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WARNING

INSTALLATION SHOULD ONLY BE PERFORMED BY QUALIFIED INSTALLATION PERSONNEL AND MUST CONFORM TO ALL NATIONAL AND LOCAL CODES

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Hyundai Robot

Hi5aPA230424FMEN4

# Hi5a Controller Function Manual

## Palletize

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# 1 Overview

## 1.1. Hyundai Robotics robot palletizing software

Robot palletizing is an operation in which workpieces are picked up and placed down onto a pallet or a rack repetitively at a certain position.

To configure an efficient robot palletizing system, the conveyors and pallets should be installed by taking into consideration the robot moving path that would affect the productivity of the line.

HRpal™ v1.0 and HRpalware™ v1.0 are programs individually based on a PC (HRpal) and a TP (HRpalware) to create Hyundai Robotics robot palletizing loading pattern and job programs automatically. They make it possible to carry out quick installation and pilot operation and review to configure an efficient robot palletizing system.

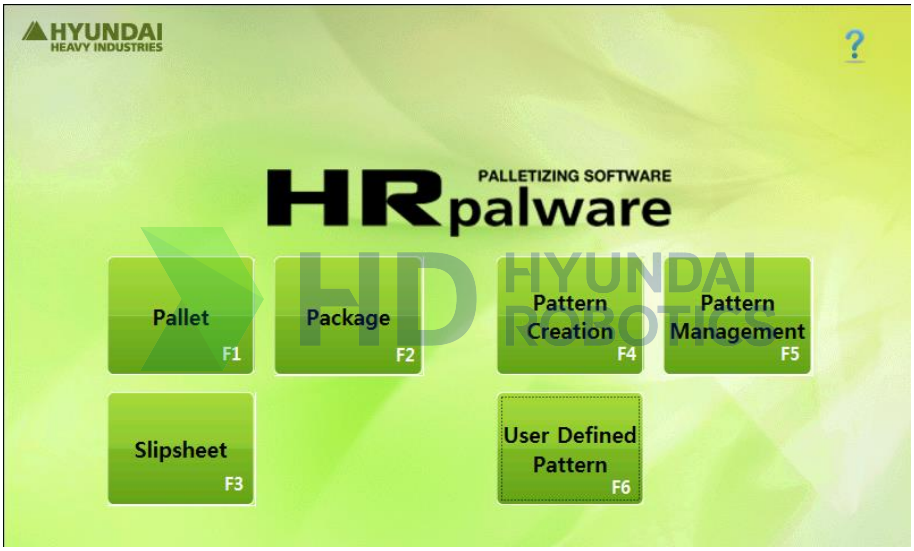


Figure 1.1 HRpalware v1.0 main screen

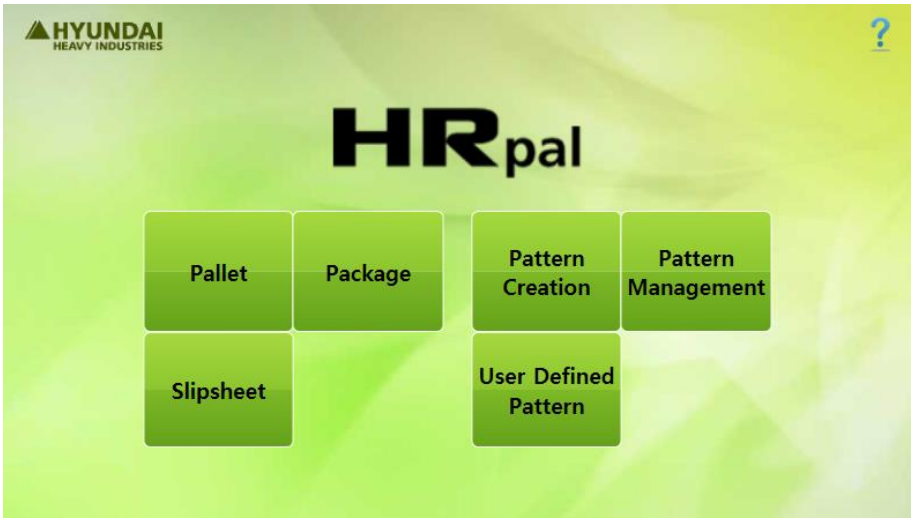


Figure 1.2 HRpal v1.0 main screen

## 1.2. Features

- Palletizing optimal loading pattern auto creating function (users can defined the pattern)
- Palletizing standard job program creating function
- Palletizing loading pattern managing function

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# 2

# HRpalware v1.0

## 2.1. HRpalware Installation

HRpalware which provided in stand-alone file is a palletizing application program based on Hi5a robot controller. An installation is able to copy the file (HRpalware_V1.exe) to ₩ResidentFlash₩Bin directory in Teach Pendant (TP511). If the palletizing is enabled, you can run this program in 『[F2: System] →[3: Application parameter] → [3: Palletizing] → [1: HRpalware].

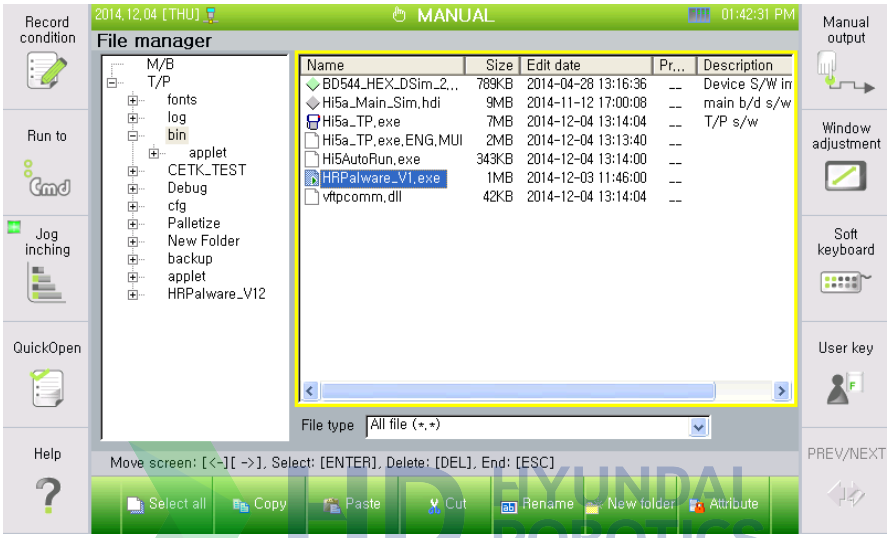


Figure 2.1 HRpalware installation directory

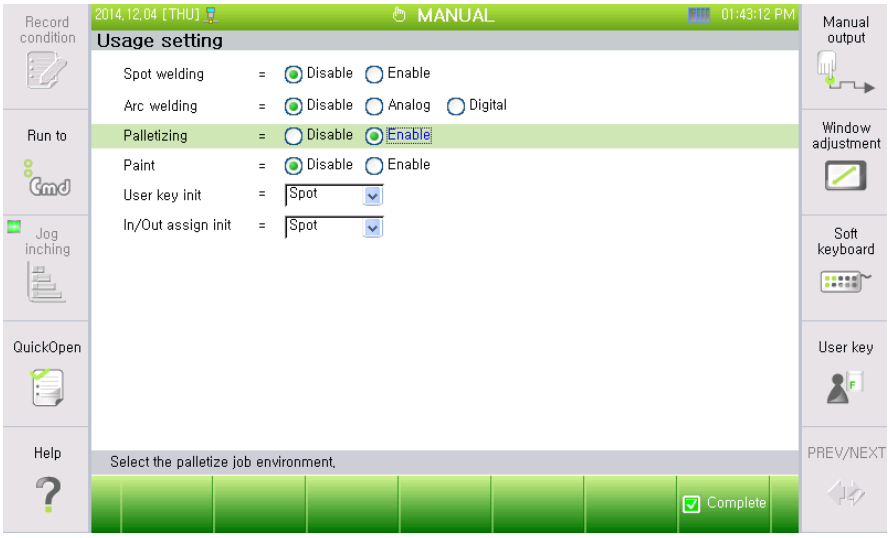


Figure 2.2 Palletizing enable switch in Usage setting menu

## 2.2. HRpalware flow chart

HRpalware can be used for 4 stages, including basic information input, pattern option setting, pattern creating, and robot application. When the 4 stages above are completed, it can be said that the configuration to palletize is very basic using an Hyundai Robotics robot. After that, palletizing can be carried out quickly only by teaching the conditions, such as robot moving path and position of the package. Refer to the following Figure 2.3 for more details.

