# ANALYSIS OF QUALITY CONTROL OF AIRKU PRODUCTS USING SIX SIGMA METHOD AT PDAM TIRTA BINANGUN KULON PROGO REGENCY

# *ANALISIS PENGENDALIAN KUALITAS PRODUK AIRKU DENGAN MENGGUNAKAN METODE SIX SIGMA PADA PDAM TIRTA BINANGUN KABUPATEN KULON PROGO*

**Lina Risnawati**
*Program Studi Akuntansi Fakultas Ekonomi Universitas Negeri Yogyakarta*
*linarisnaw.lr@gmail.com*

**Dhyah Setyorini**
*Staf pengajar Program Studi Akuntansi Universitas Negeri Yogyakarta*
*dhyahsetyorini@yahoo.co.id*

**Abstract***:* **Analysis of Quality Control of Airku Products Using Six Sigma Method at PDAMTirta Binangun Kulon Progo Regency.** The purpose of this research is to investigate the causes of defective products and to propose improvements to reduce defective product in *AirKU*packaging based on the six sigma method. This research used descriptive qualitative approach. The population in this study are *AirKU* products that were defective packaging before being handed over to consumers. The purposive sampling method was used by choosing *AirKU* products of 240 ml, 600 ml and 19 liter packaging from January to December 2018. Data analysis techniques using the six sigma method are define, measure, analyze, improve, and control (DMAIC ). The results showthat the causes of defective products are lid defects (77%), broken lid (8%), and cracked gallons (5%). The results of the calculation of *AirKU*'s product sigma value is 3.89 with a defective product average of 2.6% of total production. Sigma level shows that the performance of production is quite good and above the average of Indonesian companies (2-sigma). The most dominant causes of defects product are machine, man, method, media, and raw materials. Proposed improvements include routine maintanance of machine, expansion of production sites, increasing employee motivation, and regular trainings for employees.

**Keywords**: quality, quality control, DMAIC, six sigma

***Abstrak: Analisis Pengendalian Kualitas Produk Airku Dengan Menggunakan Metode Six Sigma Pada PDAM Tirta Binangun Kabupaten Kulon Progo.*** *Tujuan dari penelitian ini adalah untuk mengetahui faktor-faktor penyebab produk cacat serta memberikan usulan perbaikan untuk mengurangi produk cacat pada kemasan AirKU berdasarkan metode six sigma. Penelitian ini menggunakan pendekatan deskriptif kualitatif. Populasi dalam penelitian ini adalah produk AirKU yang mengalami kerusakan/cacat kemasan sebelum diserahkan kepada konsumen. Metode purposive sampling digunakan sebagai metode pengambilan sampel pada produk AirKU dengan memilih kemasan produk 240 ml, 600 ml dan 19 liter dari bulan Januari hingga Desember 2018. Teknik analisis data menggunakan metode six sigma yaitu define, measure, analyze, improve, dan control (DMAIC). Hasil penelitian menunjukkan bahwa faktor penyebab produk cacatadalah cacat lid (77%), tutup pecah (8%), dan gallon retak (5%). Hasil perhitungan nilai sigma produk AirKU adalah 3,89 dengan rata-rata produk cacat sebesar 2,6% dari total produksi.Tingkat sigma menunjukkan kinerja dari produksi cukup baik dan di atas rata-rata perusahaan Indonesia (2-sigma). Penyebab dari cacat produk paling dominan adalah faktor mesin, tenaga kerja, metode, media, dan bahan baku. Usulan perbaikan antara lain dengan mengadakan perawatan mesin secara rutin, perluasan tempat produksi, meningkatkan motivasi karyawan, dan training karyawan secara rutin.*

***Kata kunci:*** *kualitas, pengendalian kualitas, DMAIC, six sigma*

## PROBLEM BACKGROUND

The development of technology and information makes business competition in the current era of globalisation experience increase significantly. This development makes business people face intense competition. Companies must carry out their business strategies appropriately so that the products produced can survive and the company can achieve their goals. In making management decisions, the company must be able to choose the right business strategy. Business strategy by improving quality is one of the efforts to achieve a competitive advantage with competitors. Oakland (1993) state that the elements that determine the success or failure of business are quality, reliability, price, and delivery. Of the four factors, quality is the most important. When a company focuses on quality, performance will increase in terms of reliability, distribution, and cost. Quality is the primary key in winning the competition in any field of work.

