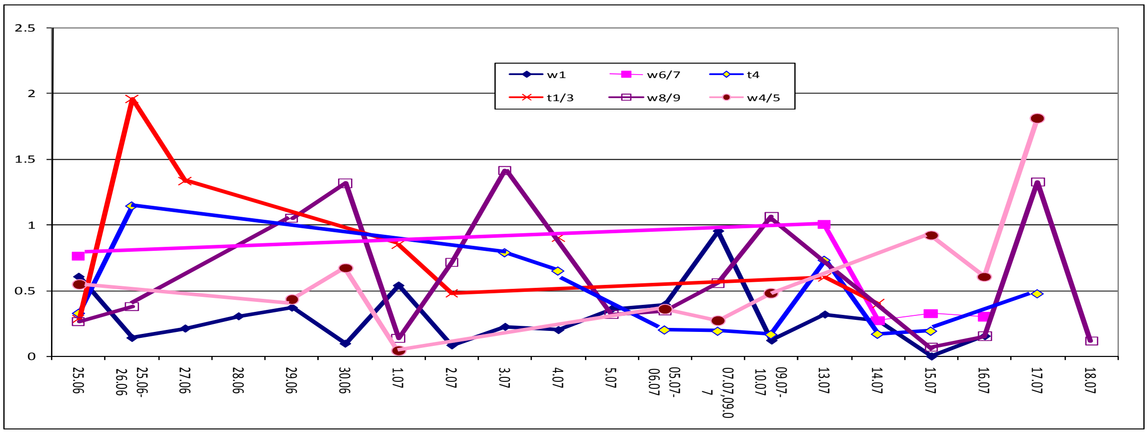

Figure12 Run chart quantity of sealing failure

4. CONCLUSION

After data processing and analysis was performed, conclusions can be drawn as follows:

1. Waste of defective product because of sealing failure is caused by:
    - Dirty working area
    - Cleanliness and sharpness of the *sealer* knife *pouch*
    - Lack of concern by the operators
    - No adequate work instructions.
    - Certain production line characteristics
    - Product size variations on the production line that occur very often in change over.
    - Variations of the intermediate product specifications
    - Characteristics of some intermediate product with a very fine particles.
    - Standardization of empty pouch space in each product size
2. Tam production line 1/3 is the production line with the highest percentage of sealing failure in production output.
3. Type 123C 600g products are finished goods product (Finished Goods) became the most defective type of products for sealing failure
4. From these results, corrective actions may reduce defects due to sealing failure up to 71.5% or at a savings of 10.75 tons of powdered milk per month.

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