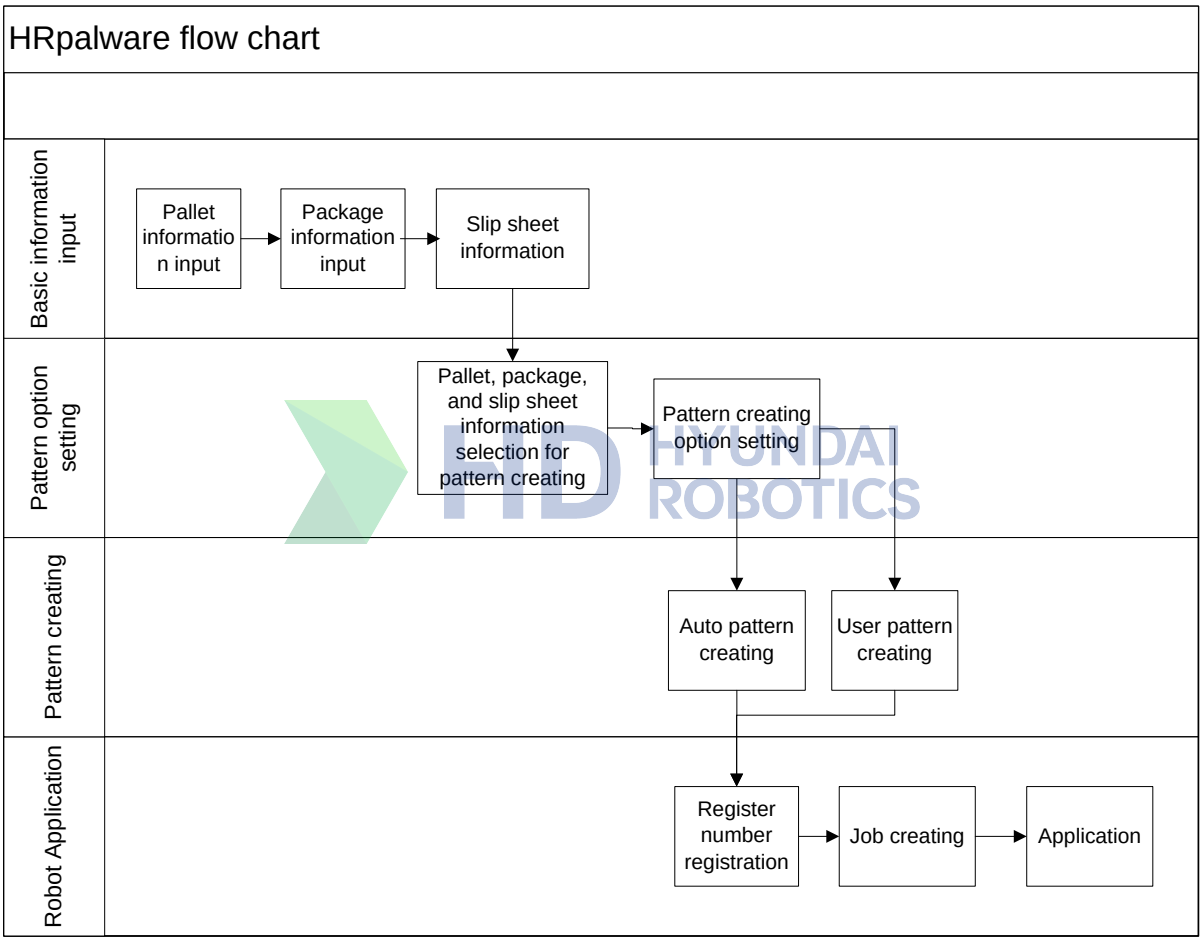


Figure 2.3 HRpalware flow chart

## 2.3. Pallet, package, and slip sheet information

### 2.3.1. Pallet information

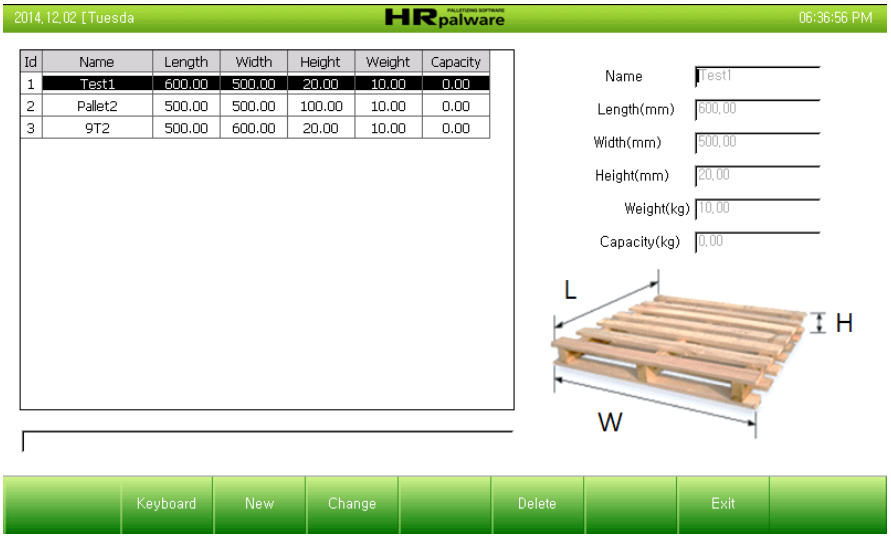


Figure 2.4 Pallet information menu

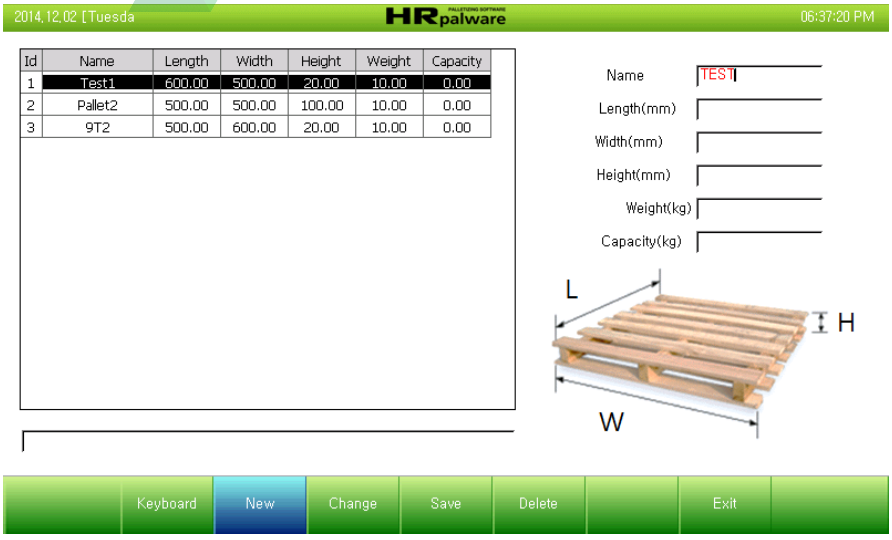


Figure 2.5 Results after pushing the New button

The pallet information consists of the name, length, width, height, weight, and weight capacity (Figure 2.4). Weight means the weight of the pallet itself, and the weight capacity means the maximum load that the pallet can endure. The button menu includes Add, Change, Delete, and Save with the following respective functions.

(1) New
The New button is used to add new data. When the New button is pressed, a soft keyboard will pop up to input the palletize name. After the input, the Save button will show up as in (Figure 2.5). After inputting the remaining data, the user shall press the Save button to save.

(2) Changing
The Change button is used to alter one of the listed items. After an item is changed, when the Save button is pressed, just like the case of using the new button, the changed content will be saved in a file.

(3) Deleting
The Delete
button is used to delete one of the listed items.

(4) Saving
The Save button is used to save the relevant content after carrying out the New or Change process.

## 2.3.2. Package and slip sheet information

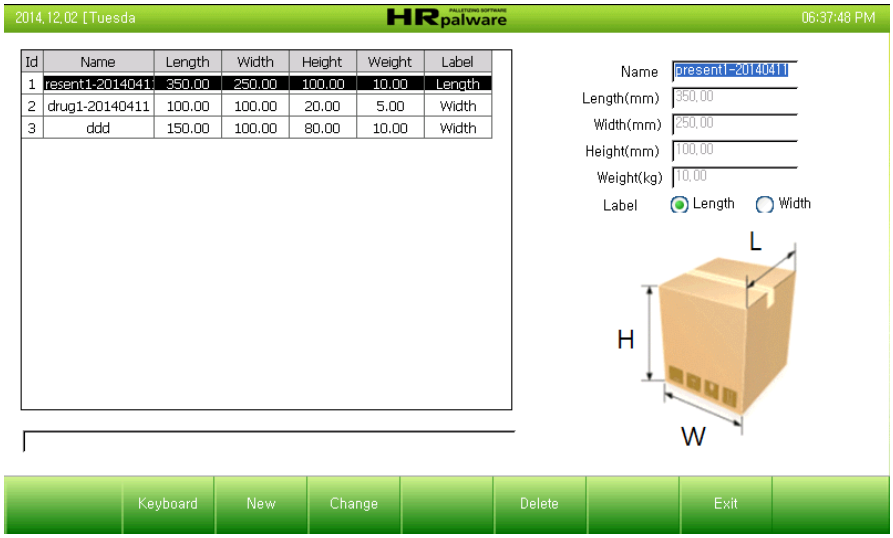


Figure 2.6 Package information menu

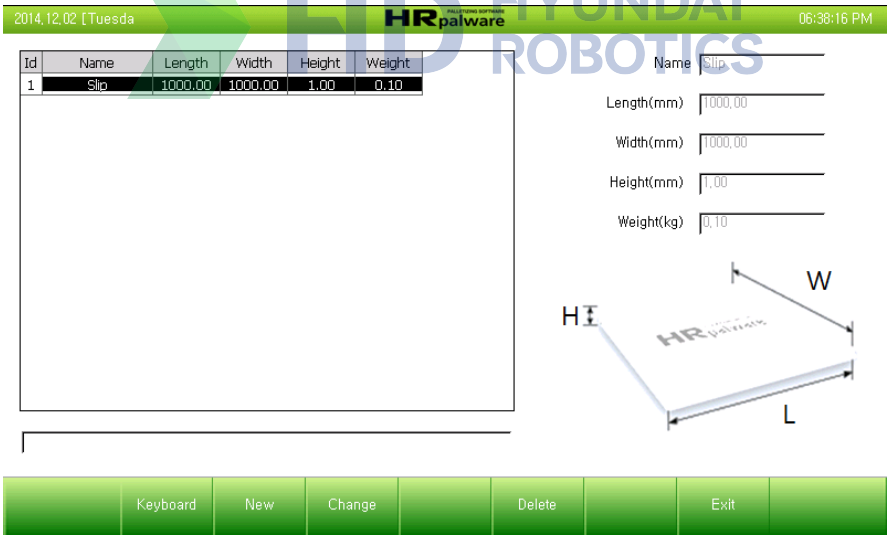


Figure 2.7 Slip sheet information menu

The package information (Figure 2.6) and the slip sheet information (Figure 2.7) can be used by inputting the name, length, width, height, and weight items. The other methods to use the information are the same with those used for the pallet information.

## 2.4. Pattern creating

### 2.4.1. Pattern creating menu

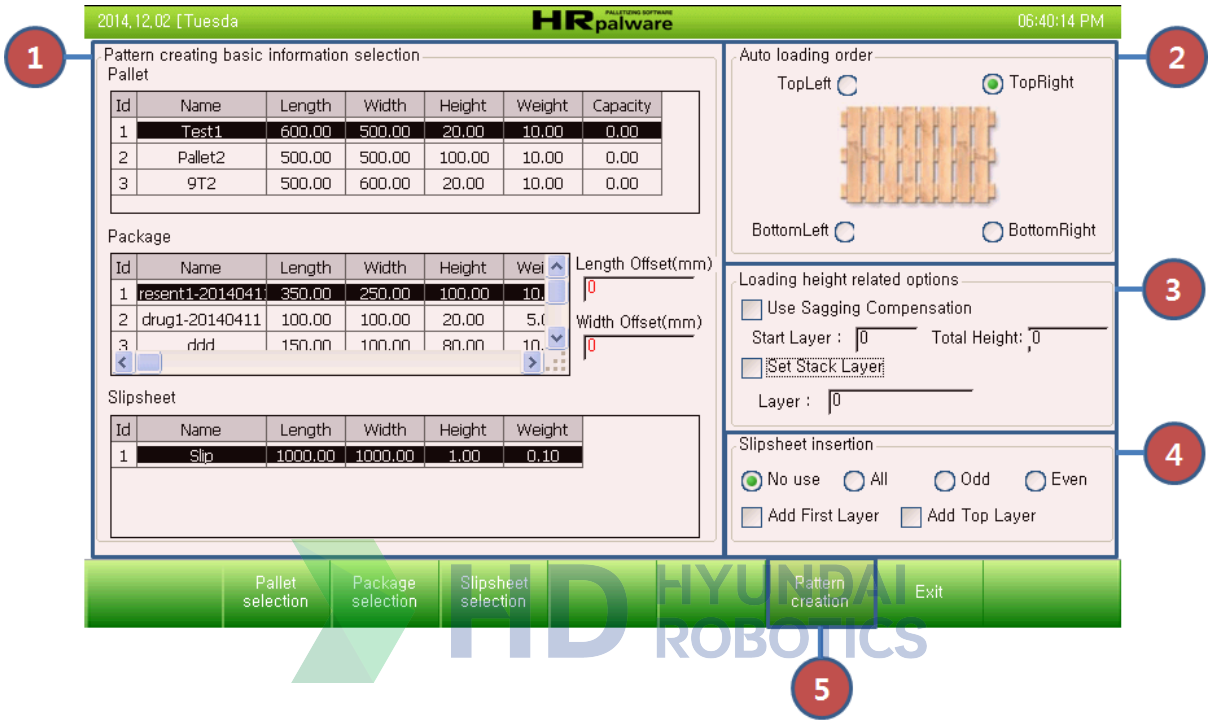


Figure 2.8 Pattern creator menu

The pattern creating menu is used to make optimal palletizing patterns by using the pallet, package, and slip sheet information (Figure 2.8). The individual menus are described below.

(1) Pattern creating basic information selection

- This shows the contents added in the above 2.3 pallet, package, and slip sheet information section. The target object for which a pattern needs to be created can be selected by clicking it.
- The package length and width offset can be used when needed to put certain intervals among individual objects.

(2) Auto loading order

- The auto loading order function is used to decide from which position, based on the pallet, the palletizing operation should start to be carried out. Basically, the top right side is the default.

(3) Loading height-related options

- HRpallware decides the layer count by taking into consideration the weight capacity of pallets. However, the layer count setting option ignores the function, and instead, it allows the user's inputted layer count to be used.
- The layer count function can be used when the layer count, such as 3 layers or 4 layers, are predefined.
- The layer sagging function is an option to take measures for a palletizing operation in which deflection results from the packages are getting layered just like in the case of bag palletizing.
- As shown in (Figure 2.9), the layer sagging function will be applied after the total compensation height is divided and distributed from the compensation starting layer to the remaining layers.

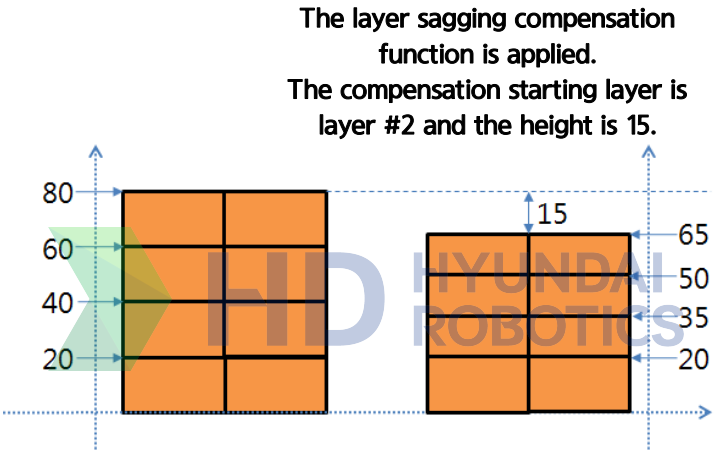


Figure 2.9 Layer sagging deflection function applied example

(4) Slip sheet insertion

- In the slip sheet option, it is possible to select among the no use, all layers, odd layer, and even layer options.
- The first layer slip sheet insertion option is to decide whether to place a slip sheet on the floor before starting the work.
- The top layer slip sheet option is to decide whether to cover the pallet with a slip sheet after completing the work.

(5) Pattern creating

- When all the options that are necessary to create a pattern are selected, the Pattern Create button will be enabled. When the button is pressed, an optimal loading pattern will be drawn based on the relevant data, bringing up a screen shown in (Figure 2.8).

### 2.4.2. Pattern creating result

The pattern creating result menu shows an optimal pattern and other patterns based on the user's selected data (Figure 2.10). When a pattern needs to be used as it is, press the Save button to save the data to extract the relevant pattern in the form of a job program through the pattern managing menu later on.
The individual functions of the pattern creating result menu are shown below.

