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Reduce Product Defect in Stainless Steel Production Using Yield Management Method and PDCA

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***Abstract*— This study aims to examine and analyze the factors that cause the emergence of defects Wavy & Curve Up on Coil Spring Plate (CSP) at PT. BNM Stainless Steel. Both types of defects are also what makes the trust of customers to the products produced by the company to be down. This is marked by the decrease of orders from Customer from 2014 to 2016. The research data is daily data from 2014 to 2016 data which is the Data of Secondary from Quality Control Department and Production Department. The research covers all product with coil spring plate type (CSP) which is 1/8 Hard, 1/4 Hard, 1/2 Hard, 3/4 Hard, Hard, Extra Hard, and Super Extra Hard (SEH), where sample which is taken by product category which has the highest defect rate among the number of processed products. This research uses PDCA method (Ishikawa Diagram and Pareto Analysis) and Yield Management (Management to produce good product). The results showed several factors that cause the emergence of defect wavy, defect Curve Up and Curve Down. Factors cause of all these problems obtained by using tools fishbone diagram. Completion of all problems using the PDCA system by promoting improvement as a foundation for eliminating all problems. The spirit is Continuous Improvement.**

***Index Terms*— Product defect, stainless steel production, yield management, PDCA.**

I. Introduction

Quality is important for the company, in addition to emphasizing the quality of the product, the company also needs to pay attention to the quality of the production process. By maintaining and constantly improving the quality of the production process, there are some advantages to be gained such as high production quality, decreasing the number of failed products (scrap) due to unfavorable processes, reducing the need for rework on defect products that will ultimately reduce quality costs and increase the company's profits. With high quality products that meet the dimensions of quality, reliability, durability, features and so on, the company can gain a competitive edge over its competitors.

PT. BNM Stainless Steel, is a company engaged in manufacturing with stainless steel production is exactly rolling mill. Rolling Mill is a material depletion process by using a milling machine to process stainless sheets from raw material into thinner sheets by passing them between rolls that work as flattening roll. Process depletion raw material is adjusted to order from customer.

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At PT. BNM Stainless Steel, there are several types of finish hardness of material that can be processed or produced among them are 1) Soft with a yield of 93%, 2) CSP (Coil Spring Plate) with yield of 91.2%, 3) EH < 0.15 with yield of 82%, 4) SEH ≤ 0.15 with yield 85.3%, and 5) SEH > 0.15 with yield of 88.6%.

Yield itself is the value of success between the achievement of the production process with scrap produced from the production process in units per cent (%) per day. Products produced by PT. BNM Stainless Steel has a wide market share of local and international markets (export). For local market, PT. BNM Stainless Steel has a market share of 40% of the total product. As for foreign markets, PT. BNM Stainless Steel has a market share of 60% with market area of Asia, Europe, Australia and America. The Fig. 1 shows the delivery of processed products with various hardness type in PT. BNM Stainless Steel from 2014 to 2016.

	CSP	EH < 0,15	S EH ≤ 0,15	S EH > 0,15	SOFT
2014	888,262	58,716	92,895	85,390	2,119,998
2015	711,260	4,391	19,847	84,670	1,551,947
2016	907,064	12,378	40,928	8,696	2,411,373

Fig. 1. Delivery coil-coil by hardness type from 2014 to 2016 (ton). Source: PT. BNM (2017)

Of the many types of finish hardness produced at PT. BNM, CSP hardness type - the most widely generated by PT. BNM. Problems faced by PT. BNM Stainless Steel is currently the number of defective products found on the production line while processing the coil with CSP hardness type. Another problem is that the defective products are un re-workable or irreversible, so the product is immediately scrapped or disposed of, causing harm to the company. This is what resulted in the high number of scrap produced by the Department of Production where the product has been through the process of re-workable course will produce a fairly high reject. In addition, if a machine re-workable process of a product, of course, will affect the productivity of the machine so that the product output of the machine will be reduced. This also impacts directly with the decline of orders from customers because the level of confidence in the products produced by PT. BNM Stainless Steel decreased. This is caused by the defect found by the customer on the product sent by PT. BNM Stainless Steel so that the product cannot be used. The order decrease for CSP hardness type from 2012 to 2014 increase due to the number of new customer who bought the product to PT. BNM Stainless Steel, but in 2015 there is a decrease in order from customer and continue until the year 2016 June due to quality problems on the resulting product. Fig. 2 shows the delivery for CSP hardness type from year 2014 until 2016.

