# An Object-orientedModelling for SimulatingWorkshop Consisted of Machining Center, Pallet Stocker, and Stacker Crane

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# An Object-orientedModelling for SimulatingWorkshop Consisted of Machining Center, Pallet Stocker, and Stacker Crane

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**Abstract.** This paper described a methodology to simulate production activities by using object-oriented programming language. Simulation of production to be modeled are the production activities in a workshop. The first step of modelling was defining objects that constitute the main part of a machining center. The main part of machining-center which was being modeled are column spindle, pallet fixture, pallet changer and tool magazine. From these objects can be created a new object that was an object of machining center. The next step was modeling pallet stocker and stacker crane. Pallet Stocker is a container used to store the workpiece or product on the pallet. A stocker crane is a device used to move a workpiece from the pallet stocker to a machining center or vice versa. The final step was modeling a workshop in which there are some machining centers, pallet stocker and stocker crane. Object modeled can be used to simulate a workpiece transfer activity undertaken by stacker crane from the pallet stocker to the machining center.

## 1. Introduction

Flexible Manufacturing System (FMS) is a manufacturing system that can react flexibly to changes. Two kinds of system changes can include changes to the type of product to be produced (machine flexibility), as well as changes in the order of processes in the manufacture of such products (routing flexibility). Product type changes occur because the system has completed previous work and will carry out the next job. The change the order of the production process occurs because of damage to one or multiple tools (cutting tools, jigs and fixtures) or damage to one of the machine tools.

The change the order of the production process requires the system to reschedule the jobs that have been planned. Rescheduling should be done carefully in order deadline of products still within a predetermined time limit. To estimate the events that may occur during the rescheduling need to be made a model that can give an overview of the behavior of the system when there is damage to the tools or machine tools.

The model developed is a natural object model that corresponds to its nature. Every physical entity in FMS is represented by a virtual model in the computer. Virtual objects in a computer has the information and intelligence that will be used to resolve problems faced by the system in accordance with the scope of each object.

In this paper, were developed an object model to describe an FMS consisting of several machining centers, the pallet stocker, and the stacker crane. The models were developed aiming to simulate the system graphically. Information and intelligence related to the decision-making process has not been developed. FMS models consisting of machining centers, stacker cranes, and the pallet stocker can be seen in figure 1.

Figure 1 FMS consisting of machining centers, stacker cranes, and the pallet stocker [3]

## 2. Object Oriented Programming

Object-oriented programming is a programming paradigm that is oriented to the object. All data and functions in this paradigm are wrapped in classes or objects. Any object can receive messages, process data, and send messages to other objects.

Class is a model that contains a set of attributes and methods in a unit for a particular purpose. For example, humans have the class attribute weight, height, age and then have a method to eat, drink, and sleep. Methods in a class can change the attributes possessed by the class. A class is the basis of modularity and strnctures in object oriented programming.

Attributes of a class is a global variable that is owned by a class. Attributes are also referred to as the condition / properties / fields that are part owned by a class that does not do operations, but her carried out the operation so that the value of the attribute are change. Method is a function or procedure that is created by a programmer in a class. In other words, the method in a class similar in function or procedure in procedural programming.

Object is the embodiment of class, every object will have the attributes and methods that are owned by his class, for example: amir, Ahmad, rendi an object of class man. Each object can interact with other objects in spite of coming from a different class.

Some programming language that supports object-oriented programming is java, php, perl, C #, COBOL, and Pharo 3.0. In this paper, a FMS model (Workshop model) developed using programming languages Pharo 3.0.

## 3. Collections

Collections is a class that can be used as a container for multiple objects. By placing several objects in a container, the management of objects such as displaying multiple objects with certain criteria, determine the average value of object attributes, sort objects, and look for objects with certain attributes can be done more easily.

## 4. Machining Center

Machining Center is a milling machine equipped with automatic control (CNC), automatic tool changer (ATC), tool magazine, the cooling system (coolant system) and the portions are arranged in an enclosed space (enclosure). Machining Center classified into Vertical Machining Center and Horizontal Machining Center.

This paper will be made a machining center morphic model. Morphic models made do not provide a complete picture related to the machining center. The model is only schematically illustrates the machining center. Model morphic machining center consists of a column spindle, pallet changer and tool magazine. Each part of the machining center models will be discussed in some of the following paragraph.