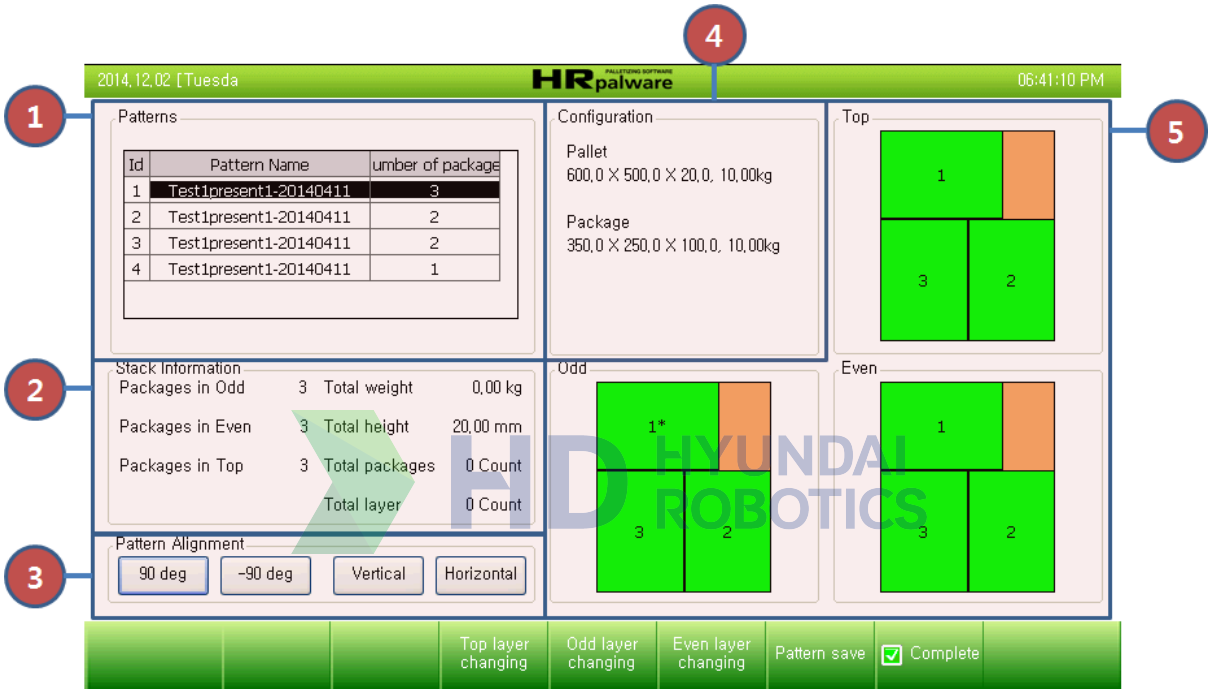


Figure 2.10 Pattern creating result menu configuration

(1) Pattern list
- This shows the lists of the pattern results created based on the user's selected data.
- Depending on selected data, the relevant contents, such as loading information, pattern shape, and configuration shape may vary accordingly.
- When the user specifically selects one of the top layer, odd layer, and even layer options shown in ⑤ and selects other list, only the relevant section will change accordingly.

(2) Loading information
- The loading information shows specific information, such as the weight and height of the selected pattern.

(3) Pattern changing
- This function is used to shift a pattern in a 90-degree direction or create a pattern symmetrically for both the left and right sides.
- When the user selects one of the top layer, odd layer, and even layer options in ⑤ of (Figure 2.10) and changes the pattern in ①, only the relevant section will change.

(4) Pattern configuration
- This shows the pallet, package, and slip sheet data used for the pattern configuration.

(5) Each layer pattern data
- This shows the pattern data of the odd, even, and top layer of the currently selected data.
- To change the pattern data of a specific layer, the screen shall be touched twice or the PF key can be used.
- Other details about the change are described in 2.5 Pattern changing.

## 2.5. Pattern changing

The pattern changing menu (Figure 2.11) has the following functions, making it possible to open a specific pattern among the odd layer, even layer, and top layer options by double-clicking it:

(1) Package position changing

(2) Loading order changing

(3) Package adding and deleting

(4) Package direction shifting

(5) Hand open direction setting

(6) Pallet coordinate origin setting

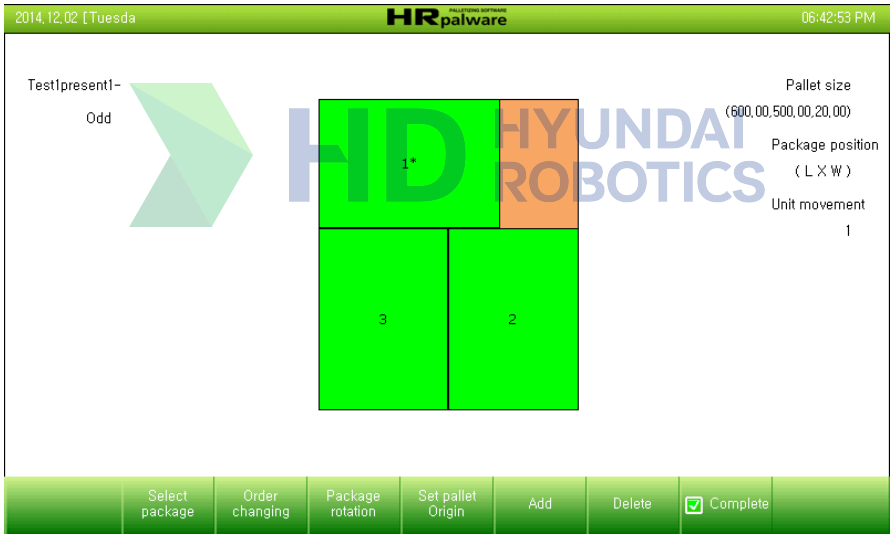


Figure 2.11 Pattern changing menu

### 2.5.1. Package position changing

The package position can be altered by applying the following methods.

(1) Move a package by touching and dragging it

(2) Select a package and change its position by using the arrow keys on the teaching pendant.

When moving using the arrow keys on the teaching pendant, it is possible to adjust the movement amount per key input by using the HI▲ and LOW▼ buttons that are used to adjust the robot speed. The adjustment range is from 1, which is the lowest, to 100, which is the highest, making it possible to adjust the position accurately.

### 2.5.2. Order changing

The order changing function is used to alter the package loading order. When the Order Change button is clicked, the loading order for all packages will be initialized as shown in (1) of (Figure 2.12) Loading order changing function. When the user touches the boxes according to the desired loading order, each box will be numbered as shown in (2) of (Figure 2.12).
At this time, when it comes to the pallet reference position, the box that was designated previously will be used as it is, and it is impossible to change the box position while the loading order change function is enabled.


(1) Loading order initialization (2) Loading order designation

Figure 2.12 Loading order changing function

### 2.5.3. Adding

Select a desired box type to add, and press the Add button. The selected box will be added (Figure 2.13).

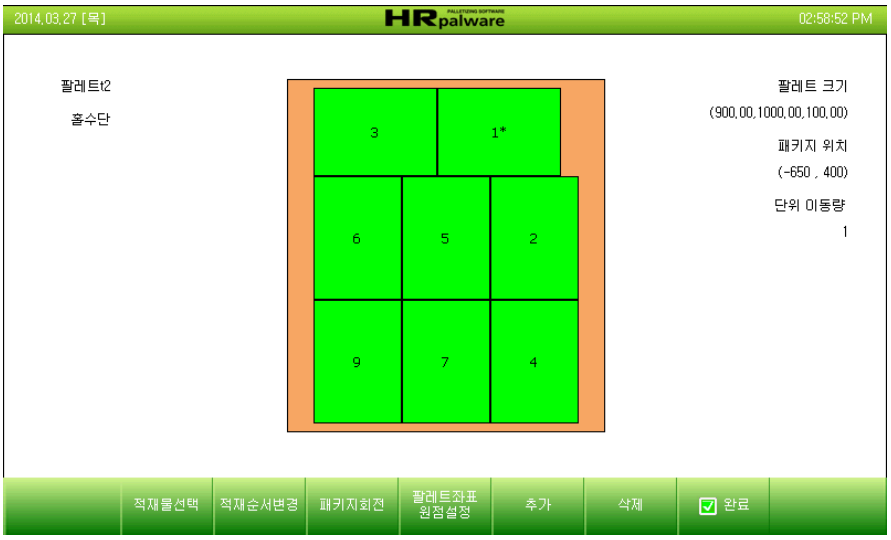


Figure 2.13 Package adding function



### 2.5.4. Direction shifting

The direction shifting function is used to shift the selected box in the horizontal or vertical direction. The following (Figure 2.14) shows the result of selecting and shifting the box #8.

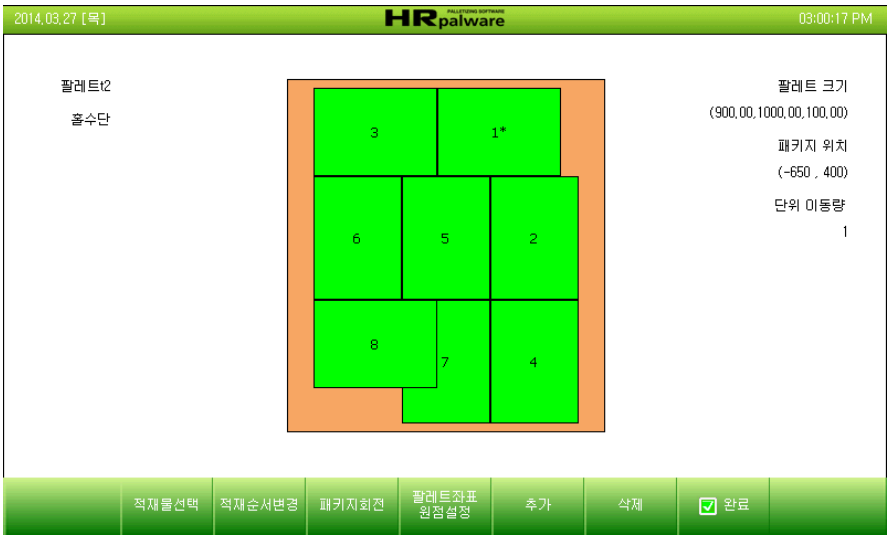


Figure 2.14 Package direction shifting function

## 2.5.5. Deleting

The deleting function is used to delete a specific package from a pattern. Select a package to delete, and press the Delete button so selected package will disappear. At this time, the packages in the later order than the deleted package will be rearranged in their loading order (Figure 2.15).

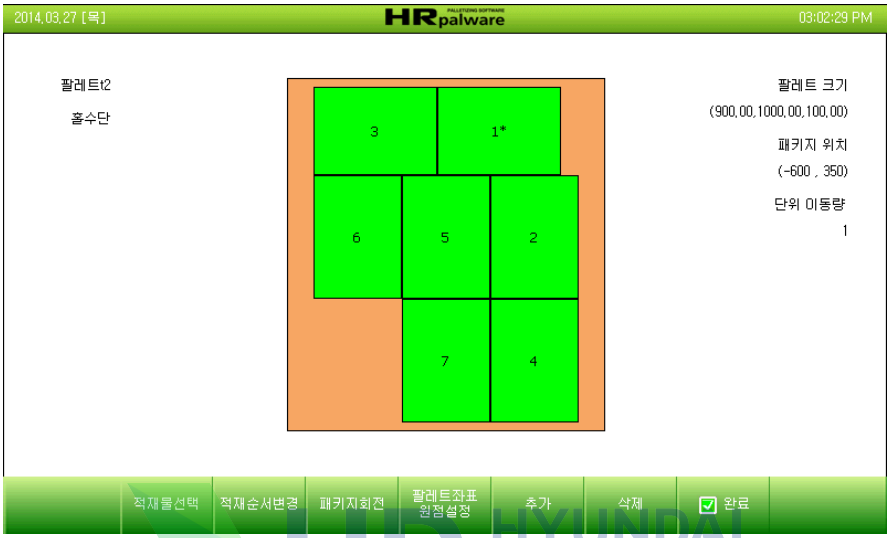


Figure 2.15 Package deleting

### 2.5.6. Pallet coordinate origin setting

In the standard job program to be created by using HRpalware, the loading pattern will be created based on the pallet coordinate. The pallet coordinate means a coordinate defined by the user on the pallet. As shown in Figure 2.16, the coordinate, similar to the shape of the right hand, is used.
Because the position, direction, and shape of pallets may vary in each case, the users are required to carry out teaching for the origin, X-axis direction, and Y-axis direction on the pallet directly. The pallet coordinate origin is a reference point to carry out the teaching of the pallet coordinate. Basically, the default is the odd layer workpiece #1. However, for the sake of user's convenience, it is possible to set other workpiece as the origin by using the pallet coordinate origin setting function.
Select the workpiece for which the pallet coordinate origin needs to be changed, and click the pallet coordinate origin setting button. Then, the * mark will be displayed on the workpiece on the relevant position, and the origin will be changed (Figure 2.16).