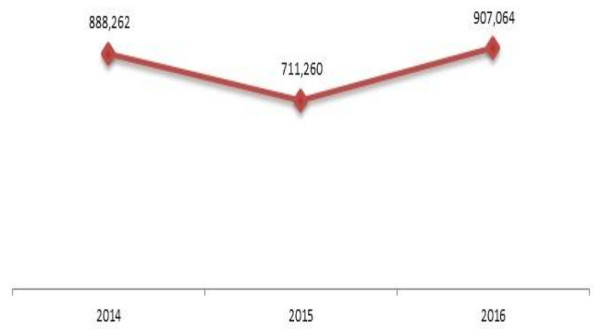
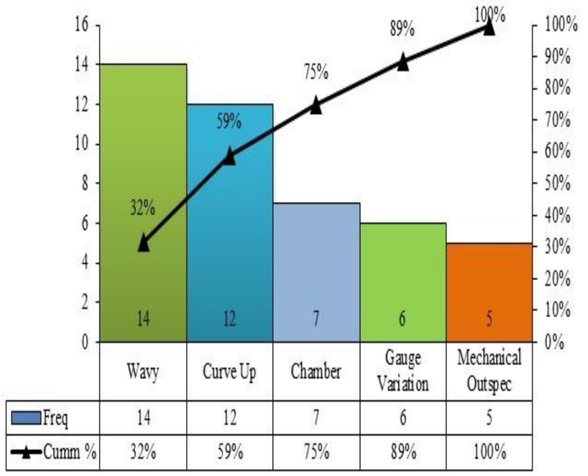


Fig. 2. Delivery hardness type CSP from 2014 to 2016 (ton). Source: BNM Stainless Steel (2017)

When viewing the data in Fig. 2 the apparent decrease in order in 2015, where the decline is due to the products shipped in the year does not match the specifications of the customer. The defect that causes the decline of the order from the customer after is resumed in Fig. 3.



	Wavy	Curve Up	Chamber	Gauge Variation	Mechanical Outspec
Freq	14	12	7	6	5
Cumm %	32%	59%	75%	89%	100%

Fig. 3. Pareto Defect that causes the decline of the order. Source: Customer Complaint based on Defect (2016)

Fig. 3 shows a Pareto of defects that result in the emergence of customer complaints. Defect wavy and Curve Up occupy the first Pareto and second Pareto so that both defects must be resolved in order not to appear complaint from customer again. Viewed from Fig. 3, the order of customer complaint above, the cause of the decrease in order viewed from the side of Production is Wavy and Curve Up, because the problem is often arising from the machine. Wavy is a wave on the outer side of a large coil strip, where this defect appears after a rolling mill process on the strip. This wavy arises because the pressure is too great from the work roll to the outer sides of the strip. While Curve Up is a condition of the curved strips both up (down) and down (down) which is caused by the amount of pressure roll to the strip, but the pass line that is formed by the roll - roll is not in a straight line.

In addition to the complaint of the customer, the problem of Wavy and Curve Up is a problem that often arise when processing coil with temperatures CSP where both problem defect is a major problem that must be immediately followed up. Re-workable is one solution that can be done if both problems arise, but this will impact on the decrease in the level of productivity to the output that must be generated. Therefore, by looking at the frequent emergence of Wavy and Curve Up defects, it is necessary to make improvements to reduce and even eliminate both problems.

There are several methods that can be done to reduce both problems. The method that will be used to handle the above problem is by Yield Management method and PDCA. Yield management is a strategy to determine price variables based on how to understand, anticipate, and influence consumer behavior in order to maximize revenue or profit. While PDCA is a step process to solve a problem or problem which consists of four iterative steps commonly used for quality control.

II. LITERATUR REVIEW

A. *Yield Management*

Yield Management (revenue management) is a technique that helps companies with large and small scale to achieve the highest profit correctly; identify the customer group that the company should serve; determine the quality of the right products and services and prepare the optimal price that will be offered to the customers (Goksen, 2011).

According to Noureddine Selmi (2011) yield management is a way for a company to maximize its capacity and profitability by managing supply and demand and balancing price and capacity through price management. This is the process of allocating the best service to the customer at the best price and at the best time. Yield management allows an industry to maximize revenue and profit by market stratification and segmentation. Yield management or also known as revenue management, has been successfully adapted to various fields of industry in the past several years, one of which is the manufacturing industry.

B. *PDCA (Plan, Do, Check, Action)*

The first step of kaizen is to apply the PDCA cycle (plan, do, check, action) as a means of ensuring the continuity of kaizen. This is useful in realizing policies to maintain and improve or improve standards. This cycle is the most important concept of the kaizen process (Imai, 2005). The concept of the PDCA cycle was first introduced by Walter

Shewhart in 1930 called the "Shewhart Cycle". PDCA stands for English from plan, do, check, action (plan, work, check, follow-up), is a four-step interactive problem solving process commonly used in quality control. Furthermore, this concept was developed by Dr. Walter Edwards Deming who came to be known as "The Deming Wheel" (Tjitro, 2009). This method was popularized by W. Edwards Deming, who is often regarded as the father of modern quality control so often called the Deming cycle. Deming itself always refers to this method as the Shewhart cycle, from the name Walter A. Shewhart, who is often regarded as the father of static quality control.

