Implementing an Automated Solution for the Johnston Timber Company

# Executive Summary

The Johnston Timber Company currently employs two people to manually spray each piece of processed timber with preservative to treat the timber for its intended purpose. This task could be performed automatically, reducing the production costs and improving safety and efficiency in the Johnston Timber processing plant.

The ABB IRB 120 is the ideal solution to replace the current workers. The IRB 120 provides high accuracy and reliability at a low cost. The predicted payback period is just over one year. Moving towards and automated solution will increase production, reduce costs and increase worker safety.

# Automated Solution

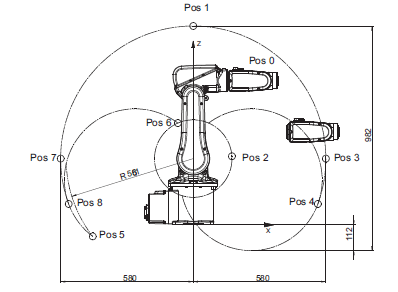
## Robot Model – IRB 120

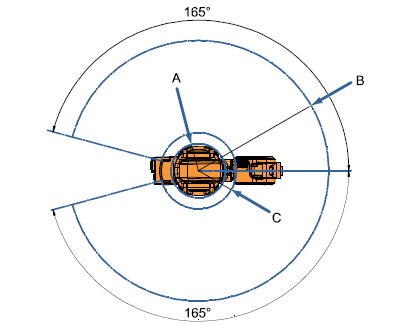
The chosen robot is the ABB IRB 120. The technical details for this robot can be found in Table 1 below.

Table 1. Technical Specifications of the ABB IRB 120 [1]

|  |  |
| --- | --- |
| **Specification** | **Value** |
| Handling Capacity | 3 kg |
| Noise Level | < 70 dB |
| Power consumption | * Max 0.24 kW * Standby 0.095 kW |
| Reach | 0.58 m |
| No. of Axis | 6 |
| Pose Repeatability | 0.01 mm |
| Pose Accuracy | 0.02 mm |
| Pose Stabilisation time | 0.03 s |
| Linear Path Repeatability | 0.16 mm |
| Linear Path Accuracy | 0.38 mm |
| Velocity | * Axis 1-3 250 degrees per second * Axis 4-5 320 degrees per second * Axis 6 420 degrees per second |
| Programming Interface | RAPID |
| Interfacing Capabilities | * File and serial channel * Logical Cross Connections * Analog Interrupts * PC Interface * FTP and NFS Client * Socket Messaging |

The IRB 120 is the ideal solution due to its flexibility and its reach. The 6 axes of movement and over 0.5 m of reach will allow the robot to reach each face of the wood to be treated without requiring the plank to be repositioned. The robot also provides a level of accuracy and reliability not afforded by a human worker. This will ensure the quality and coverage of the preservative treatment will be at a higher standard. The interfacing capabilities of the IRB 120 will allow us to easily communicate with the robot arm and remain informed of the arm’s progress. Figures 1 and 2 below demonstrate the range of movement of the robot arm.

Figure 1: Possible Robot Positions (Units in mm) [1]



*Figure 2: Robot Arm range of movement.* [1]

## End Effector – Spray Painting Gun

The necessary end effector is a custom made Spray Painting Gun. This will be modified to cover the wood in the required preservative. Additional software will be required for the IRB 120 to control the spray painting. The IRB 120 is capable of manipulating an end effector which weighs up to 3 kg [1] and so the tool will not be able to hold the required preservative and instead must be supplied from a floor based source.

## Sensors – Logitech HD Pro C920

The only required sensor is a camera required to determine the position of the wood on the conveyor belt. The height of the wood is uniform and so only a single lens camera is required. The Logitech HD Pro C920 is a high quality camera capable of providing images for processing. [2]

## Quality Control Process

Quality management will need to be conducted manually by on hand personnel. At this stage the currently proposed automation system will not detect defects or reductions in quality and so this must be supervised. The quality can be inspected at the end of each batch, not requiring inspection before progressing to the next product. This set up is a point of improvement and automatic quality control systems can be put in place after the initial implementation.

## Cycle Time and Duty Cycle

The treatment process will consist of 14 steps:

1. Conveyor moves plank into position
2. Image processing to determine position
3. Robot moves into position for first sweep
4. Robot conducts first sweep
5. Robot moves into position for second sweep
6. Robot conducts second sweep
7. Robot moves into position for third sweep
8. Robot conducts third sweep
9. Robot moves into position for fourth sweep
10. Robot conducts fourth sweep
11. Robot moves into position for fifth sweep
12. Robot conducts fifth sweep
13. Robot returns to home position
14. Conveyor removes plank.

Based on current Matlab simulations each cycle will take 60 seconds.

Our determined duty cycle is 25%. The majority of the cycle is spent moving the robot arm and plank into position while only 25% of the cycle is spent spraying the timber.

## Overall Equipment Effectiveness

The overall equipment effectiveness is a function of the performance, availability and the quality of the returned product.

