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DECISION SUPPORT SYSTEM FOR FORECASTING PRODUCTION TIME (CASE STUDY: FIBERGLASS INDUSTRY)

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ABSTRACT

Fiber glass industry is an industry that uses polyester reinforced with fiber glass as the main raw material. Various products can be made by using fiber glass. The diversity of products in the fiber glass industry often pose a problem, that is difficulty in determining when the work can be completed. Timeliness is critical to customer satisfaction. By utilizing visual feature recognition approach of the product to be produced and Artificial Neural Network, the production time based on feature standard time-making is predicted. This study consisted of modelling decision support system using artificial intelligence algorithms, testing alternative models, developing decision support system software, software testing to confirm the results with the real in field situation. With this system, fiber glass industry is expected to be able to maintain customer satisfaction by completing the work on time. By using a neural network, the timing of the completion can be done more accurately and the latest production data became the basis for considering the production time for the next orders.

Keywords: fiber glass, feature based, production time, artificial neural network, decision support system.

1. INTRODUCTION

Fiberglass Reinforced Polyester (FRP) material is polyester plastic inforced by fiberglass. This material can be used to make a variety of products, especially for lightweight construction and resistant to damp and even wet weather conditions. Due to the flexibility use of material, fiberglass industry generally face problem of small quantity and high variation order. So the problem often encountered is the determination of when the work can be completed. To set the production time for new products is difficult because there is no past data that can be used as a reference. Error in setting the time as too long will cause costumers to move to other producers and conversely if too short will cause the orders can not be completed on time. This certainly will cause costumers complaints even late fee. The new product's production time is also difficult to determine, especially with diversity of manufacturing products tolerance in accordance with the function of the product. This research aims to design decision support system to improve the accuracy of determining production time so that the order can be completed on time to improve the competitiveness of fiberglass industry.

2. MATERIALS AND METHODS

I. Theoretical background

a) Quality characteristics

The quality characteristics of fiberglass industry survey showed 91% of twenty attributes that influence the costumer's decision, namely form neatness, design aesthetics, strength, durable, modification ability, impact resistance, the design workshop facilities, processing time, increase accessories, warranty / quality assurance, manufacturing costs, skilled labor, maintenance costs, renovation costs, and location (Ikhsan, A., 2010).

b) Fiberglass material composition

The materials for producing fiberglass consist of the main and auxiliary materials. The main ingredient is resin (filler), cobalt (reinforcement material), a catalyst (as drying agents) and fiber (MAT) as bone reinforcement. The fiberglass can be replaced with coconut coir as utilization of local raw materials (Ikhsan, A., 2002) According to its use in industry, fiberglass can be used as models, molds and finished products. Models and finished products use polyester resin materials (BTQ 157) while the mold surface use a special resin called gel coat. Gel has stronger property so it is more durable. For simple shape product, fiberglass can be used as molds but for complex casting such as statues, silicone rubber material is used.

c) Factors affecting processing time

Fiberglass product manufacturing processes consist of design, molding, setup operation, laminating, finishing, coating and assembly. Each process is affected by the component sub-processes. Design is influenced by the number of design line, molding is determined by the features, setup is determined by the number of components and features, finishing process is determined by the level of tolerance and feature. Coagulation time is the time from the process of mixing with the catalyst, viscosity change of the material until the material hardened. Production time may vary depending on the composition of the materials used, the influence of the environment and the amount of catalyst is mixed. Accuracy coagulation time largely determines the efficiency and effectiveness of work. The control of coagulation time is difficult because it is influenced by the

composition of the material, ambient temperature and humidity change throughout the day (Ikhsan, A., 2010). In conclusion, factors that influence coagulation time are: a) input factors such as the composition of raw materials, b) The scale factor in the form of volume, length and speed of stirring, c) control factors such as the catalyst, d) noise factors such as temperature, humidity and air pressure.

d) Forecasting in the decision support system

In support planning and decision making processes, organizations often develop forecasting. Forecasting an integral part of the management decision-making activities, as it can play an important role in many areas of the company. Forecasting is about predicting the future accurately as possible, based on all available information including historical data and knowledge of future events which may impact the forecasting (Hyndman, 2012). Modern organizations require forecasts of short term, medium term and long term, depending on the application.

There are two general categories, namely forecasting techniques of quantitative and qualitative.

- Quantitative Forecasting Techniques include Regression Analysis, Exponential Smoothing, Moving Averages, Box-Jenkins, Trend line analysis, Decomposition, Straight-line projection, Life-cycle analysis, Simulation, Expert systems and Neural networks.
- Qualitative forecasting techniques, including neural networks, Jury of executive opinion, Sales force composite, Customer expectations (customer surveys), Delphi, and Naïve models.