C. Fishbone Diagram

Fishbone diagram is a method/tool in improving quality. Often this diagram is also called a Cause-and-effect diagram. The inventor was a Japanese scientist in the 60s. Named Dr. Kaoru Ishikawa, a 1915-born scientist in Tokyo Japan who is also a chemistry alumni at the University of Tokyo. So often also called Ishikawa diagram. The method was initially more widely used for quality management. Who uses verbal data (non-numerical) or qualitative data. Dr. Ishikawa was also identified as the first person to introduce 7 tools or methods of quality control (7 tools). That is fishbone diagram, control chart, run chart, histogram, scatter diagram, Pareto chart, and flowchart. The basic function of the Fishbone/Cause and Effects/Ishikawa diagram is to identify and organize the possible causes of a specific effect and then separate the root cause.

III. Method

The type of research used in this study is quantitative research while the design of this research is descriptive research. This research is done by collecting data related to the problem under study and then processed and interpreted and analyzed so as to give an idea of a thing. The variables used in this study are defined conceptually or operationally.

The population of this research is all coil product with hardness coil spring plate (CSP) type produced by PT. BNM Stainless Steel, where there are several types of hardness included in CSP category that is 1/8 Hard, 1/4 Hard, 1/2 Hard, 3/4 Hard, Full Hard, Extra Hard, and Super Extra Hard. Sample taken from this research is using sampling, where sample taken by product category having highest defect rate between amount of product processed with amount of product that produced.

This research is focused on finding the cause which decrease the demand from customer for products with hardness coil spring plate (CSP) type. In addition, this research is also intended to find the root of the problem that causes wavy problems and curve up. Yield management concept and PDCA is one of the tools used to find the root of the problem. Yield management is a way for companies to maximize their capacity and profitability by balancing supply and demand through price management. Yield management allows an industry to maximize revenue and profit by market stratification and segmentation. While PDCA stands for plan, do, check, action (plan, work, check, follow-up), is an interactive four-step problem solving process commonly used in quality control.

There are several techniques of data collection that is through interviews based on questionnaires or interview, field observation and documentation. The following techniques of data collection described in Table 1.

Table 1. Variable, dimension, and indicator

No	Variable	Dimension	Indicator
1.	Productivity	Production Process	Total finished goods in one days Total product that are processed in one days Total scrap from product Yield percentage in one days Time needed to produce finished goods in one days
2.	Quality of Product	Defect of Product	Percentage from NG product in one days
3.	Production planning	Schedule of process	Conformity of production process and delivery schedule Availability of stock products in the warehouse Just in time Lead time before process

Calculation yield in one day. Yield is the difference between the production process achievement and the scrap generated from the production process in percent (%). Yield will usually be calculated after the achievement of production in one day to determine how much the results obtained by the production department in units of days (prime process that can be continued for next process). The formula used to calculate the yield in one day are:

$$\text{Yield (\%)} = \frac{\text{Finish Good (FG)}}{(FG+Scrap)} \times 100\% \qquad (1)$$

Where,

Yield: Profitability and viability indicator of production process

FG: The finished product is the result of the production process that is ready delivery

Scrap: The rest of the production process that is not part of FG but still very little economic value

First Time Success (successful process) is a method used to measure the success rate of producing a product without any improvement process of the product in units of day. Or in other words first time success is the success to produce products without re-work. First time success is often used as a benchmark to measure the success of producing a product because the resulting product is a product ready for further processing without any defects that arise from the previous process. The formula used to calculate the first time success is as follows:

$$FTS = 1 - \frac{(Input - Finish\ Good\ Product)}{Input} \quad (2)$$

Where,
FTS: First Time Success
Input: The weight of the initial product before entering the machine process
FGP: The number of good products from the production process.

IV. Result and Discussion

A. *Production process the Zr. Mill*

The Zr. Mill is a machine that serves to attenuate strips in accordance with customer orders. The main function of the Zr. engine. The mill is to reduce the thickness of the material by applying a force separation using a hydraulic cylinder to a rolling assembly present in the housing mill that exerts pressure on the processed metal strip. This material depletion process uses roll-rolls that exist in the engine housing. More commonly called the rolling mill process. The rolling mill process is a deformation process where the thickness of the work piece is reduced using compressive power and using two or more rolls. Rolls rotate to pull and squeeze together work pieces or dashes between them. In the scrolling process, the strips are subjected to high compression stress derived from the movement of the pinch and the shear stress - friction surfaces as a result of friction between the roll and the strip. During the rolling process, this stress leads to plastic deformation. The end products of this process are metal plates and sheets, which generally have a plate thicker than ¼ inch. The sheets generally have a thickness of less than 1/4 inch. The main purpose of the rolling process is to minimize the thickness of the metal. There is usually a slight increase in width and length increase.

