

# Forecasting For Steel Production Using Artificial Neural Networks And Feasibility Analysis Of Plant Regeneration Acid Development In PT. XYZ

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**Abstract.** PT. XYZ is a steel production industry company. The Acid Regeneration Plant (ARP) facility has now shown a decrease in plant availability. This study aims to determine steel demand forecasting and also conduct a feasibility study for the development and replacement of ARP technology. Artificial Neural Networks, Linear Regression and Decomposition are used for forecasting experiments. The choice of forecasting method is taken by looking at the smallest MAPE value of each method. Artificial Neural Networks have the smallest MAPE value of 2.58. Then the Artificial Neural Network is used in forecasting requests for 2019 to 2020. The chosen network architecture is 24-12-1 with the traingdx training function. The results obtained are an increase in demand for steel products from 2019 to 2020. The increase in demand is 1,329,398 tons, an increase of 4.59% from the previous 2 years. Then a feasibility study is conducted to assess the construction of new ARP facilities. The feasibility study covers technology selection and investment appraisal. After making a comparison, the technology used is Spray Roaster. Based on the results of the investment appraisal using the NPV, IRR PBP, the new ARP development investment is decent and can meet future steel demand in the period until 2020.

**Keywords:** Forecasting, Artificial Neural Network, Linear Regression, Decomposition, Feasibility Study

## 1. Introduction

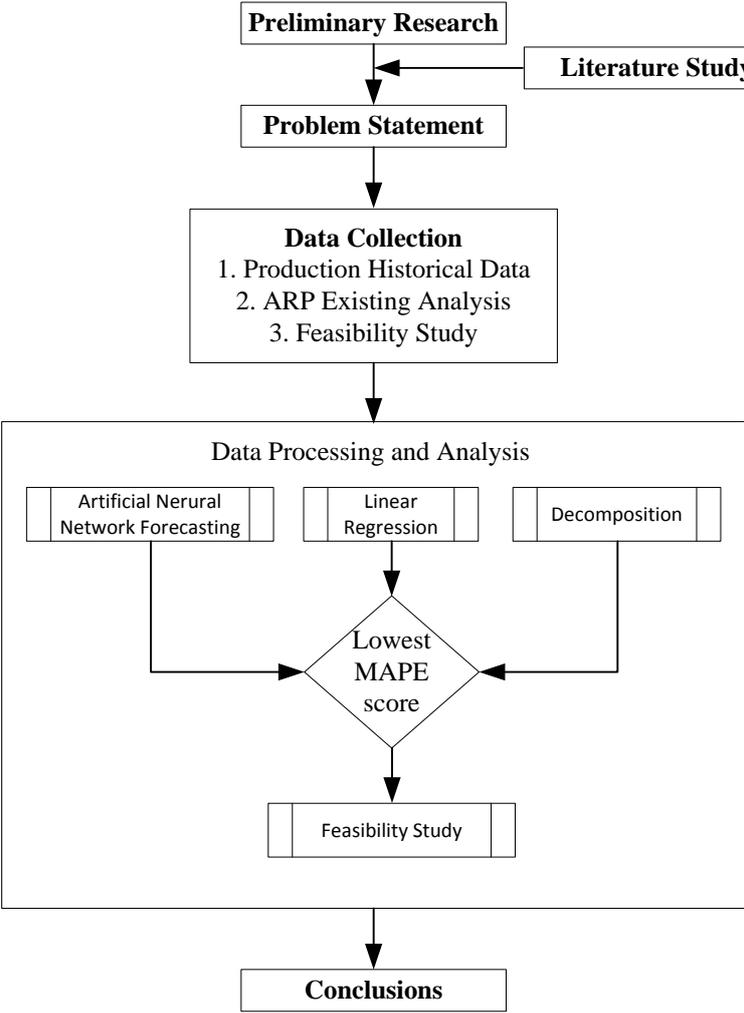
PT. XYZ produces various types of steel for various industrial uses in Indonesia. To produce various types of steel with good quality, the production at PT. XYZ must run smoothly. But now the Acid Regeneration Plant (ARP) facility has a problem. The ARP facility operates to regenerate hydrochloric acid (HCl) used for steel cleaning. The HCl will turn into Waste Pickle Liquid (WPL), which is an acidic liquid that has been mixed with Fe ions. WPL will be regenerated into Regenerated Acid (RA), which is HCl that has been regenerated and reused as steel cleaning liquid.