In addition to the above two categories, Forecasting techniques also can be categorized into:

- Time Series: using data and as the basis for estimating future results, In this category are: moving averages, exponential smoothing, Box-Jenkins.
- Causal: the output is directly affected by several other factors. In this category are: regression models, judgmental, expert opinion, Delphi, composite sales force, customer expectations (customer surveys), simulation.

Decision Support System (DSS) is computer-based systems that unify information from various sources, assist in the organization and analysis of information, and facilitate the evaluation of the assumptions underlying the use of a particular model. This system allows the decision makers to access the relevant data across the organization they need to make a choice between alternatives (Sauter, V, L., 2010). SPK is intended to support the decision of the semi structured and unstructured. There are two types of SPK is model-driven and data-driven. DSS model-driven emphasis on access to and manipulation of financial models, optimization and simulation; based on quantitative models; unlimited use data and parameters provided by decision-makers. DSS data-driven emphasis on access to and manipulation of internal time-series data of the company, and may also be the external data and real-time data; based on a simple file system that is accessed by query and data retrieval tools (Power, D., *et al.*, 2011).

Research in the field of SPK involving forecasting shows that the use of artificial intelligence-based method may offer a promising approach to produce better forecasting compared to traditional methods. This is indicated in the Decision Support System Pricing and Optimal Time Discounts on Retail Products that experienced deterioration (Yulherniwati, 2007). DSS uses an Artificial Neural Network (ANN) for forecasting demand and deterioration of the products that will be used to take optimal decisions discounts. These should include comparison with forecasting using multiple linear regression method which represents the traditional methods for forecasting causal, and it was found that using ANN forecasting more accurate than linear regression methods. Similarly, in the study conducted by Zhang, Fu, Ph.D., *et al.,* [Fu, 2010] is a decision support system capable of predicting the results of weekly tomatoes in greenhouses. Development of this system involves a set of techniques based on Artificial Intelligence, namely Neural Network, Genetic Algorithm (GA), and Grey System Theory (GST). ANN forecasting is done by using a set of input variables are optimized, selected from all available environmental parameters and measurable results. Reduction and optimization of input is done using either GA or GST and compared in terms of the performance of the ANN. Another study was conducted by Fathi Shorouq Eletter and Ghaleb Saad Yaseen namely Application of Artificial Neural networks for Credit Decisions in Jordan Commercial Banking System (Eletter & Yaseen, 2010).

e) Artificial neural network

Artificial neural network (ANN) is a computing network that is trying to simulate decision-making processes in the nerve tissue of biological cells. This is in contrast to conventional computing machines that help in improving and accelerating the computation of a human brain but does not consider the organization of a network of computing elements. (Graupe, D., 2013). ANN perform simple computing operations (addition, multiplication and basic logic elements) to solve complex problems, mathematical formulas, undefined, non-linear or also stochastic. (Graupe, D., 2013). Artificial neural networks have proven to be a useful tool in many activities in the field of scientific and professional (Tadeusiewicz, *et al.,* 2015). ANN ability to study the relationship data is non linear cause ANN widely used in forecasting applications. (Zhang, G., P. 2004). A neural network models can be described with a graph, which consists of vertices and edges connecting the vertices. JST is characterized by the network architecture, node types and rule learning (Du, K.-L, 2014).

II. Research method

The study consisted of modelling decision support systems, alternative testing models, developing the decision support system software, and software testing to confirm the results with the real situation. DSS would be

supplied data from a database. Database managed through the production data management, including data of products, features, processes, materials, equipment, operators, time, cost, scheduling, workstations and capacity. At the time of ordering, features of the product ordered by customers are identified. This process generated shape, dimensions, tolerances, quantity, and quantity of product features that will be done. Based on the results of feature identification, process is planned to be performed, the estimated time of the work product is calculated. With knowledge from of the DSS, feature production time is trained, so the system can give an estimation of the production time.

3. RESULT AND DISCUSSION

a) Pre-processing

In order entry stage, cost and completion time is usually agreed. The initial stage is the reading of the drawing

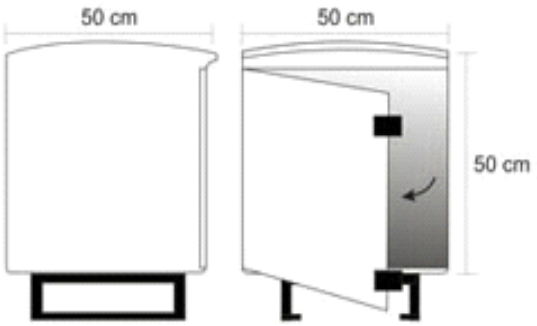

Figure-1. Example of product drawing.

