

Development of a Model for Lathe Machine's Installation, Completion Time and Due Date Prediction

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ABSTRACT: The installation and commissioning of machine tools such as the Lathe machine is very vital. Proper installation ensures appropriate functioning of equipment which minimizes chances of machine failure. Over the years, the prediction of completion time and due dates of installing and commissioning machine tools have been approached unscientifically with methods ranging from guessing to brainstorming. However, these methods were found to be unreliable and causing lots of disappointment to manufacturing companies which results in delay during installation and commissioning with attendant increase in cost implications. This study makes use of a very efficient and reliable scientific approach to develop a model that can predict the due date for lathe machine installation. Activities involved in machine installation and commissioning were first identified and critical path method was applied to predict the due date for installation and commissioning of the machine tools. The software programming language used for the prediction is MATLAB: an efficient and reliable software with Artificial Neural Network conditions (ANN), simulation model and set of data generated during the installation and commissioning of lathe machine which were iteratively trained in a MATLAB R.2010 environment. The results of the predictive model were found to be highly promising. It has almost the same value when compared to manual calculations. This conclusively confirmed that the model is a veritable and vital tool in predicting the completion time and due dates. This model will find its application in all manufacturing industries that machine installations affect their production.

KEYWORDS: Artificial Neural Network, Completion time, Critical Path, Due Dates and Simulation Model

I. INTRODUCTION

Meeting due dates is one of the most important objectives in scheduling (Gordon *et al.* 2002). Accurate prediction of installation time of machine tools enhances production scheduling and forecasting as this ensures machine tool delivery for commissioning meets targets and deadlines. It also helps develop best practices to improve production capacities, quality, reliability and man-machine interaction. Commissioning verifies that what was specified and procured was installed; that it functions properly and that it was successfully turned over to the user and reasonably ensures the next step: verification for regulated industries would be successful (Blackburn, 2012).

Over the years, the prediction of completion time and due dates of installing and commissioning machine tools have been done unscientifically via guessing, executive meetings, brainstorming etc which was found to be unreliable causing lots of disappointment, which results in delay during installation and commissioning with attendant cost implications.

As manufacturers are under tremendous pressure to meet deadline, optimize cost, improve product quality in terms of dimension while maintaining high productivity; they need to scientifically address numerous problems during installation and commissioning of machine tools especially those that causes delay and prevents timely delivery, increases manufacturing cost, bring about accidental fall and fatalities, affect the accuracy level during operation stages. Solving or improving in all those problems areas is huge work but can be addressed significantly via Provision of suitable model for predicting installation time of machine tools; and provision of veritable model for cost estimation for machine tool installation

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Prediction of machine tools installation time is a cost reduction initiative, besides it provides means of evaluation of potential safety and hazards and assist in the elimination of these hazards. This prevents delay along critical path and foster safe and healthy work environment via identification and control of risk associated with machine installation and commissioning.

II. LITERATURE REVIEW

Machine tools are devices for cutting materials (mostly metals), to impart them the required shape (Joshi et al., 2007, Adekoya, 2010). They have an in built arrangement that facilitates the use of various type of detachable cutting tools that can be changed to suit the task in hand, and removed for replacement or re-sharpening after wear. The cut off material obtained is usually in form of chips.

2.1 Installation Procedure

Procedures to include:

1. pre-installation activities
 2. installation activities
 3. use of moving equipment to move and position the machine
 4. use of metrology instruments to measure and test the equipment
 5. making mechanical and electrical connections
 6. troubleshooting, checking and testing activities
 7. completing relevant paperwork
- Commissioning is a well-planned, documented and managed engineering approach to the start up by eliminating problems up front and turnover of facilities, systems and equipment to the end users that result in a safe and functional environment that meets established design requirement and stakeholder expectation. That is, commissioning verifies what was specified was installed, that it functions properly and it was successfully turned over to the user and reasonable ensures the next step verification for regulated industries would be successful. (Blackburn, 2012) It is a process by which an equipment, facility, or plant (which is installed, or is complete or near completion) is tested to verify if it functions according to its design objectives or specifications.

In practice, the commissioning process comprises the integrated application of a set of engineering techniques and procedures to check, inspect and test every operational component of the project, from individual functions, such as instruments and equipment, up to complex amalgamations such as modules, subsystems and systems.

2.2 Methods of Prediction

There are several methods of predictions, some of which will be discussed below: guessing, brain storming, executive meeting etc.

1. Guessing

This type of prediction is almost like that of brainstorming but the difference is that the purchasing manager is left to predict a due-date for the equipment installation and commissioning time by guessing due to factors on ground concerning the equipment and depreciation status.