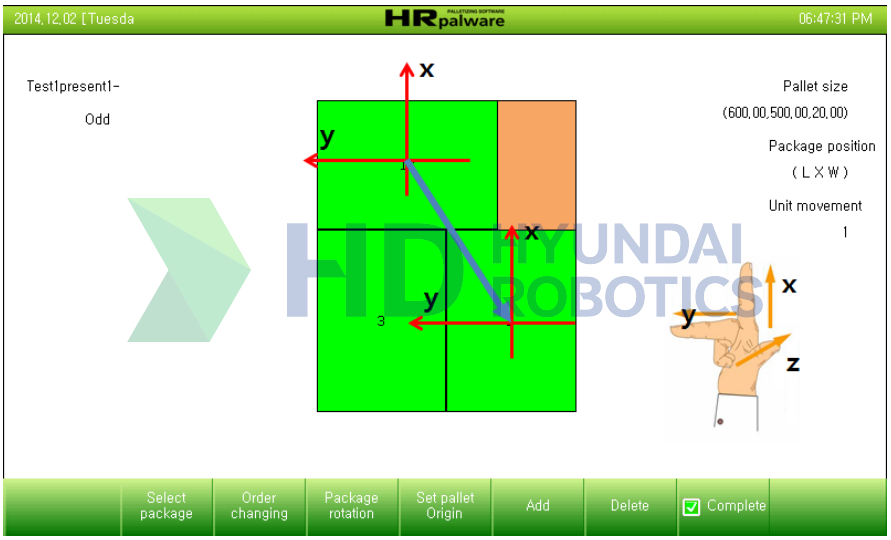


Figure 2.16 Pallet coordinate origin setting function

## 2.5.7. Hand open direction setting

The palletizing gripper is to be placed downward from above without the need to differentiate the direction as shown below. However, in some cases, the need to open the hand in specific direction (Figure 2.17) shall be considered. The hand open direction function is to designate the direction for a hand in which the hand open direction shall be considered.

Figure 2.17 Palletizing grippers

After selecting each package, press the Shift + arrow keys of the teaching pendant to designate the hand open direction. In this case, the arrow means that the hand will be open in the arrow direction. Also, the designated data are to be used to calculate and save the rotational direction of the hand when a job program is created later.

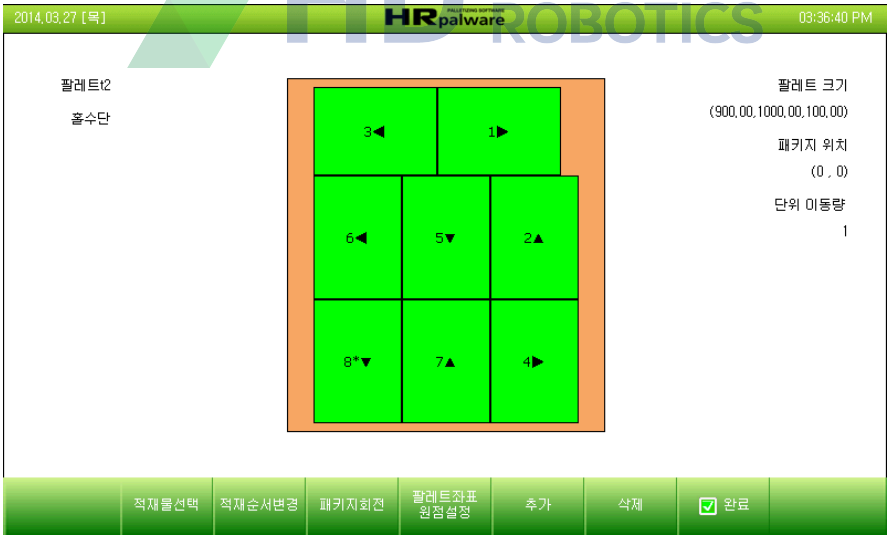


Figure 2.18 Hand open direction designation function

## 2.5.8. Completing

The Complete button is used to reflect any alteration, such as position changing or deleting after such alteration is made. When the Complete button is pressed, the relevant window will close automatically, making it possible to check if a change is made in the content of the selected layer.

## 2.6. Pattern managing

The pattern managing function is a menu to manage the patterns previously created by the user (Figure 2.19). This menu can be used to create a job program or generate a POSE file. Pattern register is a number that corresponds to a relevant pattern that is to be used in the job program and can be designated by inputting it directly. When it comes to the patterns for which the hand direction needs to be set, it is possible to designate and use relevant options.

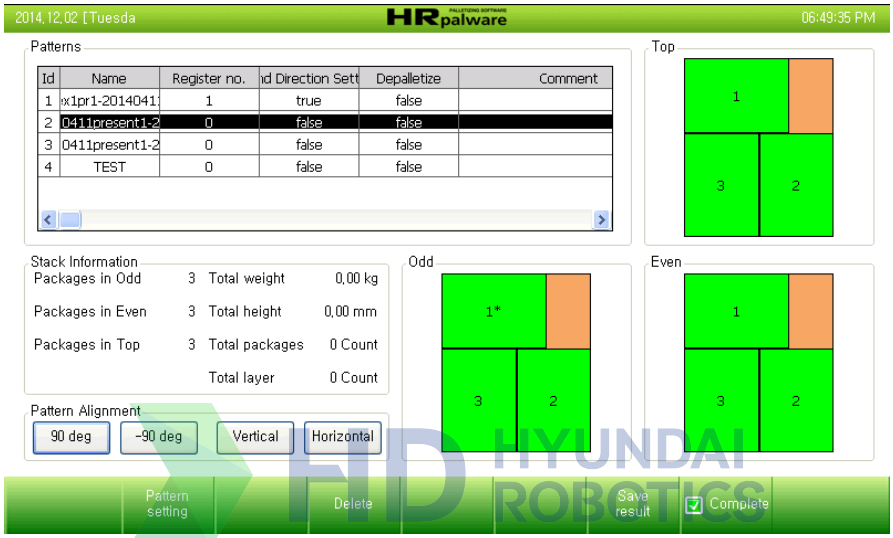


Figure 2.19 Pattern managing function

## 2.6.1. Pattern setting

The pattern setting function is used to carry out various settings related to pattern, such as pattern name, register number, and layer sagging compensation option (Figure 2.20).

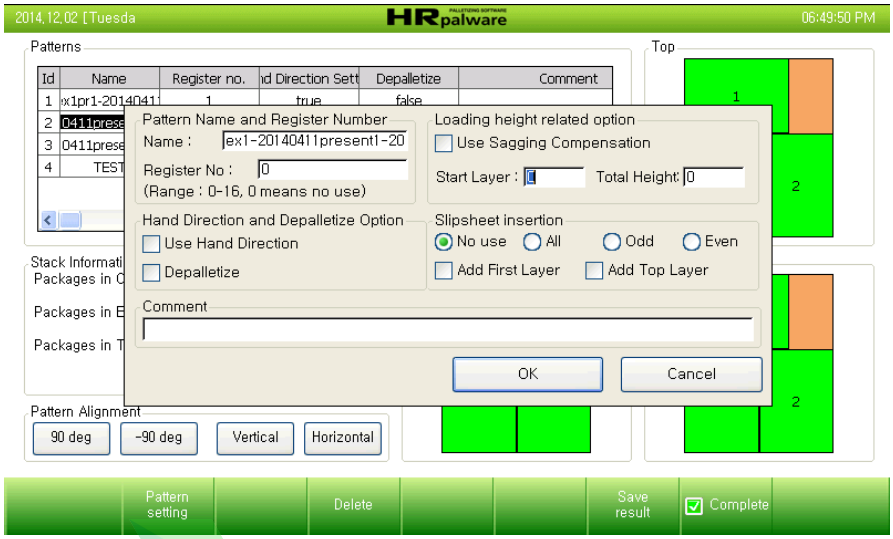


Figure 2.20 Option change menu

The hand direction setting option is used to ensure that the directions designated in [2.5.7 Hand open direction setting] are reflected when the standard job program is created. While the hand direction is designated, if the hand direction setting option is not enabled, the hand direction will not be reflected normally.

The depalletizing option is used when there is a need to create a depalletizing job program based on the same pattern and not for the palletizing job. The job programs at this time are mostly similar in their shape, but the pickup and place down positions are reverse in results.

### 2.6.2. Deleting and saving of change results

- The Delete button is used to delete the currently saved patterns.
- The Pattern Save button is used to save the content of a pattern being partially changed or altered into a file.

### 2.6.3. Completing

The Complete button is used to save the pattern change result and create a standard program for the patterns for which pattern register numbers are assigned, making it possible for 2 output functions to be carried out. In case of the standard program, it will be saved immediately in the controller, making it possible to check. You can check more details about [4. Palletizing standard program]

- Create and produce a standard program to make it possible to use the patterns in which pattern register numbers are assigned in the robot.
- The pattern registers numbers that can be assigned range from 1 to 16, while they cannot be assigned in duplication.
- When the Job Create button is pressed, a menu will be displayed to select a folder to save the job program. Select the relevant folder and click the Check button. Then, the job program will be saved in the folder.
- If the user does not want to create a job program for a pattern, the register shall be changed to 0.

## 2.7. User pattern defining

The user pattern defining function is for the user to create a pattern by arranging packages arbitrarily (Figure 2.21). Different from the auto pattern creating function, this function makes it possible to create a pattern by arranging different packages. The following show the order of using the function.

(1) Select a pallet that is to be placed on the floor.

(2) Select a package to load.

(3) Configure a pattern by using the adding, direction shifting, and deleting functions.

(4) Place the created pattern on the center by using the pattern editing function, including the clockwise or anticlockwise direction.

(5) Define the pattern for the odd layer and the top layer by using the same methods as shown above.

(6) You can use the same pattern as the odd layer by using the (*) odd layer copy function.

(7) Designate based on the layer sagging compensation or slip sheet insertion.

(8) Press the Complete [1] button and designate the pattern name to save as well as the number of layers of the pattern, and the pattern registration will be completed.

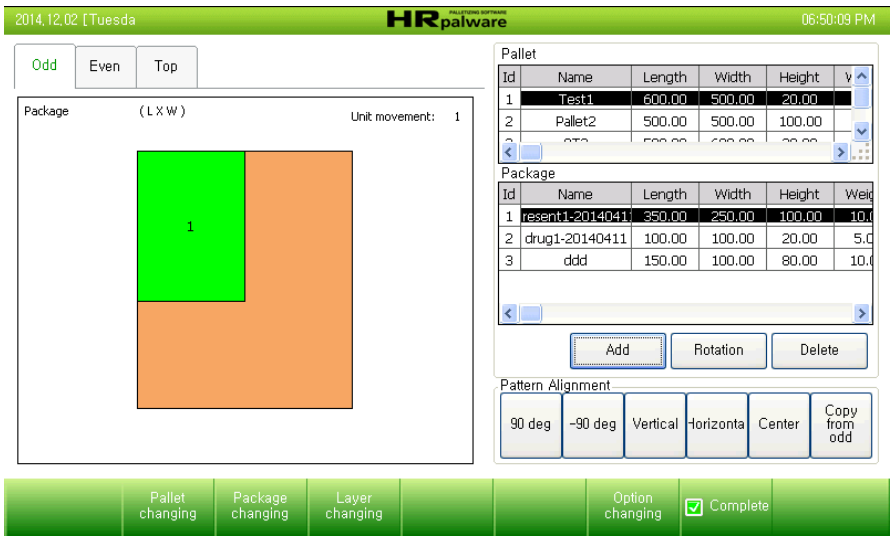


Figure 2.21 User pattern defining menu

[1]The completing function can be carried out only when the data for the odd layer, even layer, and top layer are filled out completely.

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# 3

# HRpal v1.0

## 3.1. HRpal flow chart

HRpal is PC-based application software for palletizing. Because it has completely the same functions as HRpalware, there is no big difference when using it. The function to create a HRSpace3 simulating project file is added.