The ARP facility can actually regenerate 48 m<sup>3</sup> WPL within 8 hours or per shift, but currently it can only regenerate 35 m<sup>3</sup> WPL per shift. This ARP facility becomes mandatory in the production process. In addition to providing HCl for the cleaning process, the ARP facility functions as a waste processor. If the ARP facility does not operate properly, then PT. XYZ must pay the cost to buy Fresh Acid (FA) to increase the shortage of HCl in the production process. Besides that, PT. XYZ has to pay for other companies to process WPL. This made PT. XYZ consider creating a new ARP facility to support production. The feasibility study can be an appropriate method of decision making for a new ARP facility. The feasibility analysis conducts an assessment based on several aspects such as legal

aspects, market aspects, technical and production aspects, operational management aspects, environmental aspects and also financial aspects [1].

**2. Methods**

Observation on the production floor as preliminary research has completed with literature study to get problem statement. As result of that, data collection are production historical data, ARP existing analysis and feasibility study indicator. It is used three approach of forecasting of demand which is Artificial Neural Network, Linear Regression and Decomposition and based on the lowest MAPE score from three methods it would used for feasibility study. Research steps carried out in accordance with figure 1.

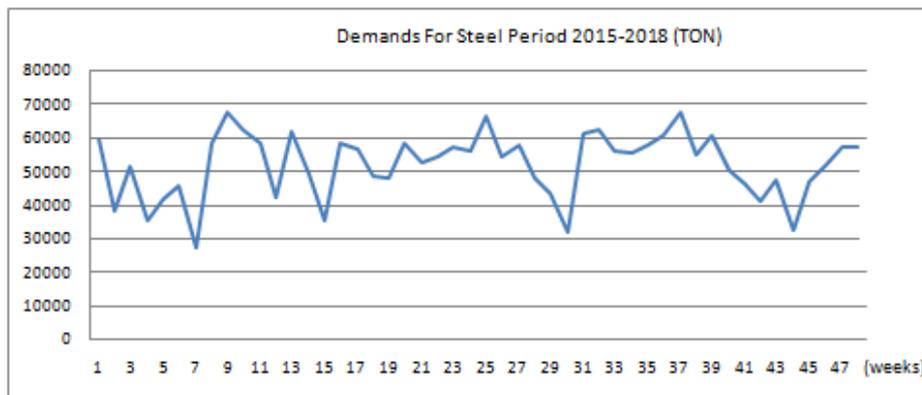


**Figure 1.** Flowchart of research methodology

**3. Result and Discussion**

*3.1 Forecasting Method of Artificial Neural Networks*

In the artificial neural network forecasting method, the data to be processed must first be normalized [2]. Sales data are transformed at intervals of 0.1 to 0.9. This transformation is a function of sigmoid activation. The result is show in figure 2.



**Figure 2.** Demands for Steel Period 2015-2018 (Ton)

### 3.1.1 Artificial Neural Network Training

Artificial Neural Networks work to recognize a pattern [2]. Artificial neural networks conduct training using these patterns in order to recognize other patterns to be further tested. The training input data pattern used is the CRC production normalization data from 2015 to 2018. While the training target is the CRC sales normalization data for 2017 and 2018. The pattern is created by taking 24 normalization data. Example pattern 1 is the normalization data for CRC sales for the first 24 periods, while the target of pattern 1 is period 25. Pattern 2 starts from period 2 to period 25 and the pattern target 2 is period 26. The pattern is made to get 24 patterns.