Every business in high competition always competes with similar industries. To win the competition, business people must pay full attention to the quality of their products. Companies that make quality as a strategy tool will have a competitive advantage over their competitors in controlling the market because it will create consumer loyalty. In this case, the company is required to produce products with high quality, low prices, and timely delivery. Production processes that pay attention to quality will provide products that are free from damage. Quality products also avoid waste, inefficiency, and can reduce production costs per unit so that product prices can be more competitive.

In the business world, it has long applied quality management as an essential management strategy to achieve competitive advantage. J. Willey and Sons (2000) state that several quality control systems that have been developed so far such as Quality Control Statistics (SQC), Total Quality Control (TQM), Continuous Improvement (CI), Kaizen, Process Reengineering, Failure Mode and Effect Analysis, Design Reviews, Voice of the C

Customer and Cost of Quality (COQ) have varying success rates and still need improvement. The control system emphasises continuous improvement efforts based on independent awareness of management. The system does not provide the right solution regarding the breakthroughs or steps that should be taken to produce a dramatic quality improvement towards the failure rate = 0 (zero defect). In the mid-1980s, engineers at Motorola Inc. (United States) uses the term "Six Sigma"

as an informal name for initiatives in companies to reduce errors (defects) in the production process (Amin Syukron and Muhammad Kholil, 2013). D. Manggala (2005) argue the basic concept of six sigma takes many ideas from Total Quality Management and Statistical Process Control. In terms of time, we can conclude that six sigma is the result of the latest evolution of quality improvement developed since the 1940s.

Regional Water Supply Company (PDAM) Tirta Binangun Kulon Progo Regency is a state-owned company that provides clean water for daily needs;the company also differentiates products in the form of Bottled Drinking Water (AMDK) with the "AirKU" trademark. In the spirit of "Bela Beli Kulon Progo" which was intensified by the Regent of Kulon Progo, dr.H. Hasto Wardoyo, Sp.OG , this product continues to grow and is increasingly in demand by the public even able to compete with products that were first famous among the people. For this product to survive, companies need to improve the quality of production, because, with the increase in the quality of production, the trust and loyalty of consumers on a product will increase which will ultimately have a positive impact on the company itself.

In this study, the authors will examine quality control in AirKU. Based on the initial survey,researcher found that AirKU defective products packaging 240 ml, 600 ml, and 19 liter (gallon) in the PDAM Tirta Binangun Kulon Progo Regency fluctuated. The highest disability rate in July and August is 4.0%, and the lowest product disability rate in February was 1.9%. Based on these facts, the company should reduce the highest defect rate of 4% become 1.9% or even 0% with the six sigma method. In the production process, PDAM Tirta Binangun Kulon Progo conducts quality control by setting a maximum limit of 3%.

The implementation of the six sigma method on AirKU production in PDAM Tirta Binangun is expected to bring the company to the lowest level of defective products and even reduce it until the production process runs towards perfection (zero defect). Thus the application of the six sigma method will improve profits and will result in reduced production costs incurred. Moreover, companies can survive and increase their market position in the face of competitive competition.

The success stories of large companies that adopted six sigma, including Motorola and General Electric (GE) in the 1980s, were able to achieve the level of six sigma, which meant there were only 3.4 product defects per million

opportunities. The higher the sigma target achieved, the better the performance of the industrial system.

Six sigma is the process management tool that has yielded higher results (Dusharme, 2006). U. Dinesh Kumar (2008) explain the fact that int this table six sigma is ranked much higher than other process improvement technique, illustrates the effect of concurrently implementing various process improvement technique given that most of this technique constitutes the Six Sigma toolbox. This fact is important because none of the remaining quality improvement initiatives has much application outside the manufacturing industry.

Therefore, quality control is a crucial thing that will have a positive impact on the company. Prawirosentono (2002) argue that three reasons for producing prime quality products are as follows: 1. Customers who buy products based on product quality will have higher loyalty compared to consumers who purchase products according to price, 2. Contradictory to traditional business thinking producing quality goods is not automatically more expensive by producing low-quality products, 3. selling goods that are not qualified, is likely to receive many complaints and return goods from consumers.