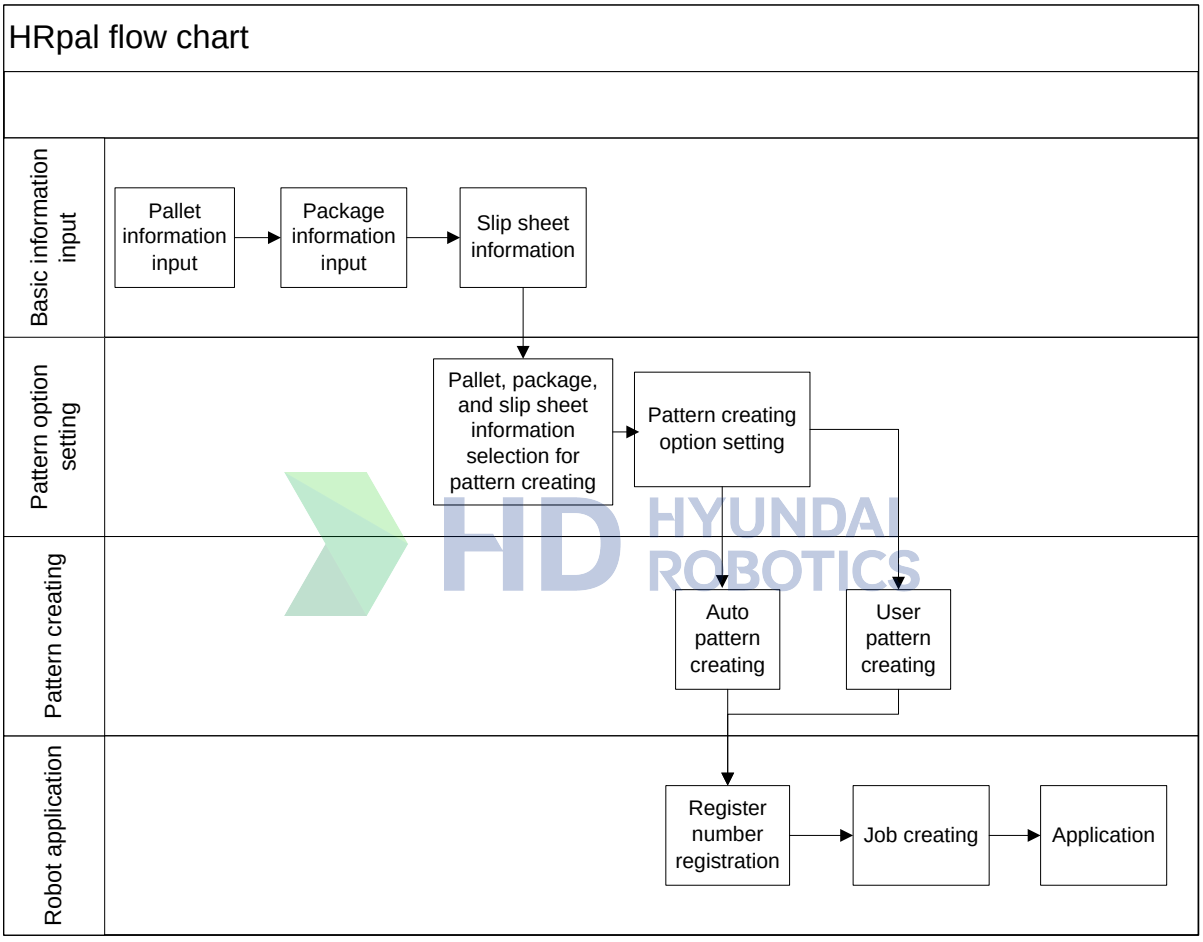



Figure 3.1 HRpal flow chart

## 3.2. Pallet, package, and slip sheet information

### 3.2.1. Pallet information

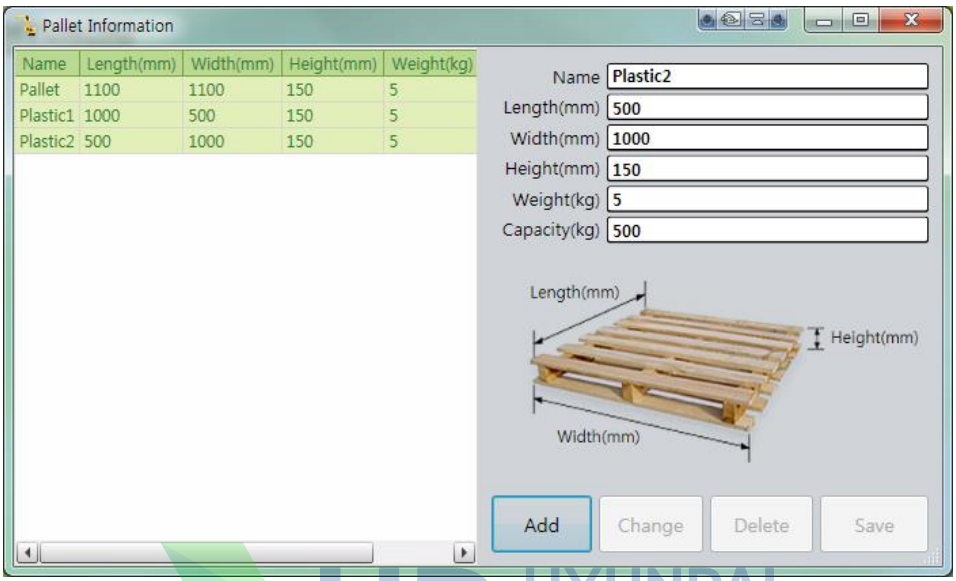



Figure 3.2 Pallet information menu

The pallet information consists of the name, length, width, height, weight and weight capacity (Figure3.2). Weight means the weight of the pallet itself and the weight capacity means the maximum load that the pallet can endure. The button menu includes Add, Change, Delete, and Save with the following functions individually

(1) Adding
The Add button is used to add new data. It will be enabled normally when all data are inputted.

(2) Changing
The Change button will be enabled when an item on the list on the left is selected. When one item of the list is selected, the relevant content will be displayed on the right side. Then, change the content and press the Change button, and the changed content will be saved in a file automatically.

(3) Deleting
Just like the Change button, the Delete button will be enabled when one item on the list on the left is selected. However, different from the Change button, the content will not be saved in a file automatically.

(4) Saving
The Save button is used to save relevant content after using the Delete button.

### 3.2.2. Package and slip sheet information

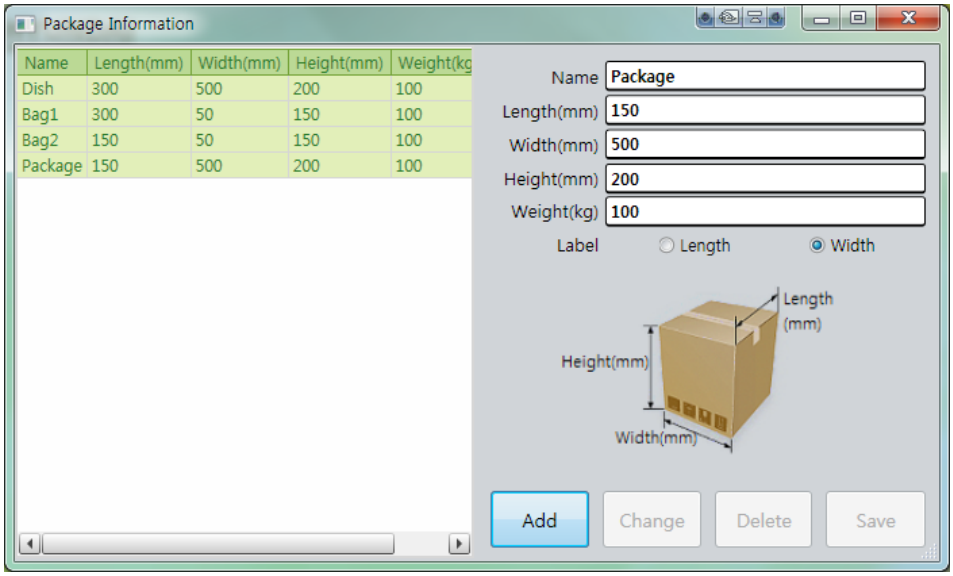



Figure 3.3 Package information menu

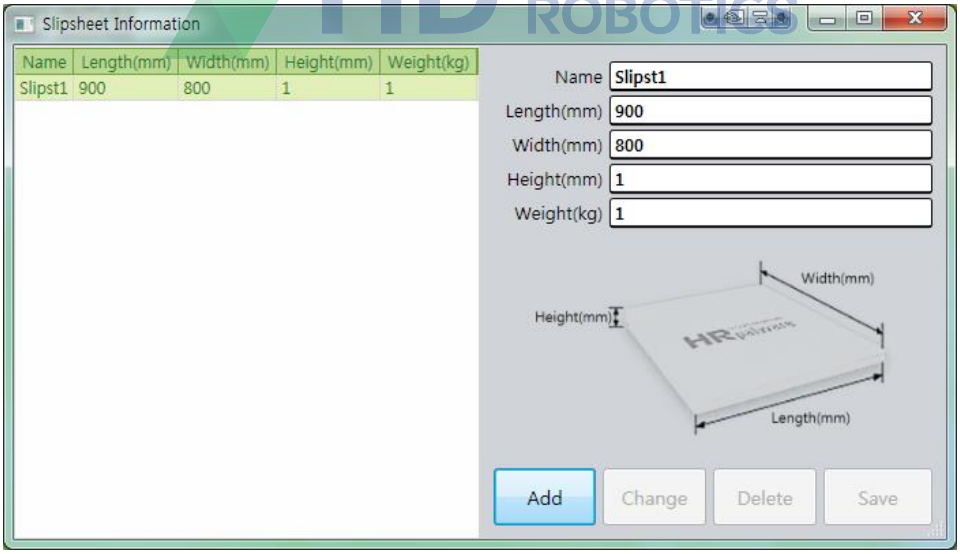



Figure 3.4 Slip sheet information menu

The package information (Figure 3.3) and the slip sheet information (Figure 3.4) can be used by inputting the name, length, width, height, and weight items. The other methods to use the information are the same with those used for the pallet information.

## 3.3. Pattern creating

### 3.3.1. Pattern creating menu

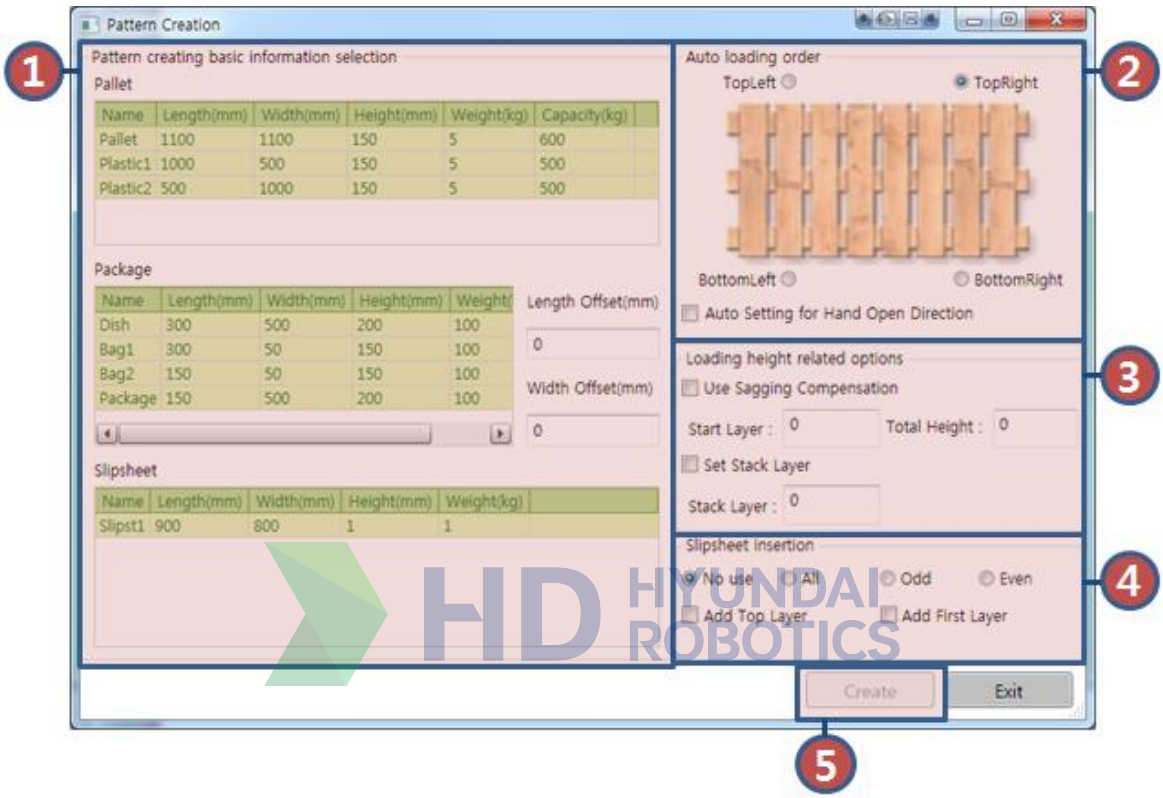



Figure 3.5 Pattern creator menu

The pattern creating menu is used to make optimal palletizing patterns by using the pallet, package, and slip sheet information (Figure 3.5). Individual menus are described below.

(1) Pattern creating basic information selection
This shows the contents added in the above 3.2 Pallet, package, and slip sheet information section. The target object in which a pattern shall be created can be selected by clicking it.
The package length and width offset can be used when there is a need to put certain intervals among individual objects.

(2) Auto loading order
The auto loading order function is used to decide from which position, based on the pallet, the palletizing operation should start to be carried out. Basically, the top right side is the default.

(3) Loading height related options

HRpal decides the layer count by taking into consideration the weight capacity of pallets. However, the layer count setting option ignores the function and allows the user's inputted layer count to be used instead.