B. *Production process of Tension Leveller Machine (TLL)*

Tension Leveller is a machine that serves to flatten the strip surface so that the strip can become more flat. This machine relies on a lot of roll to be able to flatten the surface of the strip. The working principle of this machine is to flatten the surface of the coil strip where the strip will pass through several rolls in the housing by relying on the pressure of each roll on the strip. To get flatness from the strip, the machine relies on the pressure and tension of the rolls on the machine. The machine has several functions to flatten the surface of the strip, eliminating Canoe Up and Canoe Down defects, removing Wavy defects, eliminating riple defects, removing Buckle defects (Quarter Buckle and Center Buckle), removing defects Curve Up and Curve Down.

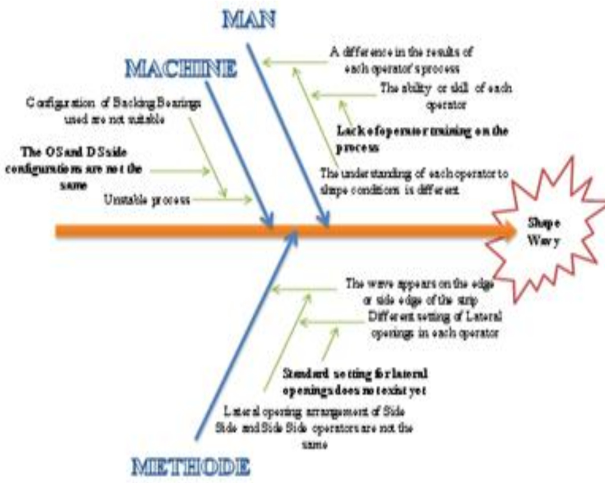


Fig. 4. Fishbone diagram of defect wavy.

C. *Plan of reduce wavy defect*

Defect Wavy is the biggest problem that must be overcome because of the percentage of defect, Wavy ranks first in customer complaint that is equal to 32% as discussed before. From the wavy fishbone in Fig. 4, there are three root problems that cause immediate cause of defect wavy. The root of the problem comes from three factors, namely from human factors, machines and methods. Root of the problem or root cause of the fishbone diagram above along with improvements made include 1) human factor, 2) engine factor, and c) method factor.

Human factor. The root of the problem that arises from this factor is the lack of operator training on the rolling mill process resulting in the result of each operator's process being different. This is related to the working period or flying hours of each different operator-different. Improvement that can be done is to do training or refresh for all operators from Zr machine. Mill is done every two weeks (in class training) and immediately practiced in the field. For instructor of in class training is Foreman or senior operator of Zr machine mill.

Engine factor. The root of the problem that arises from this factor is the configuration of the backing bearing that is used today is in accordance with the condition of Zr engine mill. Backing Bearing is the main component of housing mill that can be implemented to reduce the occurrence of Wavy defect during rolling mill process. This will be related to the configuration or crown formation of the backing bearing itself. For the process of rolling mill when defect wavy occurs still use the configuration reference from the machine maker that is I2S or Tenova (USA). For configuration of I2S use configuration between DS side (Side Side) with side of OS (Operator Side) where for side of Side altitude tolerance from bearing always lower than operator side so configuration is formed as Fig. 5.

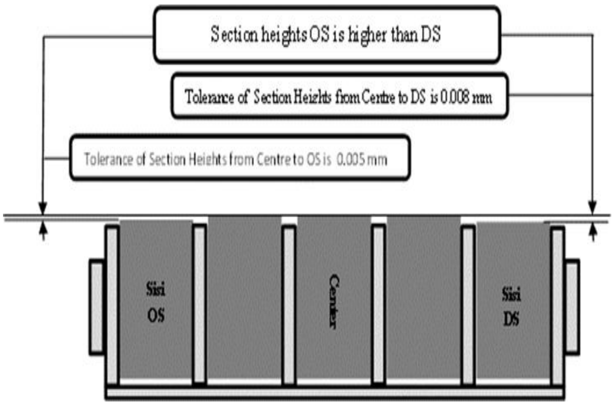


Fig. 5. Configuration of I2S.