### 3.1.2 Election of Artificial Neural Network Architecture

Based on the results of trial and error, network architecture 24-12-1 is the best architecture that gets an MSE value of 0,0009 with 816 iterations / epochs. This architecture uses the traingdx training function with a learning rate value of 0.1. This network architecture also gets optimal weights obtained from the results of trial and error iterations in the 2017 MATLAB software

### 3.1.3 Results of Artificial Neural Network Training

The results of training on artificial neural network models are forecasting for the 2017-2018 period. This value is still in the form of sigmoid activation function. To return these values to normal values, it is necessary to calculate denormalization.

### 3.1.4 Best Architecture Testing

The best architecture is an artificial neural network that can recognize training data patterns. This network architecture must first be tested with other data patterns so that it can be used for forecasting. The test data pattern used is the odd data pattern on the training data pattern. While the test target used is also the target of training in odd periods, other tests are performed by calculating the MAPE value from training in artificial neural network models. And the result of MAPE for Artificial Neural Network is 2,58.

## 3.2 Forecasting Method of Linear Regression

In processing data to forecast steel demand using historical data on steel sales. Historical sales data used are sales from 2017 to 2018. Forecasting with the linear regression method needs to calculate the values (b) and (a) to calculate the forecast value. After calculating the values of (b) and (a), we can calculate the forecast using the linear regression method [3]. And the result of MAPE for Linear Regression is 15,23.

### 3.3 Forecasting Method of Decomposition

Forecasting using the decomposition method begins by calculating moving averages from existing data [4], namely historical data on steel sales. The moving average calculates an average value of 12 months. Placement of moving average results starts from the 7th period. After calculating the 12-month moving average value, then looking for a centralized moving average value. Centralized moving average calculates the average value of 2 12 month moving average values. Next is calculating the seasonal factor by dividing the value of demand by the centralized moving average. Next look for seasonal index values. Because of the calculated seasonal factor values, there are 12 values, which are the values for each month of the year, the seasonal index is the same as the seasonal factor. And the result of MAPE for Decomposition is 10,03.

### 3.4 Selection of Forecasting Methods

The selection of methods that will be used to forecast the 2019-2020 period is done by comparing the accuracy of forecasting. The accuracy of forecasting is done using MAPE values. Table 1 is the MAPE value of the three forecasting methods;

**Table 1.** MAPE Value Comparison

No	Methods	MAPE Value
1	Artificial Neural Network	2,58
2	Linear Regression	15,23
3	Decomposition	10,03

Based on table 1. shows that the artificial neural network method has the smallest MAPE value. Therefore, the method to be used for forecasting the 2019-2020 period is an artificial neural network.

### 3.5 Current ARP Facility Analysis

The condition of the ARP facility which has been operating since 1985 is arguably very outdated. Based on data on operating hours from 2015 to 2018, the plant availability of the ARP facility only reached a value of 51%. Ideally, a facility / machine has a plant availability value of around 90%. Based on the calculation of Regenerated Acid processing data and the purchase of Fresh Acid from 2015 to 2018, the CPL line requires 18% HCl of 33,925,168 m<sup>3</sup> for each year or 31,412 m<sup>3</sup> for each shift. The ARP facility can only supply 18% HCl of 23,851 m<sup>3</sup> annually. When the ARP facility does not operate processing WPL and cannot supply 18% HCl to the CPL line, the shortfall will be covered by the purchase of Fresh Acid. With the purchase of Fresh Acid, the 18% HCl requirement will be fulfilled for use in the CPL line as a steel cleaner. Based on 2015 until 2018 demand data, the average steel demand at PT. XYZ is 624,483 tons per year or 578,225 tons per shift. So we can know the value of using HCl 18% for every 1 Ton of steel. This value is 0.0543 m<sup>3</sup> / Ton.

### 3.6 ARP Analysis With Results of Forecasting Neural Networks

Results of forecasting demand for products show an increase in steel demand to 1,329,398 tons, up 4.59% from 2017-2018. If the requirement for HCl 18% during production in the 2015-2018 period is 33,925,168 m<sup>3</sup> per year, the acid demand when demand increases is 33,419 m<sup>3</sup>.