## 5. Modeling Column Spindle

Column spindle is part of machining center which serves to rotate the cutting tool. Column spindles consists of coulmn and spindles. Column is a machinery major construction that serves as a place or the supporting spindle. Spindle is a device to rotate the cutting tool.

Column described as a square with a certain size. Spindle described as a circle or square that is attached to the column. Spindle described as a circle when the engine modeled is vertical machining center. Spindle described as a square when the engine modeled is horizontal machining center.

Column spindle modeled as ColumnSpindleMorph classes. ColumnSpindleMorph class derived from class Morph. Some the main method owned ColumnSpindleMorph class is addSpindle, changetype, scale: and shift:. AddSpindle method serves to add a spindle to the column. When This method is executed the object will ask the type of spindle orientation to be added. Having selected the type of spindle orientation, the spindle will be added to the column in accordance with the type of spindle orientation that has been selected.

Changetype method serves to change the type of spindle orientation in ColumnSpindleMorph class. When this method is executed, then the type of spindle will change from vertical to horizontal or from horizontal to vertical.

Method scale: serves to increase or decrease the size of the object ColumnSpindleMorph. Methode scale: require parameters to be passed into the method. The parameter that is passed in the form of the desired scale value. If value is passed more than one, then the object will be enlarged. If the value is passed less than one, then the object will be reduced.

Shift: method serves to shift the Morph ColumnSpindle object to the desired position. Shift: method require parameters in the form of position must be passed into the method. ColumnSpindleMorph form can be seen in Figure 2.

## 6. Pallet Changer Modeling

Pallet changer is a device of machining center that serves to hold the workpiece and set the turn of the workpiece to be done on a machining center workspace. Pallet changer usually can load two workpieces. On top of the pallet changer attached pallet fixture and on the pallet fixture attached fixture. The workpiece to be done at the workspace machining center attached to the fixture. When the workpiece is in the work space machining center being worked the operator can load and unload the product / workpiece on pallet changer located on the outer side of the machining center.

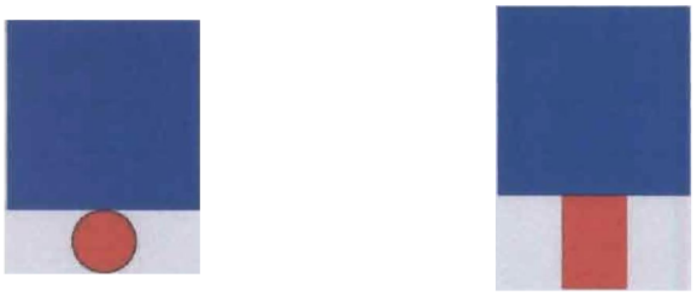

Figure 2 ColumnSpindleMorph

A combination of pallet fixture, fixture and workpiece is modeled as a PalletFixtureMorph class. PalletFixtureMorph class derived from the BorderedMorph class. PalletFixtureMorph class has a variable instant productMorph andjigMorph.

productMorph modeled as a red circle. jigMorph modeled as a yellow circle. productMorph placed on jigMorph so that both models will appear as a red circle surrounded by a yellow ring. JigMorph unity with productMorph placed in the center of PalletFixtureMorph.

The main method which is owned by PalletFixtureMorph class is scale:. Scale: method requires parameters to be passed into the method. The parameter that is passed in the form of the desired scale value. When the value is passed more than one, then the object will be enlarged. If the value is passed less than one, then the object will be reduced. PalletFixtureMorph form can be seen in Figure 3.

Figure 3 PalletFixtureMorph

After class PalletFixtureMorph completed, the next can be made PalletChangerMorph class. PalletChangerMorph class derived from the CircleMorph class. This class has a variable instant annl, ann2, palletFixtureA, and palletFixtureB. annl and ann2 described as a square of which one end attaches to a circle and its position opposing. At the ends of the open arm affixed palletFixtureA and palletFixtureB with different basic colors.

Some main method owned by the PalletChangerMorph class is changePallet, and scale:. ChangePallet method used to change the position of palletFixtureB or palletFixtureA. Scale method is used to change the class size PalletChangerMorph. PalletChangerMorph form can be seen in Figure 4.