2. Brainstorming

A department or group of persons are tasked to predict a possible date, installation and commissioning could be made for procured equipment. A due-date that will suit the installation and commissioning of the equipment would be made by this group.

3. Executive Meeting

This type of prediction involves the managers in a company to determine when equipment could be purchased based on some factors like the capital on ground, the amount of product that needs to be produced, the nature of the equipment to be procured, installed and commissioned.

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4. Qualitative tools for due date prediction

The methods mentioned above are unreliable and cause a lot of disappointment to manufacturing companies that result to a lot of delay in installation and commissioning and make them loose a lot of money within a very short time. A very good scientific approach to due date prediction is needed, for a scientific objective (or combined set of objectives) and an environment which is also specified and deterministic, an optimal allocation of resources will exist (coincidentally, there may be two or more optimal). The possibility of a solution derived by analysis as applied to search is therefore an attractive proposition. Over the last two decades there have been more example of analytically derived optima in organisation of many kinds of solution that can be obtained to problems of queuing, stock control, replacement etc. and the operational effectiveness of organisation in very many cases have been improved significantly.

According to Akinnuli and Aderoba, (2000), there are applicable methods of optimizing due-date prediction for equipment procurement some of them are: network analysis, decision theory and empirical model for job shop flow time and due-date prediction.

III. METHODOLOGY

Table 3.1: Installation Activities for Lathe Machine

Activities	Precedence	Description	Duration (days)
A	-	Pre- installation activities	5
B	A	Arrival of the machine tools into the central workshop	1
C	B	Removal of the machines from the pallet boxes	1
D	B	Exercises involving check, and inspection of the machine tools	1
E	B	Use of transport equipment in moving machine tools to correct positions	3
F	C	Assembly of all subparts	2
G	E	Making connections	1
H	G	Testing all installation works	1
I	D F H	Proper check, inspection and testing activities	1
J	I	Completion of the relevant paper work	2

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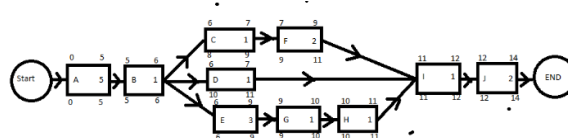


Fig. 3.1: Network Analysis for Lathe Installation

The initial path A-B-E-G-H-I-J
The non- critical path are C, D and F
The float for this analysis is as follows:

Table 3.2: Float Analysis for Lathe Machine Installation

Activities	LS T	ES T	Fl o a t s	EF T	LFT b	Normal duration (m)	Expecte d time $E = \frac{(a+4m+b)}{6}$	Variance $[\frac{b-a}{6}]^2$
A	0	0	0	5	5	5	5	0
B	5	5	0	6	6	1	2.66	0
C	8	6	2	7	9	1	3.33	0.11
D	10	6	4	7	11	1	3.66	0.44
E	6	6	0	9	9	3	5	0
F	9	7	2	9	11	2	4.66	0.11
G	9	9	0	10	10	1	4	0
H	10	10	0	11	11	1	6.5	0
I	11	11	0	12	12	1	4.66	0
J	12	12	0	14	14	2	5.33	0

LST-Latest Start Time
EST-Earliest Start Time
EFT-Earliest Finish Time
LFT-Latest Finish Time
SPT- Shortest Processing Time
EDD-Expected Due Dates

In many realistic scheduling environments, a job's processing time may be depending on its position in the sequence (Bachman and Janiak, 2004) cited by Zhao et al., (2014).

Table 3.3: Lathe Installation Activities and Processing Time

Activities j	A	B	C	D	E	F	G	H	I	J
Processing time (days)	5	1	1	1	3	2	1	1	1	2

No of jobs: 10
According to Panneerselvam, (2002) arrange the job as per SPT ordering

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Table 3.4: Lathe Installation Activities and Processing Time as Per SPT Ordering

Activities	B	C	D	G	H	I	F	J	E	A
Processing time (days)	1	1	1	1	1	1	2	2	3	5

Therefore job sequence is as follows: B-C-D-G-H-I-F-J-E-A

Computation of Mean Flow Time \bar{F}

Table 3.5: Mean Flow Time for Lathe Installation Activities

Activities j	B	C	D	G	H	I	F	J	E	A
Processing time (days)	1	1	1	1	1	1	2	2	3	5
Completion time c_j	1	2	3	4	5	6	8	10	13	18

$$\bar{F} = \frac{1}{n} \sum_{i=1}^n f_j$$

$$\bar{F}_{St} = \frac{1}{10} \sum_{i=1}^{10} (1+2+3+4+5+6+8+10+13+18)$$

$$\bar{F} = \frac{1}{10} (70)$$

$$\bar{F} = 7 \text{ days}$$

Therefore, the optimal mean low time is 7 days

Table 3.6: Lathe Installation Activities and Due Date

Activities j	A	B	C	D	E	F	G	H	I	J
Processing time t_j (days)	5	1	1	1	3	2	1	1	1	2
Due Date d_j (days)	5	3	3	4	5	5	4	7	5	5