Improvement is to change the backing bearing configuration from I2S referrals (side of OS is lower than DS operator) become the reference configuration from J-Tech (Japan Technology). For the changes made is to change the height tolerance of the backing bearing position of the original side of the lower side of the Operator side. This is done because the side of the Side is a flexible side so it is easier to make changes if there is a mismatch during the rolling process takes place. To change the configuration when shown in the picture is as Fig. 6.

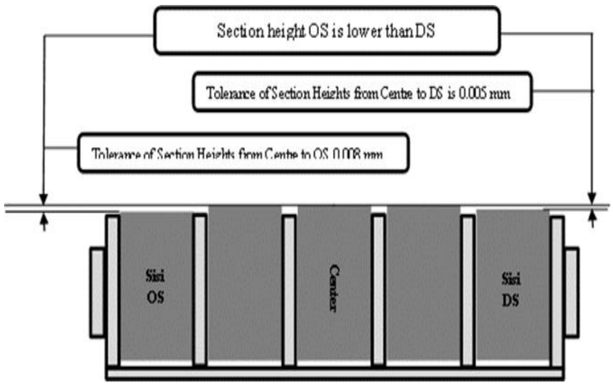


Fig. 6. J-Tech backing bearing configuration.

From the configuration changes made from the configuration of I2S into J-Tech configuration, there is a significant change. It is characterized by a change from the shape of the material from the previous wavy heavy (big wave) to riple (small wave).

***Method factor*.** The root of the problem arising from the method factor is that there is no standard or standard of the same from each operator in terms of setting the lateral roll openings during the rolling mill process. This standard is very important because it will affect the shape of the process of rolling mill. For now, the lateral setting only relies on the feeling of each operator. Though there is already a digital display that shows the number of changes from each setting of lateral openings. Improvement is done that is making standard for setting of lateral openings for standard is made by trial and error of several times so that process can get good shape during rolling process take place. The standard of each lateral roll is different, this is based on the tapper length of each lateral roll used for the rolling mill process. For standard standards that have been made based on trial and error are as Table 2.

Table 2. Standard setting for lateral openings

BNM Stainless Steel	PT. BNM STAINLESS STEEL		DEPT.	PRODUCTION	
			SUBJECT	STANDARD OF LATERALL ROLL	
	STANDARD OPERATING PROCEDURE		UNIT	SENDZIMIR MILL (Zr 23 - 25 H)	
			PAGE	1 of 1	
FLAT CALCULATION FIRST INTERMEDIATE (LATERALL) ROLL					
NO.	Mill Centre Line to End of Rollat Maximum Flat	Cylinder Stroke at Maximum Flat	Roll Tapper	Maximum Flat	Minimum Flat
1	438	102	50	625	724
2			100	525	624
3			150	425	524
4			200	325	424
5			250	225	324

In addition to the lateral opening setting method, another proposed improvement is a change in the composition of lateral coupling position settings. The lateral coupling is part of the lateral roll mounted on the lateral end portion, wherein the coupling is cross-linked on the lateral roll. Or in other words the coupling is mounted on the side of the drive side on the top lateral and mounted on the side of the operator side on the bottom lateral. Changes in the composition of this setting is intended to allow the lateral to move flexibly so that it can reduce the defect wavy slowly and maintain the consistency of the shapes formed during the rolling process takes place. The image of the improvement is as Fig. 7.

Fig. 7. Parts of the lateral coupling before improvement.

In the Fig. 7 the position of trush bearing the outer and inner parts of the lateral coupling is the trush bearing Ø 53mm paired with Ø 54 mm at outer and inner side position. So in the outer and inner side using the formula trush bearing Ø 53 mm and Ø 54 mm and the absence of spring press on threaded stopper. With conditions like this, shaft coupling to housing coupling there is no movement, or in other words shaft coupling to housing coupling becomes rigid/inflexible.

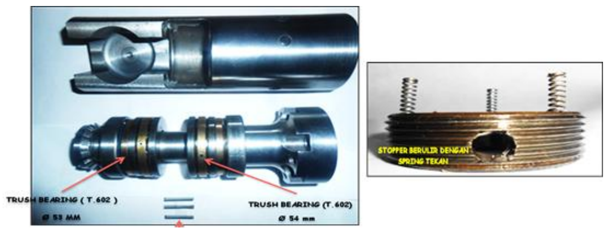


Fig. 8. Parts of the lateral coupling after improvement.

In the Fig. 8 the position of trush bearing the outer and inner side is changed from the previous using Ø 53 mm in pairs with Ø 54 mm, become Ø 53 mm with Ø 53 mm in the inner side and Ø 54 mm with Ø 54 mm at outer position side. This change is done due to the addition of spring springs on the lateral housing tie stopper for 3 pieces. Under these conditions, the shaft coupling of the housing coupling becomes more flexible (no rigid) and the lateral coupling can move freely with a free range tolerance of 2 to 3 mm.