The layer count function can be used when the layer count, such as 3 layers or 4 layers, are predefined.

The layer sagging function is an option to take measures for a palletizing operation in which deflection results from the packages are getting layered just like the case of bag palletizing. For more details, refer to [3.3.1 Pattern creating menu].

(4) Slip sheet insertion

In the slip sheet option, it is possible to select among the no use, all layers, odd layer, and even layer options

The first layer slip sheet insertion option is used to decide whether to place a slip sheet on the floor before starting the work.

The top layer slip sheet option is used to decide whether to cover the pallet with a slip sheet after completing the work.

(5) Pattern creating

When all the options necessary to create a pattern are selected, the pattern creating button will be enabled. When the button is pressed, an optimal loading pattern will be drawn based on the relevant data, bringing up a screen shown in (Figure 3.6)

### 3.3.2. Pattern creating result

The pattern creating result menu shows an optimal pattern and other patterns based on the user's selected data (Figure 3.6). When a pattern shall be used as it is, press the Save button to save the data so it is possible to extract the relevant pattern in the form of a job program through the pattern managing menu later.
The individual functions of the pattern creating result menu are shown below.

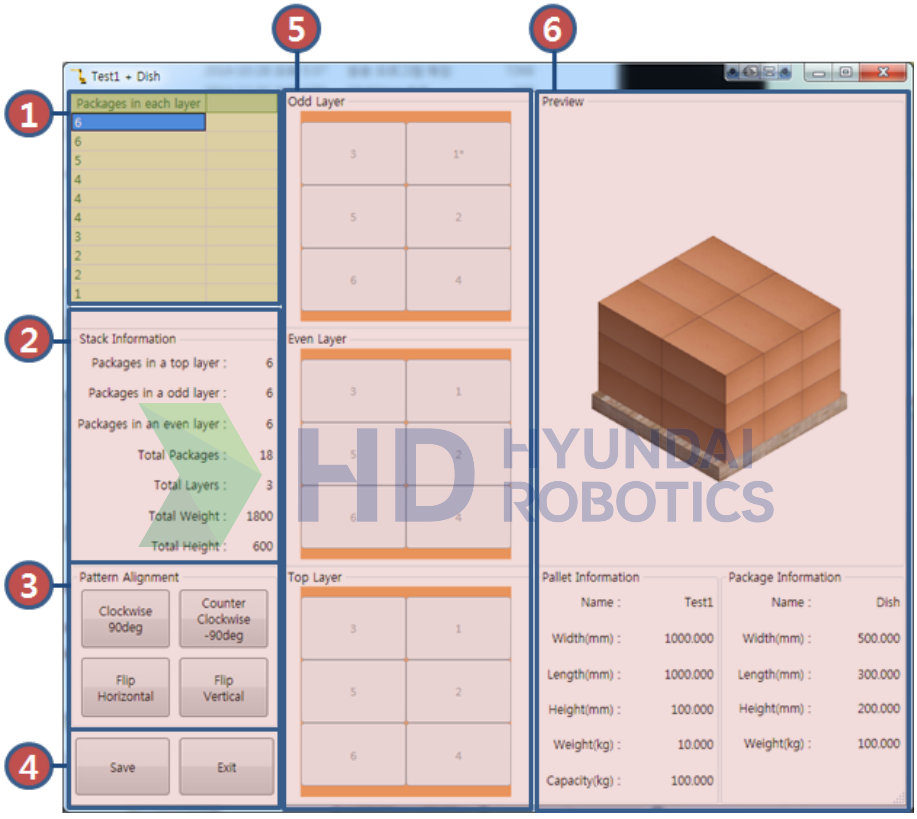



Figure 3.6 Pattern creating result menu configuration

(1) Pattern list
This shows the lists of the pattern results created based on the user's selected data.
Depending on selected data, the relevant contents, such as loading information, pattern type, and configuration type, may vary accordingly.
When the user specifically selects one of the top layer, odd layer, and even layer shown in ⑤ and selects other list, only the relevant section will change accordingly.
**(Caution) If there are more packages on the top layer than on the odd and even layers, the number of packages of all the odd and even layers should be adjusted to the number of packages on the top layer.**

(2) Loading information
The loading information shows specific information, such as weight and height.

(3) Pattern changing
This function is used to shift a pattern in a 90-degree direction or creating a pattern symmetrically for both the left and right sides.
When the user selects one of the top layer, odd layer, and even layer in ⑤ of (Figure 3.6) and changes the pattern, then only the relevant section will change.

(4) Saving and ending
This function is used to save and end a pattern.

(5) Each layer pattern data
This shows the pattern data of the odd layer, even layer, and top layer related to the currently selected data.
To change the pattern data of a specific layer, the mouse should be double-clicked.
The other details about changing are described in [3.4. Pattern changing].

(6) Configuration shape
This shows the expected configuration shape of the current pattern data in 3-D.
It is possible to adjust the angle that enables it to be seen by using left or right button of the mouse.
The bottom section shows the pallet and package information that is used to make the currently created pattern.

## 3.4. Pattern changing

The pattern changing menu (Figure 3.7) has the following functions, making possible to open a specific pattern among the odd layer, even layer, and top layer by double-clicking it.

(1) Package position changing

(2) Loading order changing

(3) Package adding and deleting

(4) Package direction shifting

(5) Hand open direction setting

(6) Pallet coordinate origin setting

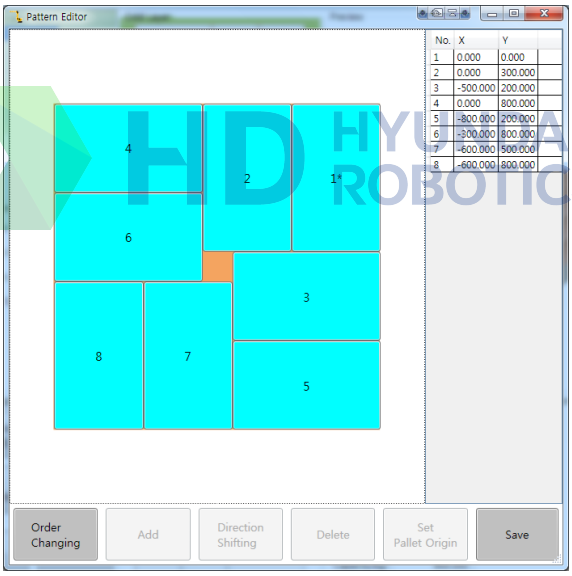



Figure 3.7 Pattern menu changing

### 3.4.1. Package position changing

The package position can be altered by applying the three following methods

(1) Select a package with a mouse and change its position by the drag and drop function.

(2) Select a package and change its position by using the arrow keys on the keyboard.

(3) Input the X and Y values on the grid window directly.

If interference between workpieces occurs while changing their positions, the objects that are interfering with each other will be displayed in red as shown in (Figure 3.8).

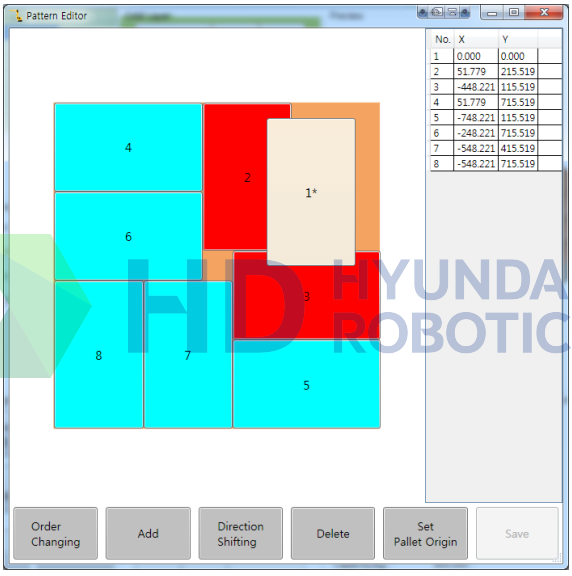



Figure 3.8 Interference occurring mutually while changing the pattern

In addition, a box could be arranged outside the pallet, and if its center is out of the pallet, the box will be displayed in red (Figure 3.9).

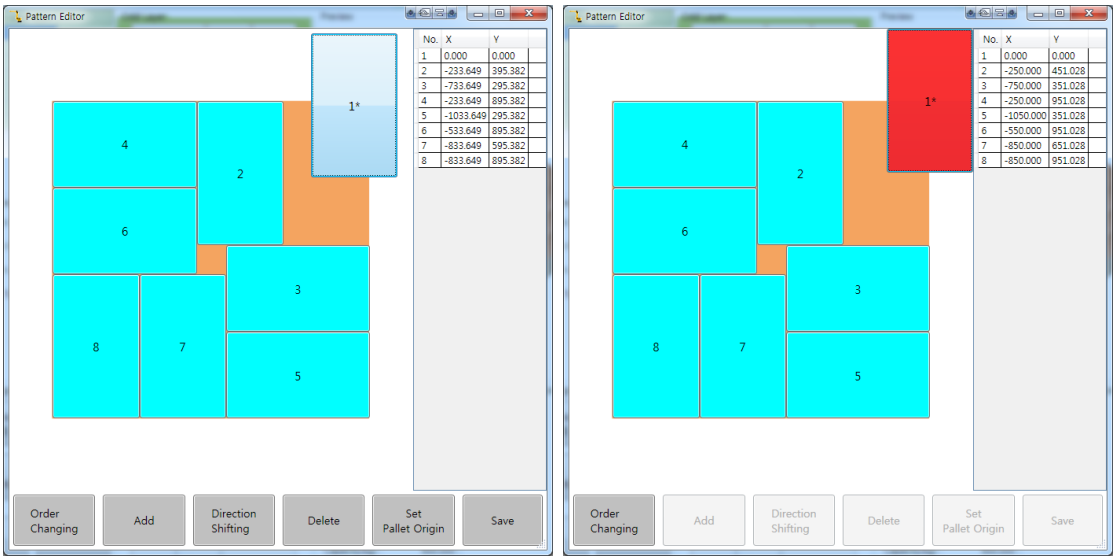
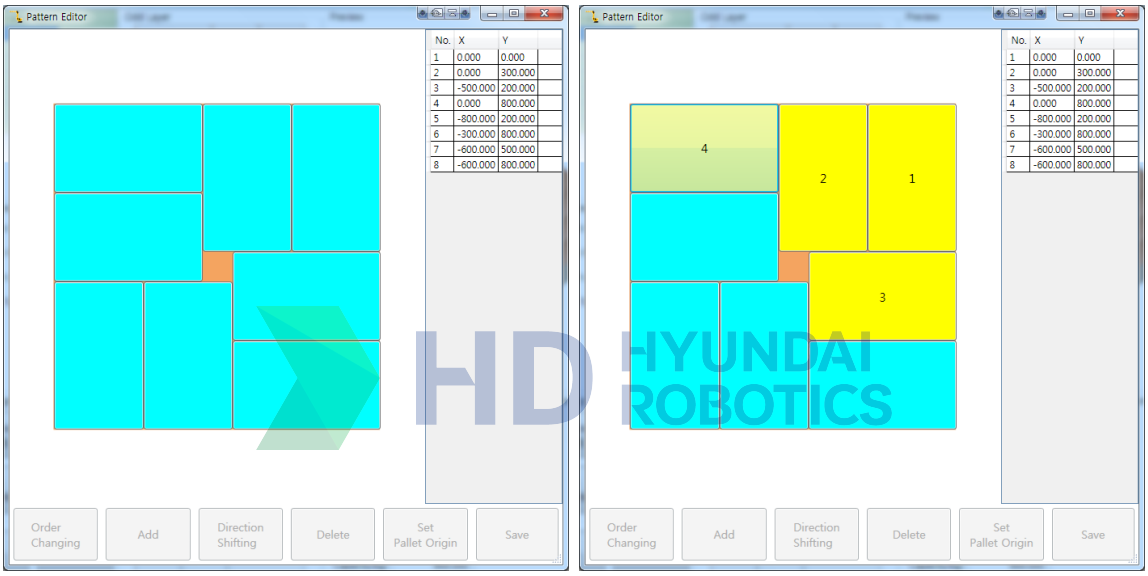



Figure 3.9 The center of gravity of a package moving outside the pallet

### 3.4.2. Order changing

The order changing function is used to alter the package loading order. When the order changing button is clicked, the loading order for all packages will be initialized as shown in (1) of Figure 3.10 Loading order changing function. When the user touches the boxes using a mouse according to the desired loading order, each box will be colored in yellow and numbered as shown in (2) of Figure 3.10.
If there is a need to change the number after a specific number during the changing process, the box of the relevant number needs to be clicked. Then, all the changes previously made after the number will be initialized all, while the changes before the number will remain. However, it is designed that the pallet coordinate reference point will be changed to the odd layer order #1.