The job as per EDD rule (i. e. increasing order of their due dates)

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Table 3.7: Lathe Installation Activities and Completion Time

Jobs j	B	C	D	G	A	E	F	I	J	H
Due dates d_j (days)	3	3	4	4	5	5	5	5	5	7
Processing time t_j (days)	1	1	1	1	5	4	3	1	2	1
Completion time c_j (days)	1	2	3	4	9	13	16	17	19	20
Lateness l_j (days)	-2	-1	-1	0	4	8	11	12	4	13
Tardy/Non tardy (1/0)	0	0	0	0	1	1	1	1	1	1

The EDD sequence is B-C-D-G-A-E-F-I-J-H. From the last row in table 3.7, 0 means corresponding job is untardy and 1 means that the corresponding job is tardy. There are six tardy jobs, the first is in the fifth column ($k=5$)

The maximum lateness value is 13, so this EDD sequence gives the minimum value for L_{max} which is equal to 13. In some situations, the tardiness penalties depend on whether the jobs are tardy, rather than how late they are. In these cases, the number of tardy jobs should be minimized (Yin et al. 2013) cited by Zhao et al., 2014.

Resilient back propagation is employed in training the network because its algorithm is one of the fastest for this purpose (Shifmann et al., 1994, Rocha et al., Kumar and Zhang 2006 and Almeida et al., 2010 as cited by Gunther and Fritsch 2010.

The algorithm employed for training the data set is the Levenberg Marquardt algorithm.

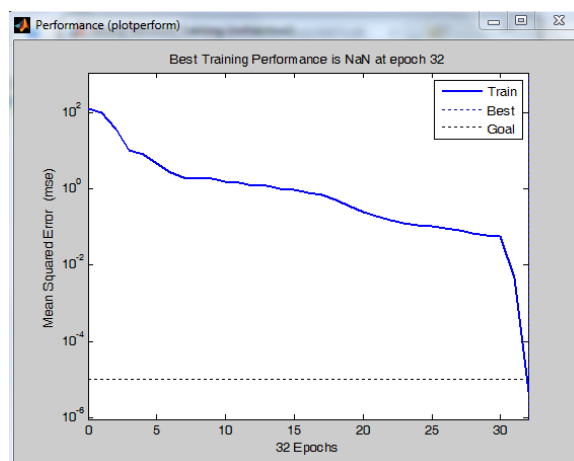


Fig. 4.1: Training Performance Graph

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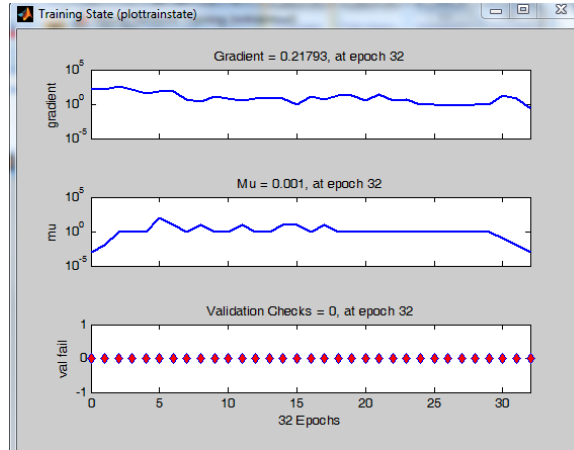