In simulation the performance of the robot arm has been 100%. However, we will not know the actual robot performance of the robot until the system is implemented. We do not foresee any possible circumstances which could limit the performance of the robot and so assuming we are able to acquire the requested equipment we can predict the robot will perform similarly to the simulation.

The robot will have 24/7 available time. However, the predicted Uptime for the IRB 120 is not expected to be 24/7. The temperature of each motor will need to be carefully monitored to ensure that it does not over heat. This will reduce our uptime and overall availability. Our estimations put the robot availability at 60%. This number has room to improve as with the use of the robot we will have the ability to determine the optimal length of time the robot can operate for.

Due to the repeatability and accuracy of the IRB 120 we can expect the number of defective units to be very low. Units requiring additional treatment will likely be less than 5% of all units.

Combining our performance, availability and quality values we can predict an overall equipment effectiveness of 54%.

# Cost-Benefit Analysis

The cost of the entire setup can be found in table 2 below, the cost of the conveyor belt is not included as the existing one can be modified for use. Prices in AUD.

Table 2: Cost of Robot Setup

|  |  |
| --- | --- |
| **Item** | **Cost** |
| ABB IRB 120 | $22,000 [3] |
| Logitech HD Pro C920 | $100 [2] |
| Custom Spray Gun | $5,000 |
| Camera Rig | $2,000 |
| Robot Table | $2,000 |
| Safety Enclosure | $10,000 [4] |
| Control System | $6,000 [5] |
| Installation and Programming | $60,000 [5] |
| Running Cost | $6,000 p.a. [5] |
| **Total** | $107,100 |

## Investment Analysis

The Johnston Timber Company currently employs two employees to treat the timber. This will be reduced to one employee who will conduct quality control on the treated product. Currently these workers work at an hourly rate of $20.00 [6]. In this time they are able to treat roughly 50 planks of timber each, for a total cost of 40 cents per piece of timber. The robot arm will work 60% of the available time allowing for one day a week for maintenance. This means that the robot will process 270,000 planks of timber per year. In the first year this will result in a total savings of $102,000 with the operational costs of the robot only equalling $6,000 per annum. The payback period for the robot arm will be under 13 months. The robot can be expected to last for 10+ years, which is 9 years past the payback period. [7]

After this period the operational costs will include $6,000 per annum and $60,000 per annum for the quality inspector. This reduces the cost per piece of timber for 40 cents to 24 cents. Table 3 and figure 3 below illustrates the cumulative cost of the robot over the next five years compared to the labour costs.

Table 3: Showing Cumulative Robot costs and Labour Costs

|  |  |  |
| --- | --- | --- |
|  | **Cumulative Robot Cost** | **Cumulative Labour Cost** |
| **Year 1** | $107,100 | $60,000 |
| **Year 2** | $113,100 | $120,000 |
| **Year 3** | $119,100 | $180,000 |
| **Year 4** | $125,100 | $240,000 |
| **Year 5** | $131,000 | $300,000 |

Figure 3: Comparison of Robot and Labour costs in dollars per annum

## Strategic Analysis

With the reliability and accuracy of the IRB 120 the overall quality of the timber will increase. This will increase our product value, customer satisfaction and brand reputation. The increased reliability of the overall production process will also increase our company’s ability to secure high demand contracts showing we are able to produce the expected number of units in an accurate time frame.

## Potential Changes in Productivity and Flexibility

Currently the Johnston Timber produce 200,000 planks of treated timber per year. The automation of the treatment process has the ability to increase our production to 270,000 planks per year, a 35% increase.

The automation process will reduce our ability to handle custom treatment orders of wood not in a uniform rectangle shape. This will greatly reduce our flexibility. However, it is required to keep one of the workers to act as quality enforcement which will require significantly less time than their previous task, and so this worker can fulfil orders with non-uniform pieces of wood. The process will not affect our ability to handle custom batch sizes or sequences.

## Potential Changes to Overall Safety

There is potentially great changes to the overall safety of the Johnston Timber Company workplace through the implementation of automated robot arm. Industrial robots must conform to strict safety standards such as the AS 4024.3301 Robots for Industrial Environments – Safety Requirements and the AS 2939 Industrial Robot Systems – Safe Design and Usage. The enclosure surrounding the robot equipment will have to conform to the AS4024-1-1996 Safeguarding of Machinery – General principles. Safety Features of the system include but are not limited to:

* Several strategically placed emergency stops
* Light curtain
* Safety fencing
* An enclosed system
* Comprehensive Safe Work Procedure and Risk Assessment

All of these features will greatly improve the safety of the workplace by removing the workers for the hazardous areas. The use of industrial robots has been shown to reduce work place incidents if safety measures are properly implemented. [8] [9]

# Simulation

The following figures provide snapshots into the working of the simulation. A detailed description of the actions taking place can be found after each image.

# References

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| [8] | B. Jiang and C. J. Gainer, “A cause-and-effect analysis of robot accidents,” *Journal of Occupational Accidents,* vol. 9, no. 1, pp. 27-45, 1987. |
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