(1) Loading order initialization (2) Loading order designation

Figure 3.10 Loading order changing function

### 3.4.3. Adding

Select a box of desired shape to add and press the Add button. A box with the same shape as selected) will be added (Figure 3.11)

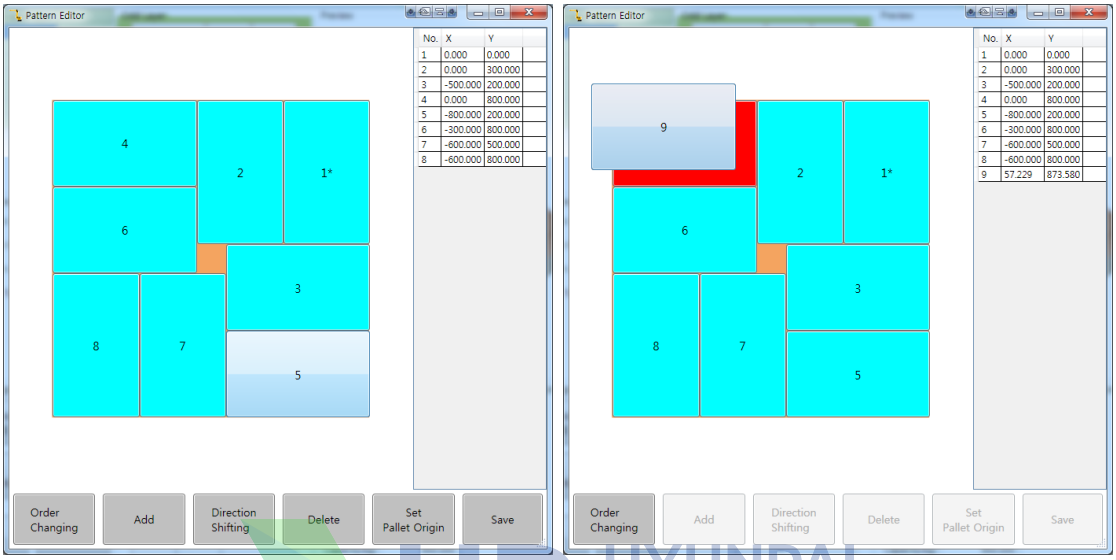



Figure 3.11 Package adding function

### 3.4.4. Direction shifting

The direction shifting function is used to shift the selected box in the horizontal or vertical direction. (Figure 3.12) below shows the result of selecting, shifting, and rearranging the box #3.

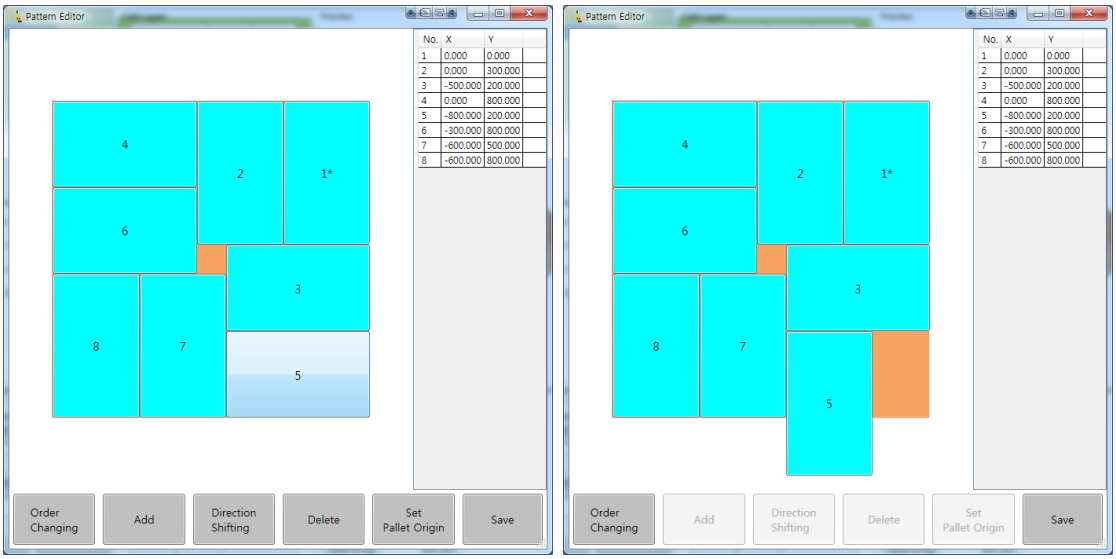



Figure 3.12 Package direction shifting function

### 3.4.5. Deleting

The deleting function is used to delete a specific package from a pattern. Select a package to delete and press the Delete button so the selected package will disappear. At this time, the packages in the later order than the deleted package will be rearranged in their loading order. (Figure 3.13)

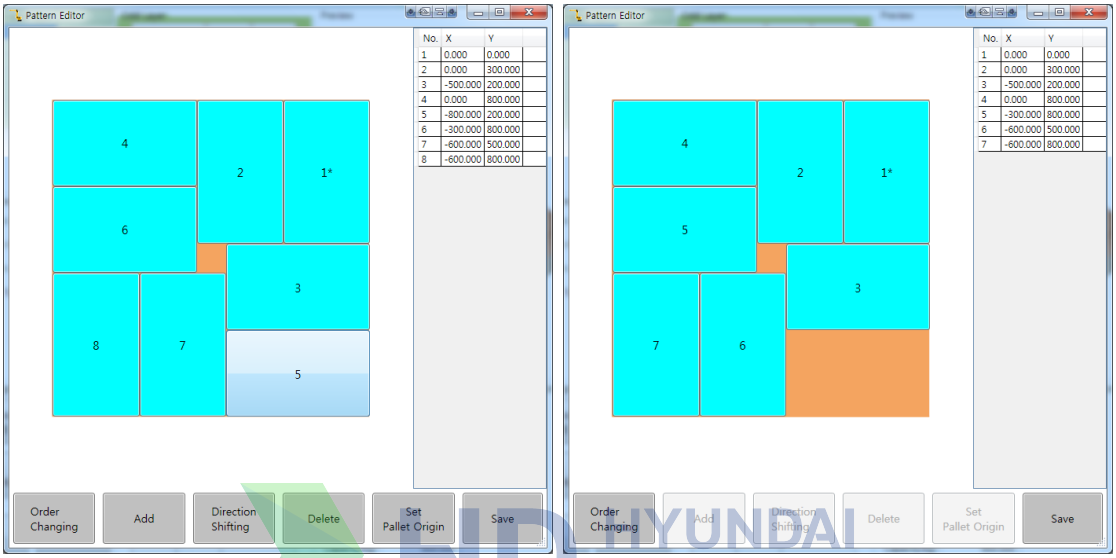



Figure 3.13 Package deleting

### 3.4.6. Pallet coordinate origin setting

In the standard job program to be created by using HRpal, the loading pattern will be created based on the pallet coordinate. The pallet coordinate means a coordinate defined by the user on the pallet. As shown in Figure 3.14 below, the coordinate, which of the same shape as a right hand is used.
Because the position, direction, and shape of pallets may vary in each case, the users are required to carry out teaching for the origin, X-axis direction, and Y-axis direction on the pallet directly. The pallet coordinate origin is a reference point to carry out the teaching of the pallet coordinate. Basically, the default is the odd layer workpiece #1. However, for the sake of user's convenience, it is possible to set other workpiece as the origin by using the pallet coordinate origin setting function.
Select the workpiece for which the pallet coordinate origin needs to be changed, and click the pallet coordinate origin setting button. Then, the * mark will be displayed on the workpiece on the relevant position, and the origin will be changed (Figure 3.14).

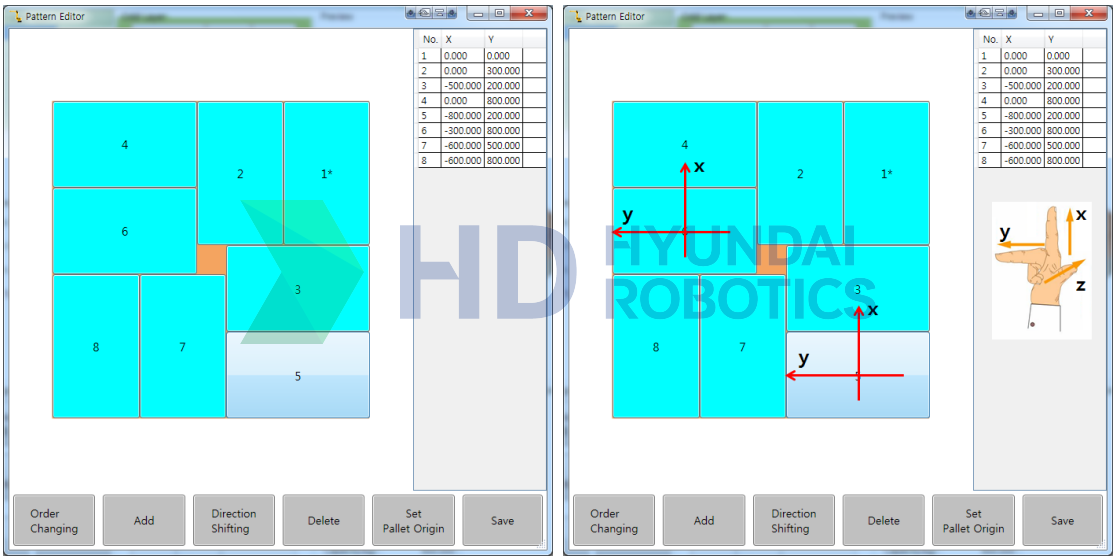



Figure 3.14 Pallet coordinate origin setting function

### 3.4.7. Hand open direction setting

The palletizing gripper is to be placed downward from above without the need to differentiate the direction as shown below. However, in some cases, the need to open the hand in a specific direction shall be considered (Figure 3.15). The hand open direction function is used to designate direction for a hand in which the hand open direction shall be considered.

Figure 3.15 Palletizing grippers

When the mouse right button is clicked on each package, the arrow direction key will be enabled, making it possible to automatically designate the direction as up, down, left, or right by moving the mouse (Figure 3.16). If the user does not want to designate the direction, click the mouse left button on the center right after pressing the mouse right button.
In this case, the arrow means that the hand will be opened in the arrow direction. Also, the designated data are to be used to calculate and save the rotational direction of the hand when a job program is created later.

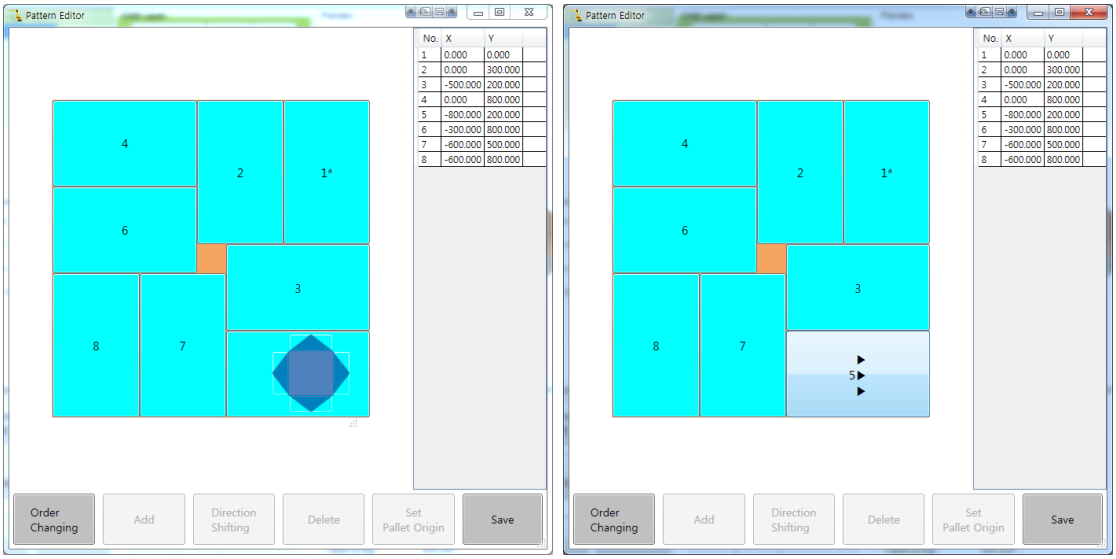



Figure 3.16 Hand open direction designation function

### 3.4.8. Saving

The Save button is used to reflect any alteration, such as position changing or deleting, after such alteration is made. When the Save button is pressed, the relevant window will be end automatically, making it possible to check if a change is made in the content of the selected layer.

## 3.5. Pattern managing

The pattern managing function is a menu to manage the patterns previously created by the user (Figure 3.17). This menu can be used to create a job program or to generate a POSE file. Pattern resister is a number that corresponds to a relevant pattern that is to be used in the job program and can be designated by inputting it directly. When it comes to the patterns for which the hand direction shall be set, it is possible to designate and use relevant options.