At this stage, information about what features contained in the product, the relationship between feature and size are obtained. Based on the feature database, processes required for each product is known. Total weights of the production process is represented by weighting feature.

b) Artificial neural network model for forecasting time

In solving this problem, forecasting techniques used are causal forecasting with Artificial Neural Network. Some studies have suggested a number of variables that affect forecasting time processes, namely product features, labor, equipment, materials and working methods, and others. This study used six variables, namely the number of products, the number of components, the number of setup, the number of features, unit area, and the number of assembly. These variables are used because they have the most significant effect on the processing time.

c) Input data

Based on data from the earlier image data processing, input data for forecasting time is derived from past production data. Input data format and sample are presented in Table-1.

Tabel-1. Input data format and sample.

Product	NUM PROD	NUM COMP	NUM SETUP	NUM FEA	AREA	NUM ASSY	PROCESSING TIME
A	**10**	**2**	**3**	**6**	1.0441	4	**238.42**
B	8	2	4	6	1.6871	4	248.91
C	4	6	8	12	2.8784	12	261.00
D	3	6	8	13	2.8784	12	200.45
E	12	6	8	10	1.3909	11	588.83

d) Scaling data

With such input given in Table 1, the time prediction model with 6 variables as predictors is scaled. Data is scaled using a minimum value and a maximum value on the input vector. The minimum value is 0, while the maximum value remains a maximum value of the input vector. Results scaling (x) of the value of a variable (value) obtained from the formula (1). In this case, there is a pre-condition that the maximum value is not equal to the minimum value.

$$X = \frac{value - value_{minimum}}{value_{maximum} - value_{minimum}} \quad (1)$$

ANN architecture used for time forecasting in this case is the multi-layer feed forward network, consist of:

a. An Input layer with 6 nodes: number of products, number of components, number of setup, number of features, unit area, the number of assembly.
b. An output layer with one node as the predicted value: time.
c. A Hidden layer with the number of nodes specified by the user.

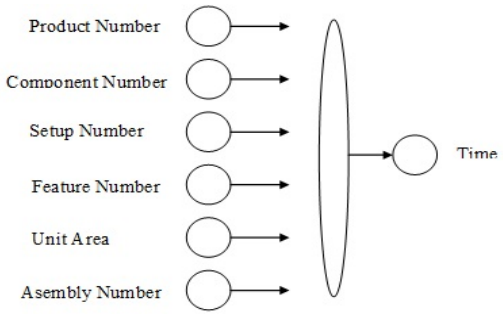

Figure-2. ANN architecture for time forecasting.

Figure-2 presents the architecture of neural networks to predict time with 6 predictors. The learning algorithm used is backpropagation algorithm with sigmoid activation function.

e) ANN architecture for time prediction

The application consists of two main parts as shown in Figure-3. The first part is the setting of artificial neural network to be used for forecasting. It consist of 1)

determining predictors of forecasting as an input layer node (Figure-4); 2) Determination of architecture and network parameters (Figure-5); 3) training the network (Figure-6); 4) testing the network (Figure-7). The goal is to get the weights that minimize the learning errors. This process can be repeated until the desired ANN architecture and corresponding parameters obtained, and ready to be used for forecasting. The second part is the use of neural networks for forecasting, by providing input predictor values (Figure-8) and yield forecasting of fiberglass products' production time (Figure-9).

f) The error rate

The results quite accurately forecast the average error rate = 6.66% thus the industry should consider flexibility in the timing of the completion of the product to costumers.

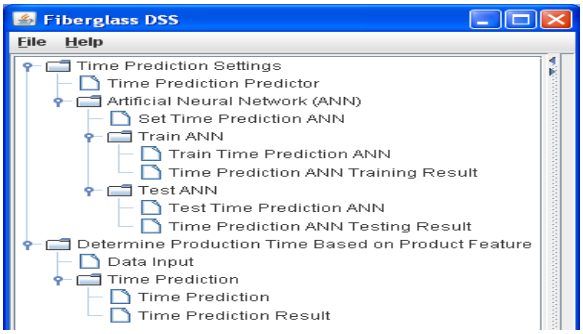

Figure-3. The application menu.