The motivation that encourages the author to carry out this research is that the PDAM Tirta Binangun in Kulon Progo Regency has not carried out quality control with the six sigma method. This research, is expected to be considered for the company to take the concept of quality control by using the six sigma method.From the description above, the author wants toresearch with the title **"Analysis of Quality Control of AirKU Product Using Six Sigma Method at PDAM Tirta Bianangun Kulon Progo Regency."**

## RESEARCH METHOD

### Type of Research

This research is a descriptive research. Indriantoro and Supomo (2009) argue that descriptive research is a study of problems in the form of current facts of a population. The reasearch is a case study with qualitative and quantitative approach.

### Time and Place Research

This research was conducted at the PDAM Tirta Binangun in Kulon Progo Regency especially in the production area of *AirKU*and was held in December 2018 until February 2019.

### Research Subject

The population in this study is AirKU bottled water products which are damaged/defective in the production process and after passing the quality control before being handed over to consumers. This study used purposive sampling technique with samples of 240 ml, 600 ml and 19 liter (gallon) defects products from January to December 2018.

**Techniques and Instruments**

**Data Collection**

The data collection method used in this study is to make direct observations in companies that are the object of research. The data collection techniques carried out are as follows:

a. Interview

An interview is a way to get data or information with a question and answer directly to people who know about the object under study. In this case, the AirKU management/management is the data on the types of defective products and their causes, production processes and raw materials used.

b. Observation

Observation is an observation or observation directly at the research site, namely in the production section of AirKU by observing the system or observing the production process from beginning to end, and quality control activities.

c. Documentation

Documentation is done by studying company documents in the form of reports on production activities, reports on the amount of production and the number of defective products.

**Data Analysis Technique**

Data analysis techniques are carried out by implementing (applying) product quality control using the six sigma approach. The method used refers to the principles contained in the six sigma method. This method is used to anticipate the occurrence of errors or defects by using measurable and structured steps. Based on existing data, continuous improvement can be made based on the six sigma methodology which includes define, measure, analyze, improve, control (Pete & Holpp, 2002).

**Validity and Reliability of Instruments**

In this research, rearcher use the triangulation. Wilian Wiersma (1986) defines triangulation as checking data from various sources, in various ways, and at various times. Source triangulation is to restore the credibility of the data by updating the data that we obtain through several sources. To restore the credibility of the data with the triangulation technique is to return data to the same source with a different method.

## RESULT AND DISSCUSSION

Analysis of research results using the six sigma method which consists of five stages, namely define, measure, analyze, improve, and control the AirKU products of PDAM Tirta Binangun are as follows:

### Define

Defining the problem

a. Lid Defect

The lid is a top cover in the form of plastic containing AirKU brand writing on a 240ml cup size product. Lid not made by PDAM Tirta Binangun but ordering from a supplier. Lid defects can occur due to the adjustment factor of the particular filling machine on the wrong press machine, besides lid defects can also be caused because the helper is in the form of an uneven cup lip so that when the lid is placed, it causes seepage. There are several kinds of defects in the lid, including the lid is slanted/not right, the lid is seeping, and a foreign object punctures the lid.

b. Broken Lid

Broken lid occur on 600 ml of bottle packaging products. The cause of the broken lid occurs when setting on the capping machine is not right so that the machine rotates the lid more than 360 ° which results in the seal on the lid being broken.

**c.** Cracked gallons

This type of product defect in the form of a gallon of crack occurs due to human error, namely the lack of accuracy of the employee in treating and sorting each incoming gallon package. So that the product defects will usually be discovered after the gallon is filled with water and sealed.

### Measure

a. Analysis of Control Charts (P-Chart)

Table 1. Calculation of P, UCL, CL, LCL values

| Period | n | np | P | UCL | CL | LCL |
|---|---|---|---|---|---|---|
| Jan | 10486 | 210 | 0,020 | 0,041 | 0,027 | 0,013 |
| Feb | 6717 | 134 | 0,020 | 0,043 | 0,027 | 0,011 |
| Mar | 11311 | 226 | 0,020 | 0,040 | 0,027 | 0,014 |
| Apr | 12432 | 249 | 0,020 | 0,040 | 0,027 | 0,014 |
| May | 18614 | 372 | 0,020 | 0,038 | 0,027 | 0,016 |
| Jun | 17224 | 517 | 0,030 | 0,039 | 0,027 | 0,015 |
| Jul | 20088 | 804 | 0,040 | 0,038 | 0,027 | 0,016 |
| Aug | 19742 | 790 | 0,040 | 0,038 | 0,027 | 0,016 |
| Sep | 14277 | 383 | 0,027 | 0,039 | 0,027 | 0,015 |
| Oct | 17696 | 531 | 0,030 | 0,038 | 0,027 | 0,016 |
| Nov | 16080 | 322 | 0,020 | 0,039 | 0,027 | 0,015 |
| Dec | 12828 | 256 | 0,020 | 0,040 | 0,027 | 0,014 |
| **Total** | **177495** | **4794** | | | | |