From the calculation above, it shows that the HCl requirement of 18% is still in the design capacity of the ARP facility which is 48m<sup>3</sup> / Shift. In fact, the ARP facility was unable to continue to supply the 18% HCl requirement every day. This was supported by the purchase of Fresh Acid in 2015 to 2018 to cover the 18% HCl deficiency originating from the ARP facility. The value of plant availability from this facility is only around 51%. With the addition of the high maintenance cost value every year, it becomes a driving force to construct new ARP facilities.

### 3.7 Feasibility Study of ARP Development

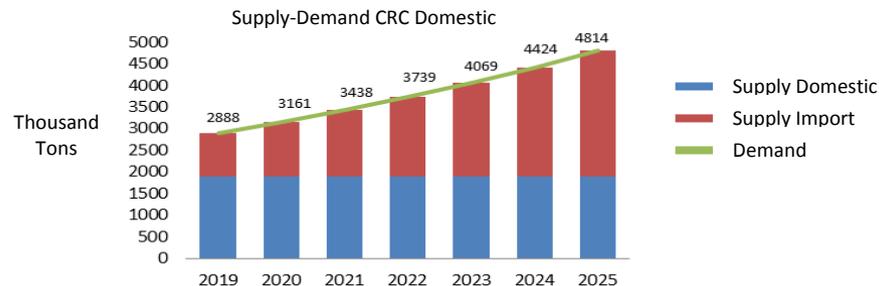
Some aspects that can be used as an evaluation are legal aspects, market aspects, technical and production aspects, management aspects, environmental aspects and also financial aspects.

### 3.7.1 Legal Aspects

PT.XYZ is a steel company that produces steel from upstream to downstream. PT.XYZ already has permission operating license is also called an Industrial Business License (IUI). In the ARP production unit technology replacement project, no external permission is required based on this regulation. The ARP production unit technology replacement project only requires approval from PT.XYZ's top officials because this project is a corporate action.

### 3.7.2 Market Aspects

The demand for steel products is predicted to continue to increase. This increase was followed by the development of infrastructure and automotive industry in domestic. Based on research results from the Market Research & Development Division of PT. XYZ as well as from the POSCO Research Institute, the demand for Cold Rolled Coil (CRC) steel products from 2019 to 2025 will increase as shown in figure 3.



**Figure 3.** Supply-Demand Domestic

### 3.7.3 Technical and Production Aspects

The ARP facility currently uses fluidized bed technology. One of the technology options to choose from is fluidized bed and spray roaster technology. With almost the same investment value, the technology chosen is based on aspects of energy consumption efficiency, price aspects and the number of technology users is a spray roaster.

### 3.7.4 Management Aspects

The project to build a new ARP facility will be carried out by the winning contractor, followed by several ARP technology vendors. The contracting company will handle all construction.

### 3.7.5 Environment Aspects

ARP is a production unit in the Cold Rolling Mill plant. The ARP production unit functions as a waste processor at the CRM plant. The resulting waste is Waste Pickle Liquid (WPL). WPL is a waste from the Continuous Pickling Line (CPL) production line. WPL is a concentrated HCl acid containing iron. The WPL will be regenerated to produce Regenerated Acid (RA) used in the CPL production line.

PT.XYZ already has an AMDAL document (government regulation) regarding environmental Feasibility [5]. According to the head of the Health, Safety and Environment Department, project the replacement of the ARP production unit does not require a government permit because PT. XYZ already has the AMDAL documents that have been mentioned.

### 3.7.6 Financial Aspects

Investment valuation criteria used in this aspect are Net Present Value (NPV), Internal Rate of Return (IRR) and Payback Period (PBP) [6]. From the results of the calculation, the project for Spray Roaster is DECENT with the consideration of the value of the payback period <economic age, ie 2 Years 9 Months <10 years. Table 2 show the summary of Spray Roaster Investment Valuations.