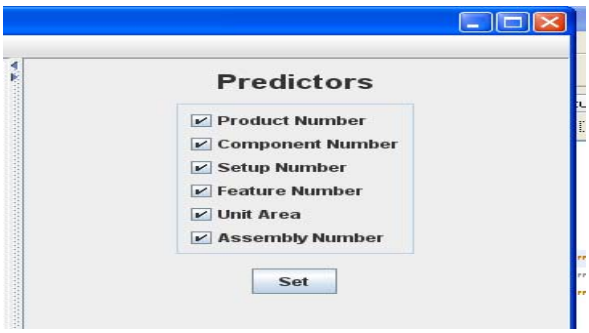

Figure-4. Determination of predictors of forecasting.

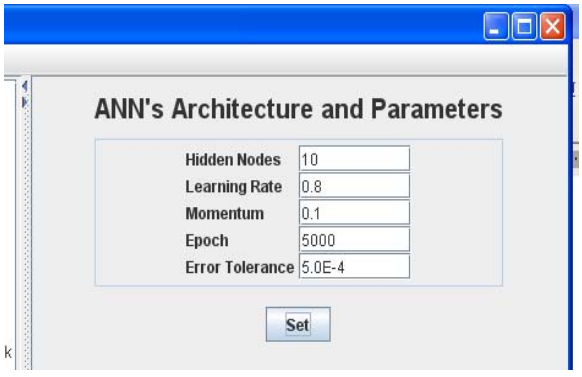

Figure-5 Architecture and ANN parameter.

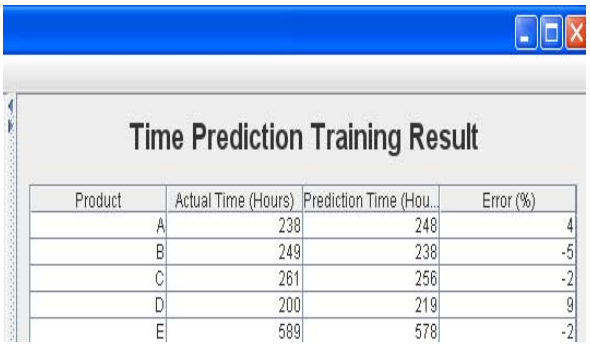

Figure-6. The results of ANN trainings.

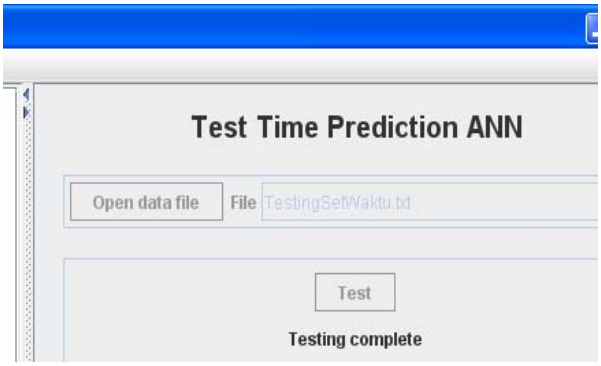

Figure-7. Test results ANN.

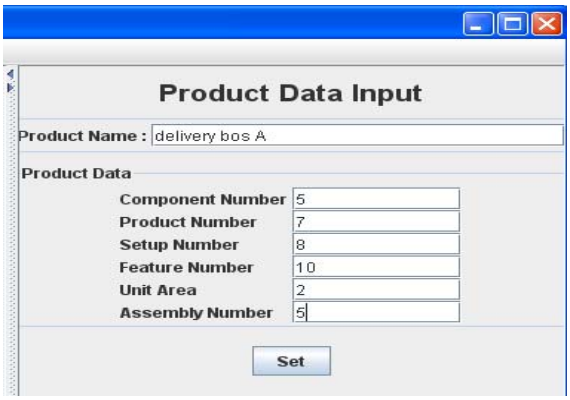

Figure-8. Input data products that will be predictable.

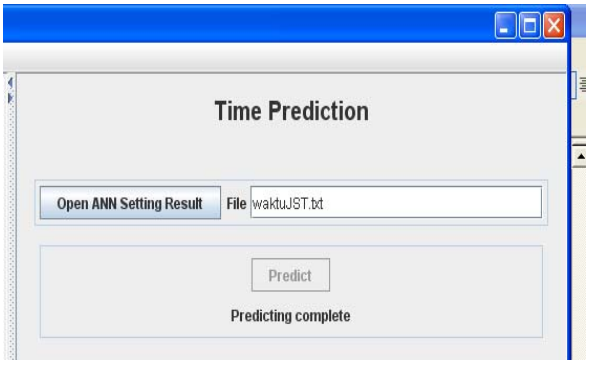

Figure-9. Time forecasting results.

4. CONCLUSIONS

- By using a neural network timing of the completion of orders can be made more accurately.
- The latest production data form the basis for considering the production time dynamically.
- The results quite accurately forecast the average error rate = 6.66%

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