D. Improvement of defect wavy

The result of the change to be better is the purpose of an improvement where the three proposed improvements made a significant change, especially from the flatness of the coil strip. The following is the data showing the change of the proposed improvement is done as Table 3.

Table 3. Improvement for wavy defects

No	No.Coil	Grade	Size		Flatness					
			Thickness	Width	Before Improvement			After Improvement		
			(mm)	(mm)	h	p	I - Unit	h	p	I - Unit
1	FD 4993 311	301 H2D	0.220	170.00	4.8	340	49.1	1.2	280	4.5
2	FD 4993 312	301 H2D	0.220	170.00	5.6	358	60.3	1.7	284	8.8
3	FD 5027 420	301 H2D	0.254	203.20	4.1	280	52.9	1.9	230	16.8
4	FD 4490 400	301 H2D	0.178	215.00	4.4	325	45.2	0.3	240	0.4
5	FD 5026 100	301 3/4 H2D	0.500	442.00	3.2	310	26.3	0.5	216	1.3
6	FD 5020 300	301 3/4 H2D	0.600	280.00	3.7	324	32.1	1.6	254	9.8
7	FD 5019 400	301 H2D	0.300	206.00	4.6	313	53.2	1.4	191	13.2
8	FD5002 100	301 S EH2D	0.254	328.00	5.3	298	78.0	4.0	530	14.0
9	FD5002 200	301 S EH2D	0.200	320.00	4.7	390	35.8	1.7	235	12.9
10	FD5002 300	301 S EH2D	0.308	299.72	4.9	360	45.7	4.2	450	21.5
11	FD5003 100	301 S EH2D	0.305	299.72	5.4	278	93.0	3.3	414	15.7
12	FD4973 100	301 S EH2D	0.102	299.70	3.9	276	49.2	1.2	150	15.8
13	FD4973 220	301 S EH2D	0.102	299.72	4.1	244	69.6	1.5	145	26.4

Table 3 shows significant changes to the shape that is generated after changes in the configuration of the backing bearing and change the arrangement in the lateral coupling. Defect wavy by looking at the data above, for I - unit before improvement when averaged at 53.1 I - unit and after improvement decrease 23% to 12.4 I - unit. In terms of yield and first time success any after the improvement of this show significant changes. Table 4 shows the yield and first time success data before and after the improvement.

Table 4. Data before improvement

NO.	NO.COIL	GRADE	SIZE		WEIGHT		SCRAP	FINISH GOOD	YIELD	FTS (FIRST TIME SUCCES)
			THICKNESS	WIDTH	INPUT	OUTPUT				
1	FD 4939 100	301 S'EH	0.254	356.00	2,629.00	2,051.00	578.00	2,051.00	78.01%	78.01%
2	FD 4940 200	301 S'EH	0.254	356.00	2,576.00	2,097.00	479.00	2,097.00	81.41%	81.41%
3	FD 4939 200	301 S'EH	0.254	356.00	2,560.00	2,156.00	404.00	2,156.00	84.22%	84.22%
4	FD 4892 400	301 H	0.400	216.00	1,206.00	1,042.00	164.00	1,042.00	86.40%	86.40%
5	FD 4973 300	301 S'EH	0.100	299.72	2,466.00	1,975.00	491.00	1,975.00	80.09%	80.09%
6	FB 4999 210	304 H	0.203	248.00	1,870.00	1,599.00	271.00	1,599.00	85.51%	85.51%

Data before the improvement shows the yield and first time success generated only amounted to 78.01%. This Fig. is far below the target set by the company that is equal to 85.3%. Table 5 shows the data after the improvement to see the changes in yield and first time success.

Table 5 Data after improvement

NO.	NO. COIL	GRADE	SIZE		WEIGHT		SCRAP	FINISH GOOD	YIELD	FTS (FIRST TIME SUCCES)
			THICKNESS	WIDTH	INPUT	OUTPUT				
1	FD 4993 311	301H2D	0.22	170.00	1,370.00	644.00	82.00	1,288.00	94.01%	94.01%
2	FD 4993 312	301H2D	0.22	170.00		644.00				
3	FD 5027 420	301H2D	0.25	203.20	923.00	821.00	102.00	821.00	88.95%	88.95%
4	FD 4490 400	301H2D	0.18	215.00	1,330.00	1,230.00	100.00	1,230.00	92.48%	92.48%
5	FD 5026 100	301 3/4H	0.50	442.00	3,800.00	3,686.00	114.00	3,686.00	97.00%	97.00%
6	FD 5020 300	301 3/4H	0.60	280.00	3,550.00	3,452.00	98.00	3,452.00	97.24%	97.24%
7	FD 5019 400	301H2D	0.30	206.00	1,173.00	1,137.00	36.00	1,137.00	96.93%	96.93%
8	FD 5002 100	301 S'EH	0.25	328.00	2,457.00	2,250.00	207.00	2,250.00	91.58%	91.58%

Data after improvement shows yield and first time success generated 89.03%. This Fig. exceeds the target set by the company that is equal to 85.3%. Or in other words for yield and first time success increased by 11.02% from the original 78.01% raise to 89.03%.