**Table 2. Summary of Spray Roaster Investment Valuations**

Criteria	Value	Status
NPV	5.292.000	Decent
IRR	51,25%	Decent
PBP	2 Tahun 9 Bulan	Decent

For the calculation of the Fluidized Bed Investment Rating, this project is DECENT with the consideration of the payback period value <economic age, ie 3 Years 7 Months <10 years. Table 3 show the summary of Spray Roaster Investment Valuations.

**Table 3. Summary of Fluidized Bed Investment Valuations**

Criteria	Value	Status
NPV	3.363.072	Decent
IRR	40,21%	Decent
PBP	3 Tahun 7 Bulan	Decent

### 3.7.7 Sensitivity Analysis

This sensitivity analysis will analyze three parameters, namely investment, annual benefit and also annual cost [7]. These three parameters are used because all three parameters are included in the cash flow calculation. Investment is the value of capital spent to finance the project. Annual cost is the cost that must be spent in each year. While annual benefit is a benefit that is obtained every year. The following table summarizes the sensitivity values for all parameters for Spray Roaster and Fluidized Bed.

**Table 4. Summary of Sensitivity Analysis of Spray Roaster and Fluidized Bed**

Parameter	Spray Roaster			Fluidized Bed		
	Cashflow	Sensitive Value	Deviation	Cashflow	Sensitive Value	Deviation
Investment	\$ 2.546.876	\$ 5.919.402	132 %	\$ 2.437.264	\$ 4.580.508	88 %
Annual Benefit	\$ 2.714.477	\$ 1.725.817	36 %	\$ 2.581.477	\$ 1.953.182	24 %
Annual ICost	\$ 979.197	\$ 1.967.857	101 %	\$ 1.238.695	\$ 1.866.990	51 %

Based on the calculation results of the sensitivity analysis of the two technologies, it can be seen that the fluidized bed technology has a greater sensitivity level compared to the spray roaster technology. The smaller the value of the percentage difference, the more sensitive the parameter. Both technologies have the same pattern in the order of the smallest percentage of difference value. The percentage value of the difference from the smallest to the largest is the annual benefit, annual cost and investment parameters.

Based on the results that have been described, it shows that between the two technologies, fluidized bed technology is the most sensitive to changes. Very sensitive changes are in the annual benefit parameter with a change of 24% has reached the point of sensitivity.

### 3.7.8 ARP Projection Analysis After Development

The construction of new ARP facilities is intended to replace the current ARP facility. The ARP facility currently has a design capacity of 48m<sup>3</sup> per shift. In fact, the ARP facility can currently supply 18% HCl of 31.412 m<sup>3</sup> per shift for the CPL line, only the 18% HCl supply must be supported by additional supply from the purchase of Fresh Acid. If the ARP facility continues to operate, the costs incurred to operate it will be fairly high. That was caused by the purchase of Fresh Acid and also the cost to carry out maintenance.

After the construction of this new ARP facility, the ARP can supply as much as 48m<sup>3</sup> per shift. This new ARP facility can meet the design capacity of existing ARPs. With the new ARP facility, it can also supply 18% HCl for projected demand in 2019-2020 with an estimated HCl requirement of 18% of 33.419 m<sup>3</sup> per shift.

#### 4. Conclusions

Demand forecasting is done by 3 methods, namely Artificial Neural Networks, Linear Regression and Decomposition. The chosen method based lowest value of MAPE is the Artificial Neural Network method with a value of 2.58. The results of forecasting steel demand for 2019-2020 is 1,329,398 tons, increased by 4.59% of the total demand for 2017-2018.

ARP development is declared DECENT based on Legal Aspects, Market Aspects, Technical and Production Aspects, Management Aspects, Environmental Aspects and also Financial Aspects. The selected ARP technology, Spray Roaster, is based on Technical and Production Aspects. The investment appraisal of this development project was also DECENT with a NPV value of \$ 5,292,000, an IRR of 51% and a payback period of 2 Years 9 Months.

The study state that the construction of a new ARP facility with Spray Roaster technology can meet the demand for steel based on forecasting results.

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