Source: Data processed

Based on data above P is between UCL and LCL, the process capability runs well, so it can explain that the process capability can meet the desired tolerance limit specifications, but there needs to be tight control because there are several samples above UCL. The highest control limit reaching 4.0%. The high proportion of products rejected in July and August was caused by high product demand from consumers but not followed by good

engine readiness. When the engine is damaged the production must be stopped, while in repairing it requires experts. In terms of labor the fatigue factor which results in decreased concentration also results in production performance.

b. Stage of sigma level measurement and Defect Per Million Opportunities (DPMO)

From the table of stage of sigma level and DPMO the average DPMO from January to December is 8523, it can be interpreted that from the one million opportunities there will be 8523 possible products to be rejected. Based on the control map above, the DPMO pattern of failure of AirKU production products shows a sigma level of 3.89. The disability level of AirKU products is at the rate of 2.7% of the 3% tolerance limit set by the company.

**Analyze**

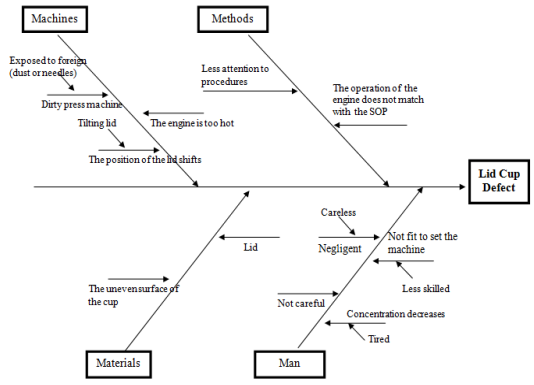


Figure 3. Fishbone Diagrams for Types of Lid Cup Defect

Based on the fishbone diagram in in Figure 3. it can be seen that the causes of the lid cup defect include:

1) Machine Factor
   a) On press machines that are rarely cleaned often cause foreign objects or dust to stick, so the lid becomes less sticky or hollow which is confused with the foreign object so that the water becomes seepage.
   b) The machine used to put the lid shifted, usually caused by rolls that are too large so that the label of the AirKU product becomes shifted or does not fit in the middle.
   c) The press machine is too hot; the standard on the press machine should have a temperature of 90 °. If the press machine is too hot it will result in the lid and also the cup lip becoming uneven.
   d) Melt from the press that is too hot will stick to the lid of the cup afterwards, so the lid becomes dirty and can cause leaking
2) Method Factors

   In the method factor for the cause of the lid defect, the operator does not pay attention to the procedure when setting up the machine; it can also occur because the operator does not understand the operation of the machine because it is usually carried out by specialized technicians.
3) Human Factors

a) The setting of a press machine is not appropriate because employees are less skilled at operating the machine.
b) Fatigue because it works for eight hours so that it can reduce the concentration level of employees.
c) A negligent employee when the lid rolls start to enlarge should be checked whether the position is still right or not in the cup.
d) Lack of motivation for employees to work optimally.

4) Material Factors
a) Lids do not fit the cup size.
b) The quality of the cup from the supplier is not good; the cup lip is not flat so that when the lid set on the press, the machine cannot close perfectly.

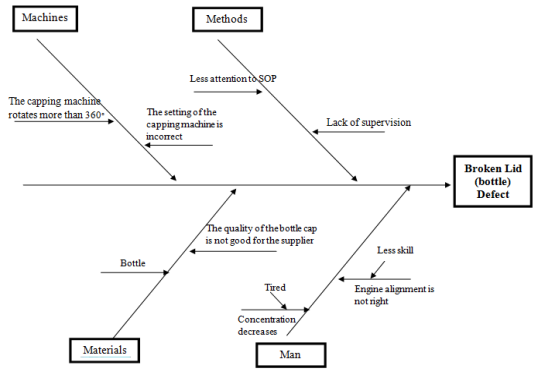


Figure 4. Fishbone Diagram for Broken Lid (bottle) Defect

Based on the the fishbone diagram in Figure 6, that causes of the broken cover include:

1) Machine Factors
a) Constraints that often occur with this type of defect in a broken cover are improper capping machine settings
b) The capping machine which functions to close the bottle cap rotates more than 360 ° which results in the bottle cap breaking

2) Method Factors
a) Employees do not pay attention to the SOP, every time they will make production, the employee should check the capping machine settings first or not
b) Inspection of bottle caps from suppliers is lacking

3) Material Factors

In the raw material factor causing the lid to break is the quality of the cap that is not good from the supplier, the bottle cap has scratches, the lid is closed, and the seal is not right.