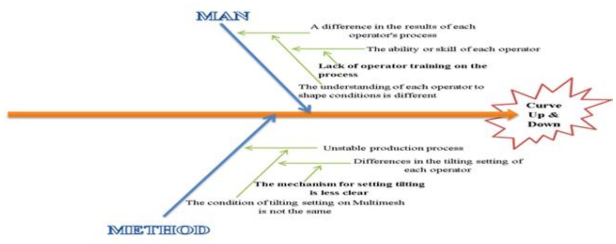


Fig. 9. Fishbone diagram defect curve up & curve down.

E. Defect Curve Up Monitoring Plan

Defect Curve Up is the biggest problem that must also be overcome because of the percentage of defect, Curve Up ranks second in customer complaint that is equal to 27%. From the above Curve fishbone diagram, there are two root problems that are the immediate cause of the Curve Up defect. The root of the problem comes from two factors, namely from human factors and methods. Root of the problem or root cause of the fishbone diagram above along with improvements made include human factors and method factors.

Human factors, the root of the problem arising from this factor is the lack of operator training to the tension leveler process, especially the tilting function, resulting in the result of each operator's process is different. This is related to the working period or flying hours of each different operator - different. Improvement that can be done is to do training or refresh for all operators of the tension leveler machine is done every two weeks (In class training) and immediately practiced in the field. For Instructor of In class training is Foreman or senior operator of tension leveler machine. Even to refresh all foreman and tension leveler operators, within a period of one year brought demsko party to provide training.

Factor method, the root of the problem arising from the method factor is that there is no standard or standard of the same from each operator in terms of setting the function of tilting when the tension leveler process takes place. This standard is very important because it will affect the shape results of the tension leveler process. For now, setting tilting of intermesh 4 or multi mesh only rely on the feeling of each operator. The proposed improvement is to create standardized standard for setting tilting of intermesh 4 or multi mesh where for standard is made by trial and error of several times so that process can get good shape during process leveling take place. Also added marking or markers on tilting to measure the movement of tilting to be arranged when the shape to be processed under conditions Curve Up or Curve Down. For standard standards that have been made based on trial and error are as follows:

- Marking on the right and left side of the tilting intermesh 4 area by using a colored sticker as a marker of the degree position of the tilting movement. Maximum movement of this tilting is 15 ° (degrees) where this tilting can be moved up and down. If the tilting is moved on the upward rotary lever, then the defect that can be eliminated is Curve Up, while if tilting is moved on the lever downwards, the defect that can be eliminated is Curve Down. Fig. 10 shows marking improvement on tilting intermesh 4.

- Preparation of standard standards for tilting movement when both Curve Up and Curve Down defects are found during the process by which the standard is obtained from various experiments.

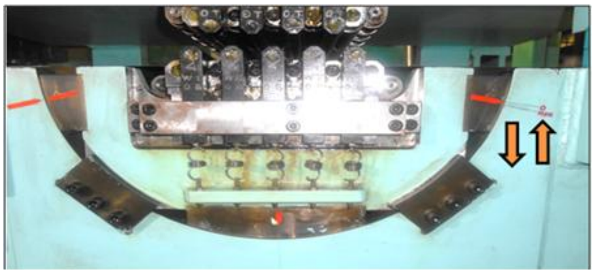


Fig. 10. Marking improvement on tilting intermesh.
Captions: * The down arrow indicates tilting is moved downwards to fix the Curve Down, and the upward arrow direction indicates tilting is moved upward to fix the Curve Up.

F. *Improvement (Defect Curve Up & Curve Down)*

The result of change to be better is the purpose of an improvement where the two proposed improvements made show significant changes, especially from the flatness of the coil strip. The following is the data showing the change of the proposed improvement is done as Table 6.