## 7. Tools Magazine Modeling

Tools-magazine is the device of machining center that serves as a place to store several different types of cutting tools that will be used to cut the workpiece in a series of machining operations. Tools magazine described as a main circle that includes several smaller circle. Small circles are placed in main circle with a uniform distance. The circles illustrate cutting tools contained in the tools magazine. One of the small circle is colored with other color to illustrate that the cutting tool is a cutting tool that is being actively used to cut workpiece.

Figure 4 PalletChangerMorph

ToolsMagazineMorph class derived from the CircleMorph class. PalletFixtureMorph class has a variable instant cutterArray. cutterArray is a container that used as a place to store the cutting tools. Some the main method owned by ToolsMagazineMorph class is drawMagazine, changeNumberOITools:,useToolsNumber: and scale:.

DrawMagazine method used to add some cutting tools that will be placed on ToolsMagazineMorph. changeNumberOffools: method used to change the number cutting tools contained in ToolsMagazineMorph. useToolsNumber: method used to change the cutting tool modeled as a cutting tool that is being actively used to cuting workpiece. scale: method used to change the size of the object Too1sMagazineMorph.ToolsMagazineMorph form can be seen in Figure 5.

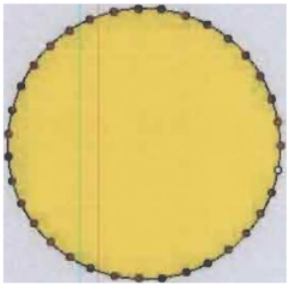

Figure 5 ToolsMagazineMorph

## 8. Machining Center Modeling

Machining centers on modeling is considered to have three main components, namely column spindle, pallet changer and tool magazine. Each component has been modeled. The models of these components can then be used as an instant variable of the model machining center.

Machining center is described as a square in which there are column spindle, pallet changer and tool magazine. MachiningCenterMorph class derived from class Morph. This class has the main variable instant csMorph, pcMorph, and tmMorph. csMorph is the object of the class ColumnSpindleMorph,pcMorph is the object of the class PalletChangerMorph, and tmMorph is the object of the class ToolsMagazineMorph.

Some the main method owned by MachiningCenterMorph class is changeColumnSpindleType, changePallet, changeToolsMagazine:, scale., shiftCenter:, useToolsNumber:. ChangeColumnSpindJeTypemethod used to change the type of machining center. If this method is executed, the type of machining center will be changed from the vertical machining center into a horizontal machining center or vice versa.

ChangePallet method used to change the position of the pallet changer. When this method is executed, the pallet changer will rotate the swivel angle of 180 °. ChangeToolsMagazinemethod used to change the number cutting tools in machining center magazine. When this method is executed, the number cutting tools that are in the magazine will change in accordance with the parameter value is entered into the function.

Scale method is used to change the size of the machining center. UseToolsNumber method used to change the current cutting tool is used to cut the workpiece. ShiftCenter method used to shift the position of machining center as far as the vector is introduced into the method. MachiningCenterMorph form can be seen in Figure 6.

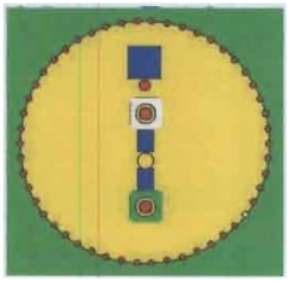

Figure 6 MachiningCenterMorph

### 9. Pallet Stocker Modeling

Pallet Stocker is a device used to store raw materials to be processed and the product of the production process. Pallet Stocker modeled as a rectangle in which there are several rectangles arranged in rows and columns.

PalletStockerMorph class derived from Morph class. This class has an instance variable rowArray and colom.Array. rowArray is a container containing colomArray class. colomArray is a container that contains objects of class SimpleButtonMorph that each object is labeled in accordance with the position of the object in a container of rowArray or colomArray.

Some method are owned by the PalletStockerMorph class is a shift: and returnPalletCoordinat:. Shift method is used to move the object PalletStockerMorph to the desired position. Method retumPalletCoordinat: used to find the coordinates of an object SimpleButtonMorph who have a specific label. PalletStockerMorph form can be seen in Figure 7.

Figure 7 PalletStockerMorph

### 10. Stacker Crane Modeling

Stacker crane is a means of transport used to move products and raw materials from machine tools to the pallet stocker or vice versa. Stacker crane considered to consist of three main components, namely the base, arms, and the end effector.