4) Human Factors
a) Employees work for eight hours, so they become tired which results in decreased concentration.
b) Lack of skills in operating a capping machine so that there is a mistake in setting the machine.
c) Lack of employee motivation at work.

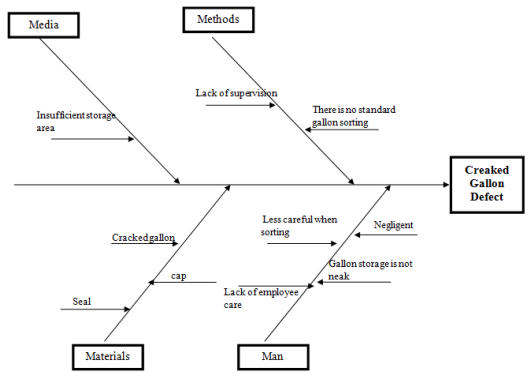


Figure 5. Fishbone Diagram for Broken Cracked gallon

Based on the fishbone diagram in figure 5. it can be seen that the causes of leaked gallons include:

1) Media Factors
   a) The gallon storage space or space is less extensive so that the condition becomes poorly maintained
   b) A thin storage room causes the gallons to accumulate in disarray
   c) Lack of maintaining cleanliness and tidiness of gallon storage.
2) Method Factors

   In the method factor, the cause of the leaky gallon was the absence of operational standards used when sorting the gallons from the AirKU sales agents. Also, supervision of the condition of the gallons is lacking because the gallons are immediately cleaned and then entered into the process of filling the water.
3) Material Factors

   In the raw material factor, usually, the cause of the final product defect in the gallon is that the gallon does not have prime condition.
4) Human Factor
   a) Lack of employee awareness of the condition of the returned gallons, because they have trusted agents that the gallons returned are in good condition, and there are no defects
   b) When sorting from the supplier, the employee are not careful
   c) Negligence of employees in storing gallons, for example, stacking gallons more than what they should or are not cautious in putting.

**Improve**

Recommendations to proposed improvements for types of defective products:

a. Machine factors
   1) Make a routine preventive engine maintenance schedule.
   2) Check engine elements before and after the production process (mould, compressor, cooling tower, bolt, pan belt)
   3) Clean the machine before making production and after production
b. Method factors
   1) Repair and add existing SOPs
   2) Supervise employee performance
   3) Work instructions must be clear by providing steps that are easily understood and carried out in

writing and accompanied by verbal explanations

4) Provide guidance in using the machine and how to care for and repair the machine

c. Material
   1) Select suppliers who can provide raw materials that are consistent with company's specifications
   2) Evaluating supplier performance
   3) Re-sort the raw materials that received before productions.
d. Man
   1) Hold training programs for work both old and new regularly
   2) Conduct intensive inspections of operators by supervisors
   3) Providing material and immaterial rewards to employees who can meet the targets at work.
   4) Increase employee awareness in maintaining company assets
e. Media
   1) The addition of a large space is used to store a stock of raw materials and finished goods so that there is no buildup in terms of conditions.
   2) Maintain cleanliness and tidiness of storage.

**Control**

Control is the last stage of analysis of the Six Sigma project that emphasizes documenting and disseminating the actions taken including:

a. Routine maintenance and repair of machines are not only when the engine is damaged (preventive maintenance) because if the engine is already damaged, new repairs are carried out and also the energy released will be higher. Machine maintenance is done to maintain engine performance and to avoid damage.
b. Hold guidance and training programs for employees, both old and new, regularly improve employee skills - the need for appropriate guidance and supervision and strict discipline. Guidance and supervision are intended so that there are no mistakes in the production process and the personality of irresponsible workers emerges. Companies need to do this because there are still some employees who lack discipline such as not cleaning the machine before and after being used for production.
c. Conduct inspection before the production process. Checks here are carried out on all engine components directly involved in the process. This check aims to prevent interference with the engine during the production process. Operators carry out checks before the production process.

d. Reporting the results of weighing defective products based on product type are recorded to the supervisor or the responsible part of a production. Monitor the course of production and analyze every problem that exists on the production floor by all workers involved in the problem. This action is an action that controls the problem or process problem that can be done as early as possible by working with workers involved (work team).