Fig. 4.2: Training State

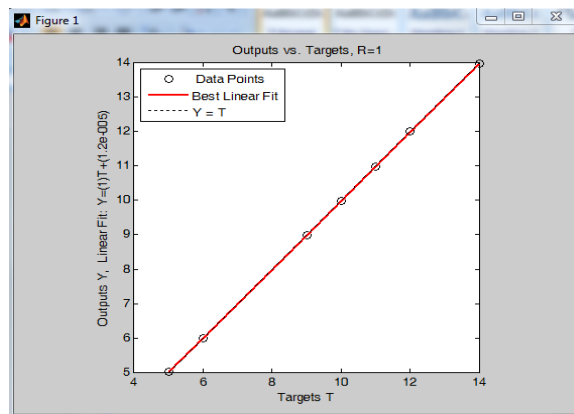


Fig. 4.3: Output- Target Graph

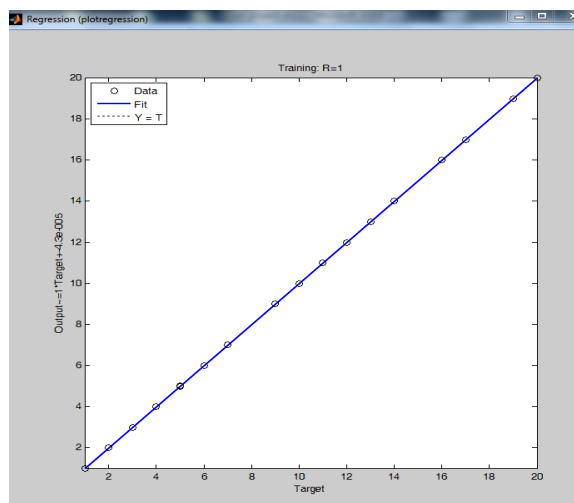


Fig. 4.4: Regression Graph

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After 32 iterations, the target was reached as shown in Fig. 4.1 with the line cutting across the vertical axis of performance training graph. The negligible value of the Mean Square Error (MSE) from Fig. 4.1 and the linearity of the regression graph from Fig. 4.4 is an indication that the Artificial Neural Network is highly efficient and that the network is well trained with predicted values in agreement with calculated values..

The degree of correlation will be significant if correlation coefficient r is close or equal to 1. From Fig. 4.4, the coefficient of correlation r is 1, this confirms that there is good agreement between the input, target and predicted results. From Fig. 4.4: there is no deviation of data points from the line of best fit indicating that there is high degree of correlation between calculated and predicted values.

Comparing table 4.1 and 4.2, predicted values were very close to the calculated values an indication of the viability of the predictive model.

Table 4.1: Values of Completion Time and Due days Using Manual Calculation

Activities	LST (days)	EST (days)	Processing time (days)	Float	EFT (days)	LST (days)	Completion time (days)	Due Date (days)
B	5	5	1	0	6	6	1	3
C	8	6	1	2	9	7	2	3
D	10	6	1	4	11	7	3	4
G	9	9	1	0	10	10	4	4
A	0	0	5	0	5	5	9	5
E	6	6	4	0	9	9	13	5
F	9	7	3	2	11	9	16	5
I	11	11	1	0	12	12	17	5
J	12	12	2	0	14	14	19	5
H	10	10	1	0	11	11	20	7

Table 4.2: Predicted Values of Completion Time and Due days Using Artificial Neural Network

Activities	LST (days)	EST (days)	Processing time (days)	Float	EFT (days)	LST (days)	Completion time (days)	Due Date (days)
B	4	4	1	0	5.9981	5.9990	0.9943	3.0012
C	6	5	1	1	8.9991	6.9999	1.9974	3.0002
E	5	5	1	0	10.9997	7.0008	2.9949	4.0005
F	7	6	1	1	9.9977	9.9981	3.9996	4.0018
G	6	6	1	0	4.9997	5.0009	9.0007	5.0010
H	7	7	1	0	8.9985	8.9992	12.9950	5.0036
I	8	8	1	0	10.9995	9.0022	16.0000	5.0010
J	10	10	2	0	11.9985	11.9989	17.0015	5.0008
D	5	5	3	0	13.9980	13.9985	18.9948	4.9999
A	0	0	4	0	10.9983	10.9985	19.9992	7.0014

IV. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of this project was met at the end of this research work. The following inferences and conclusions were deduced after the successful completion of this research work.

- a) Activities involved in machine installation and commissioning were clearly identified;

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- b) Critical paths in machine installation and commissioning were also identified and critical path method was employed in predicting the due date for installation and commissioning procured equipment (a) above;
- c) The developed algorithm and software for implementing the critical path method were highly efficient;
- d) The predictive model for the prediction of completion time and due-date of machine tools was developed, because the artificial neural network employed could closely predict values of due-dates having studied the interaction among imputed values
- e) The calculated values were very close to the predicted values for each of the selected machines. Thus it can be concluded that the training of data set was effectively and successfully carried out and the model is a veritable tool for prediction of due-date.
- f) From all the negligible values gotten from mean square error, it can be inferred that data were properly trained and the calculated values are not far from the predicted values.

5.2 Recommendations

The following are recommended in case this work may be carried out in future;

- 1) Emphasis should be made on the application of MATLAB software in Mechanical Engineering courses, as it offers divers solution to vast problems in the field.
- 2) The application of this research should be extended to other machine tools

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