Table 6. Data before improvement

NO.	NO. COIL	GRADE	SIZE		WEIGHT		SCRAP	CURVE UP & DOWN
			THICKNESS	WIDTH	INPUT	OUTPUT		
1	FD 5207 100	301 3/4H	0.600	350.00	2,010.00	1,940.00	70.00	CD = 63 MM
2	FD 5210 310	301 3/4H	0.800	298.00	660.00	600.00	60.00	CU = 15 MM
3	FD 5207 220	301 3/4H	0.600	310.00	645.00	592.00	53.00	CU = 18 MM
4	FD 5206 300	301 3/4H	0.400	335.00	1,865.00	1,774.00	91.00	CU = 25 MM
5	FD 5209 100	301 H	0.200	245.00	1,880.00	1,791.00	89.00	CD = 30 MM
6	FD 5208 100	301 3/4H	0.400	430.00	2,410.00	2,304.00	106.00	CU = 20 MM
7	FD 5208 200	301 3/4H	0.400	428.00	2,376.00	2,292.00	84.00	CU = 12 MM

Pre-improvement data show Curve Up and Curve Down are measured between 12 mm to 63 mm. This Fig. is far above the target set by the company that is a maximum of 5 mm. After the improvement, there are significant changes to defect Curve Up and Curve Down with the data in Table 7.

Table 7. Data after improvement

NO.	NO. COIL	GRADE	SIZE		WEIGHT		SCRAP	CURVE UP & DOWN
			THICKNESS	WIDTH	INPUT	OUTPUT		
1	FD 5268 300	301 3/4H	0.400	285.00	2,245.00	2,170.00	75.00	CU = 5 MM
2	FD 5287 120	301 3/4H	0.400	382.00	1,243.00	1,163.00	80.00	CU = 1 MM
3	FD 5293 300	301 3/4H	0.400	229.00	1,854.00	1,776.00	78.00	CU = 0.5 MM
4	FD 5295 300	301 3/4H	0.400	325.00	2,677.00	2,569.00	108.00	CU = 2.8 MM
5	FD 5287 200	301 3/4H	0.400	430.00	3,680.00	3,594.00	86.00	CU = 3 MM
6	FD 5297 300	301 3/4H	0.400	430.00	3,290.00	3,189.00	101.00	CU = 4 MM
7	FD 5311 200	301 3/4H	0.400	375.00	1,950.00	1,851.00	99.00	CU = 3.5 MM

From the data after the improvement above is clearly visible significant changes to defect Curve Up and Curve Down where after improvement measurement results show a decrease in high Curve Up or Curve Down. From the data above, Curve Up and Curve Down are measured that is 0.5 mm up to 5 mm. when looking at both data above, there was a decrease in Curve Up and Curve Down measurement results from the previous 12 mm to 63 mm, down to 0.5 mm to 5 mm or 79% down.

V. Conclusion

There are three factors that cause of main problem defect wavy in stainless steel production namely human factor, the engine factor and method factor. Human factor is the lack of training from the operator to the rolling mill process so that the working period of each operator greatly determines the success rate of the rolling mill process. The engine factor is the configuration of the backing bearing that is used today is less suitable with the condition of the current rolling mill machine. Configurations that are used today still use the reference configuration of the machine maker I2S Tenova. Factor of the method that causes it is because there is no standard for the setting lateral roll openings that resulted in differences when setting the lateral opening roll of each operator.

For defect curve up and curve down, there are two factors that cause i.e. the human factor, which is the cause of this is the lack of operator training on processes in the tension leveler machine especially the understanding of the function of intermesh 4 or multi mesh and the method factor, which is the cause is the unclear mechanism for setting intermesh 4 or multi mesh. In addition, the direction of intermesh 4 or multi mesh movement is also unclear, especially for the tilting process.

To overcome the two problems that often arise (wavy & curve), the right method used is the PDCA method (plan, do, check, action). At the stage of the plan, some planning is done to determine the root of the problem what causes both problems and the tools used are fishbone diagram. The root of the problem is found from the human factor, machine factor, and the method of the method. Once found the root of the problem, then determined what kind of improvement steps will be taken to handle the problem. Further examination of the results of such improvements and if declared effective, then made standard so that the whole process is done as expected. The results of the improvement that has been done to overcome the two defects are:

- Significant changes occur for the resulting shape after changes in the configuration of the backing bearing and the change in the arrangement of the lateral coupling. For I - unit before improvement when averaged at 53.1 I - unit and after improvement decreased by 23% to 12.4 I - unit. Yield and first time success generated after the improvement also increased to 89.03%. This Fig. exceeds the target set by the company that is equal to 85.3%. Or in other words for yield and first time success increased by 11.02% from the original 78.01% rose to 89.03%.

- After the above improvements clearly visible significant changes to defect Curve Up and Curve Down where after improvement measurement results show a decrease in the high Curve Up or Curve Down. Curve Up or Curve Down measurement results from the previous 12 mm to 63 mm, down to 0.5 mm to 5 mm or 79% down.

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