**Discussion**

The results of the research show that the quality control of PDAM Tirta Binangun using the six sigma method shows that the average DPMO is 8523.The DPMO value can be interpreted that from the one million opportunities there will be 8523 possible products to be rejected. Based on the DPMO pattern of failure of AirKU production shows a sigma level of 3.89. The sigma level shows that the company's performance is quite good because its performance is above the average of companies in Indonesia (2-sigma). At the level of the sigma value achievement, cost of poor quality which is assumed by the company is 15-25% of sales.

Based on the control method carried out by the company, the product defect rate is 2.6% of the total production with a maximum limit of 3%. The defect rate means that quality control is under the maximum limit set by the company. However, if it is associated with the results of six sigma calculations the product defect rate is still quite high. Therefore there is need to overcome the obstacles faced by companies in improving product quality.Several factors that become obstacles in the production process that affect quality include machine, method, materials, manpower, and media.

**CONCLUSION**

Based on the results of the research and discussion, we can draw the following conclusions:

1. Defining quality problems with the Six Sigma quality control system for the final AirKU product has three causes of defective products, namely the highest percentage of disability namely lid defect (88%), close (7%) and leaky gallons (5%). In setting the goals and objectives of improving the quality of Six Sigma based on observations, namely reducing and pressing defective products to 0%.
2. Measurement of the number of final products using Statistical Quality Control during January to December 2018 the company's performance is at the level of 3.89 Sigma with a DPMO value of 8,523 and has a percentage of

defective products 2.6% of total production. When looking at using the Six Sigma method the quality control on AirKU has not yet reached six sigma, but when looking at company indicators, quality control is good because the percentage of defective products is below 3%.

3. The causal factors for each type of defect based on fishbone diagrams include machine, labour, raw material, method, and media factors. In conventional systems not classifying the causes of defects in AirKU products into Pareto diagrams and causal diagrams, the company will have difficulty in handling what has become a constraint so far in the production process because the company only estimates the causes of disability in AirKU products.
4. Based on existing problems, in the stage of improving the company needs to make improvements in an effort to improve quality, especially in machine, human factors, raw materials, methods, and media.
5. During the control phase, AirKU produced are still within the control limit. If the sample falls within the prescribed limits, the production process is controlled and a predetermined remedial solution can continue. However, if the sample is outside the control limit, the repairs must be determined due to irregularities that occur. The solution specified is not yet appropriate, both on human factors, methods, machines, raw materials and media.

**SUGGESTION**

From the results of the discussion and conclusions of the study, some suggestions that can be considered related to the results of the study include:

1. For PDAM Tirta Binangun Kulon Progo Regency

   The results of this study are expected to contribute ideas by controlling product quality continuously and in balance (continuous improvement). To improve production quality control the company can carry out engine maintenance to prevent damage, renew and repair the engine before and after use. In the workforce, there is a need for guidance, regular training and giving rewards to outstanding employees so that their skills and motivations can increase. In part of the method, the company needs to make a structured work plan so that it is easy to deliver information, observation of the results of improvement. Product material also

needs to be increased by being selective in selecting suppliers and sorting products more carefully before being produced. Expand the storage area, maintain the cleanliness and tidiness of the production area so that employees feel comfortable working. All parties concerned must have awareness and responsibility to carry out the control of the quality of AirKU products.

2. For further research

   All types of defects should occur in the production area due to the presence of several new AirKU products at the end of 2018 to minimize the possibility of defective products. Further research can also be carried out by looking at the impact on the effect of applying the six sigma method in the Tirta Binangun PDAM in Kulon Progo Regency.

**REFERENCE**

Aboelmaged MG. 2010. Six Sigma Quality: A Structured Review and Implications For Future Research. The International Journal of Quality & Reliability Management. Vol 27. 3: 269-318.

Ahlstrom P. 1998. Sequence in The Implementation of Lean Production. European Management Journal. Vol. 16 No. 3 : 327-334.