The base is the basic constmction of stacker crane that can move in a certain path. On the above of the base there is an arm that can move forward or backward. On top of arm there is end effector that can be moved to take the product or the raw materials contained in the machining center and pallet stocker.

StackerCraneMorph class derived from Morph class. This class has an instance variable arm and end.Effector. arm derived from Morph class and placed on the base. end.Effector also derived from Morph class and placed on the arm.

StackerCraneMorph class has a method goToMc: toPallet: on: which serves to take products from the machining center to be moved to the pallet stocker then take the raw material of pallet stocker to machine tools. Once the removal process is completed, the stacker crane back to its original position. StackerCraneMorph form can be seen in Figure 8.

Figure 8 StackerCraneMorph

### 11. Workshop ModeJing

Work shop being modeled has several machining center, a pallet stocker, and one stacker crane. WorkShopMorph class derived from Morph class. This class has an instance variable mcArray, pStocker, and sCrane. mcArray is a container of objects of class MaciningCenterMorph, pStocker is the object of the class PalletStockerMorph and sCrane is the object of the class StackerCraneMorph. WorkShopMorph class has several methods namely transferProductFromMc: toPallet: on:, transferWorkFromPallet: on: toMc:. Method transferProductFromMc: toPallet: on: serves to move products from the machining center to pallet stocker. Method transferWorkFromPallet: on: toMc: serves to move the raw materials from the pallet stocker to the machining center. The second method is actually a method belongs to a class stacker cranes. In this case the workshop class object only sends a message to the stacker crane so that the object perform the desired operation by the object workshop. Illustration workshop being modeled can be seen in figure 9, 10, and 11.

### 12. Conclusion

This paper has described methodology to model workshop consisting of several machining centers, pallet stocker and stacker cranes. Simulation model developed is one of the activities to move the products or raw materials from the machining center to pallet stocker or vice versa.

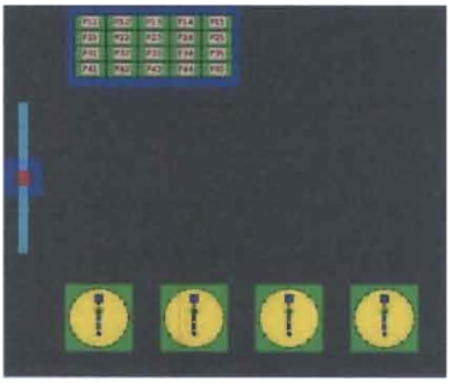

Figure 9 Workshop being modeled

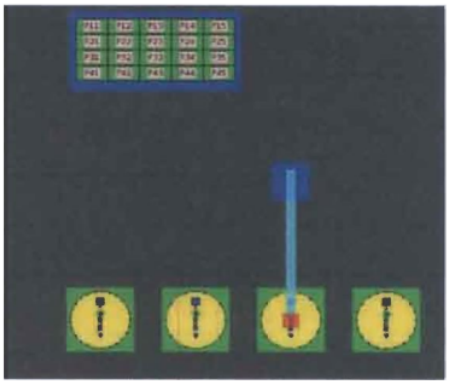

Figure 10 Stacker cranes pick up the products from the machining center

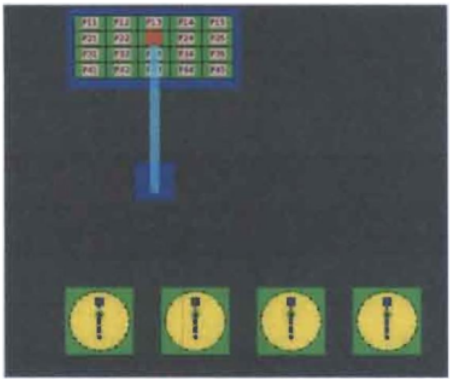

Figure 11 Stacker Crane put the product to the pallet stocker

At this modeling, workshop can manage the role of each component production without regard to how the individual components of the production completed its task. Coordination control machining center components made by machining centers, the search for raw materials in pallet stocker carried by pallet stocker, and transfer of products or raw materials from macining center to pallet stocker or vice versa performed by the stacker crane.

The model developed has not fully describe the production activity in the workshop. Activity stacker crane is still set by the user. Activity stacker crane should be the action of a workshop when one macining center has finished making a product.

The model that has been created can then be developed further by providing information and intelligence related to the decision making process. Thus the object model that have been made are expected to simulate the dynamic conditions of the production activity in workshop.

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