Andersson, Roy, Dkk. 2006. Similarities and Differences Between TQM, Six Sigma and Lean. Emerald Group Publishing Limited. 18(3): 282-296.

Anjayani, Indah. 2011. *Analisis Pengendalian Kualitas Produk Dengan Metode Six Sigma Pada Cv. Duta Java Tea Industri Adiwerna – Tegal*. Skripsi. Fakultas Ekonomi. Universits Negeri Semarang.

Ardita, Fika. 2012. Analysis Of Paper Defect Reduction In Paper Industry With Lean SixSigma Approach. Skripsi. Faculty of Agricultural Technology.Bogor Agricultural University

Arikunto, Suharsimi. 1997. *Prosedur Penelitian Dengan Suatu Pendekatan Praktek*. Jakarta: Rineka Cipta

Assauri, Sofjan. 1998. *Manajemen Operasi Dan Produksi*. Jakarta : LP FE UI

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative studies in psychology. Qualitative data: An introduction to coding and*

*analysis.*New York, NY, US: New York University Press.

Evans, James R. dan William M. Lindsay. 2007. *Six Sigma and Process Improvement.* Jakarta: Salemba Empat

Gasperz, Vincent. 2001. *Total Quality Management*. Jakarta: PT Gramedia

Gasperz, Vincent. 2003. *Sistem Manajemen Kinerja Terintegrasi Balanced Scorecard dengan Six Sigmauntuk Organisasi bisnis dan Pemerintah*. PT GramediaPustaka Utama, Jakarta.

Gasperz, Vincent. 2007. *Lean Six Sigma for Manufacturing and Services Industries*. Jakarta: PT Gramedia Pustaka Utama

Kumar, U. Danish, dkk. 2008. *On the optimal selection of process alternatives in a Six Sigma implementation.* International Journal of Production Economics. 111: 456-467

Kwak YH dan Anbari FT. 2006. Benefits, Obtacles and Future of Six Sigma Approach. Technovation26 : 708-715.

Latief, Yusuf dan Retyaning Puji Utami. 2009. *Penerapan Pendekatan MetodeSix Sigma Dalam Penjagaan Kualitas Pada Proyek Konstruksi.* Dalamjurnal Makara, Teknologi, Volume 13, No. 2. Hal 67-72 Depok: Universitas Indonesia.

Linderman K, Schroeder RG, Choo AS. 2005. Six Sigma : The Role of Goals in Improvement Teams. Journal of Operations Management 24 : 779-790.

Nasution MN. 2004. Manajemen Mutu Terpadu (Total Quality Management). Jakarta: Ghalia Indonesia.

Oakland JS. 1993. *Total Quality Management*. Clays St. Ives, Great Britain.

Patilima, Hamid. 2007. *Metode Penelitian Kualitatif*. Bandung: Alfabeta

Pande, Peter S., Robert P. Neuman, dkk. 2000. The Six Sigma Way. Yogyakarta: ANDI

Pete & Holpp. 2002. *What Is Six Sigma*. ANDI. Yogjakarta.

Prawirosentono, Suyadi. 2002. *Filosofi Baru Tentang Manajemen Mutu Terpadu Abad 21 Studi Kasus dan Analisis*. Jakarta: Bumi Aksara

Reksohadiprojo, Soekanto dan Indriyo Gito Sudarmo. 2000. *Manajemen Produksi. Edisi keempat*. Yogjakarta: BPFE.

Singgih, L. Moses dan Renanda. 2008. *Peningkatan Kualitas Produk Kertas Dengan Menggunakan Pendekatan Six Sigma di Pabrik Kertas Y.* Dalam jurnal Teknik Industri, Surabaya: Institut Teknologi Sepuluh Nopember.

Su, Chao-Ton, dkk. 2006. *Improving Service Quality By Capitalising On An Integrated Lean Six Sigma Methodology*. International Journal Six Sigma and Advantages. 2(1): 1-22

Sugiyono. 2004. Metode Penelitian. Bandung: Alfabeta

Stainback, Susan and William Stainback. 1998. *Understanding and Conducting Qualitative Research.* Lowa: Kendall Publishing Company

Syukron, Amin dan Muhammad Kholil. 2013. *Six Sigma quality for Business Improvement.* Yogyakarta: Graha Ilmu

Russel, R.S. and Taylor III, Bernard W. 2006. *Operations Management : Quality and Competitiveness in A Global Environment*, 5th Edition, John Wiley and Sons., Inc. New York