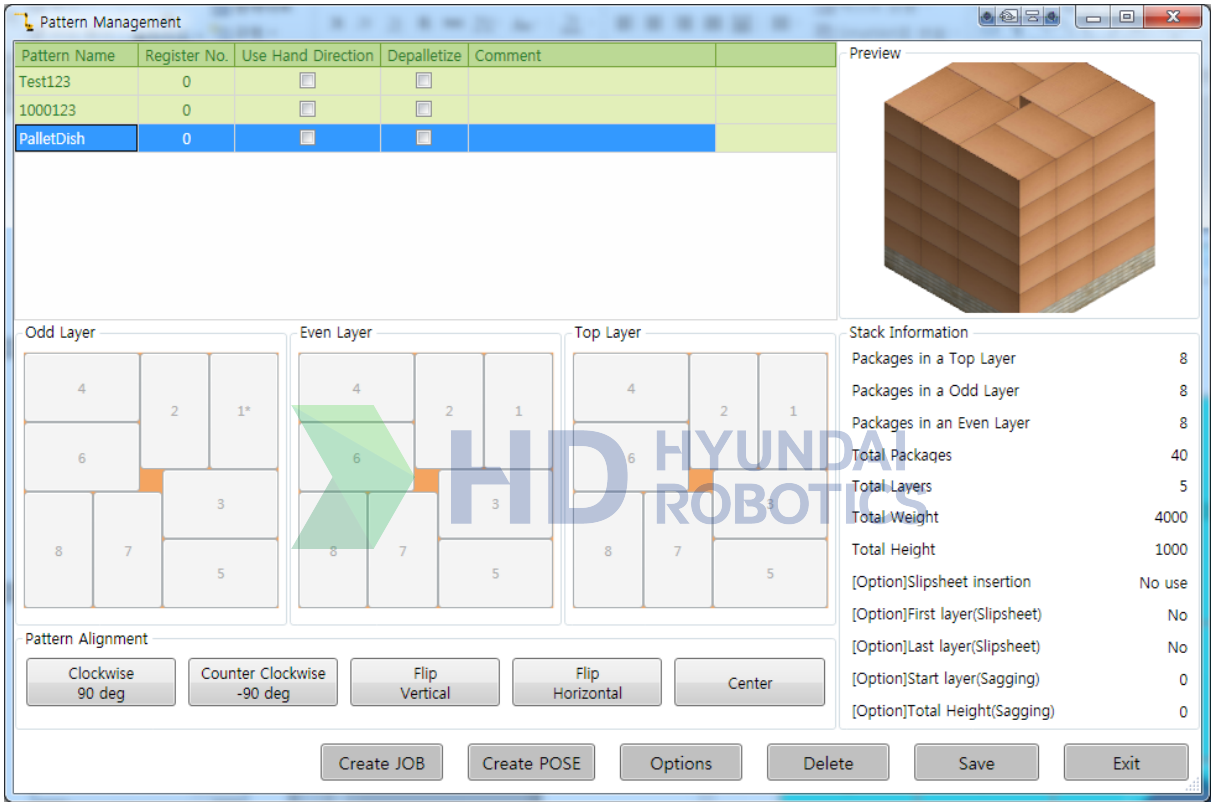



Figure 3.17 Pattern managing function

### 3.5.1. Job creating

The job creating function is used to create and produce a job program[2] and HRSpace4 simulation environment in order to execute palletizing for the pattern for which the register number is designated. The features of the relevant function are written below.

- Create and produce a standard program to make it possible to use the patterns for which pattern register numbers are assigned in the robot.
- Automatically create a package model for the relevant pattern for the sake of convenience in simulation in HRSpace3.
- The pattern register numbers that can be assigned range from 1 to 16, while they cannot be assigned in duplication.
- While the hand direction setting option is enabled, if the package hand open direction is not designated, a job program cannot be created.
- When the Job Create button is pressed, a menu will be displayed to select a folder to save the job program. Select the relevant folder and click the Check button so the job program will be saved in the folder.
- It would be impossible to execute if any pattern register is not set.
- If the user does not want to create a job program for a pattern, the register shall be changed to 0

### 3.5.2. Option changing

The option changing function is used to make a change related to the sagging compensation options and the slip sheet insertion (Figure 3.18).

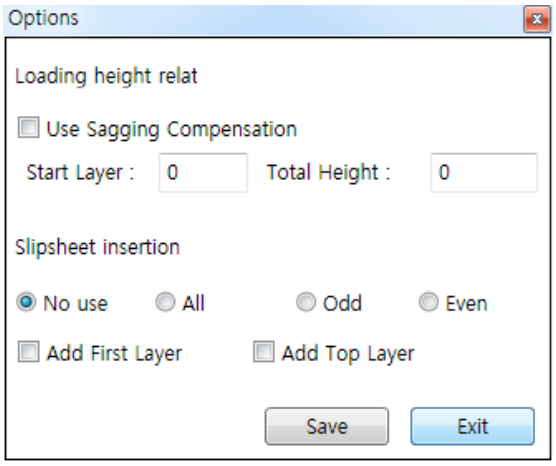



Figure 3.18 Option changing menu

[2] Refer to "3. Palletizing standard program:" for more details about the standard program.

### 3.5.3. Pattern deleting, saving, and ending

- The Pattern Delete button is used to delete the currently designated pattern.
  **(Caution)** Even when the pattern is deleted from the current screen, it will not be reflected in the file without pressing the Pattern Save button.

- The Pattern Save button is used to save the partially changed or altered content in a file.

## 3.6. User pattern defining

The user pattern defining function is for the user to create a pattern by arranging packages arbitrarily (Figure 3.19). Different from the auto pattern creating function, this function makes it possible to create a pattern by arranging different packages. The following show the order of using the function.

(1) Select a pallet that is to be placed on the floor.
(2) Select a package to load.
(3) Configure a pattern by using the adding, direction shifting, and deleting functions.
(4) Place the created pattern on the center by using the pattern editing function, including the clockwise or anticlockwise direction.
(5) Define the patterns for the odd layer and the top layer by using the same methods as shown above.
(6) You can use the same pattern as the odd layer by using the (*) odd layer copy function.
(7) Designate the loading layer count.
(8) Designate based on the layer sagging compensation or slip sheet insertion
(9) Press the Save button[3] and designate the pattern name to save so the pattern registration will be completed.

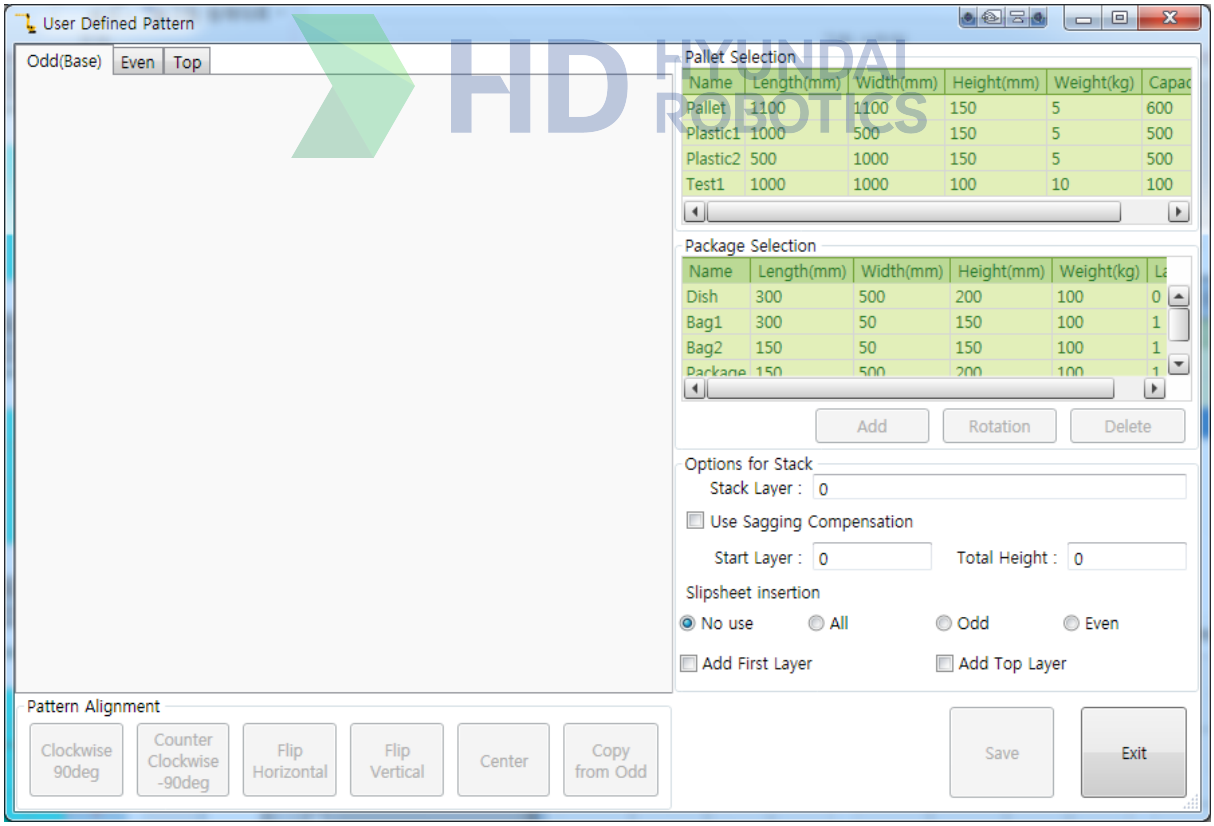



Figure 3.19 User pattern defining menu

[3] The saving function will be enabled only when the data for the odd layer, even layer, and top layer are filled out completely.

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# 4

# Palletizing Standard Program

# 4. Palletizing Standard Program



The palletizing program is a program group configured in advance to contain frames that are necessary for palletizing. When the user carries out palletizing by using HRpalware or HRpal, if a relevant program is used, palletizing can be carried out easily and quickly only by recording the work-related position and changing variables.

## 4.1. Variable configuration

Table 4-1 Numbers and usage of shift variables and pose variables in the standard program

| Shift variable (R) | | |
|---|---|---|
| **Number** | **Count** | **Content** |
| 1001~1060 | 60 numbers | #1 process slip sheet shift variable |
| 1061~1120 | 60 numbers | #2 process slip sheet shift variable |
| … | | |
| 1901~1960 | 60 numbers | #16 process slip sheet shift variable |
| 2001~2500 | 500 numbers | #1 process loading pattern shift variable |
| 2501~3000 | 500 numbers | #2 process loading pattern shift variable |
| … | | |
| 9501~9999 | 499 numbers | #16 process loading pattern shift variable |
| **Pose variable (P)** | | |
| Number | **Content** | **Remark** |
| 1001 | Home position | 1001~1007 are the positions that will change continuously because of the pallet setting |
| 1002 | Right above the pickup position | |
| 1003 | Pickup position | |
| 1004 | Right above the pickup position | |
| 1005 | Right above the loading pattern position | |
| 1006 | Loading pattern position | |
| 1007 | Right above the loading pattern position | |
| 6001~6016 | Basic position (home position)of #1 ~ #16 processes | No change in 6001~7016 as they are preassigned pose variables |
| 6501~6516 | Position (pickup position) for picking up packages of #1~#16 processes | #1 package (5 types of packages per pattern can be used.) |
| 6551~6566 | Position (pickup position) for picking up packages of #1~#16 processes | #2 package (5 types of packages per pattern can be used.) |
| 6601~6616 | Position (pickup position) for picking up packages of #1~#16 processes | #3 package (5 types of packages per pattern can be used.) |
| 6651~6666 | Position (pickup position) for picking up packages of #1~#16 processes | #4 package (5 types of packages per pattern can be used.) |
| 6701~6716 | Position (pickup position) for picking up packages of #1~#16 processes | #5 package (5 types of packages per pattern can be used.) |

| | | |
|---|---|---|
| 7001~7016 | Position (slip sheet pickup position) for picking up slip sheets of #1~#16 processes | |

Table 4-2 Numbers and roles of general variables in the standard program

| General variable (V%) | | |
|---|---|---|
| **Number** | **Description** | **Remark** |
| 1 | Start signal | |
| 2 | Continue, previous flag | |
| 5 | Current process number | |
| 6 | Previous process number | |
| 7 | Current package or slip sheet number | If 7 more, treat it as a slip sheet |
| 8 | Previous package or slip sheet number | |
| 31~46 | Workpiece counter | |
| 61~76 | Slip sheet counter | |
| 91~106 | Layer counter | |
| 121~136 | Workpiece count | |
| 151~166 | Odd layer workpiece count | |
| 181~196 | Even layer workpiece count | |
| 211~226 | Top layer workpiece count | |
| 241~256 | Slip sheet count | |
| 271~286 | First layer slip sheet insertion or not | |
| 301~316 | Top layer slip sheet insertion or not | |
| 331~346 | Variation for layer counting | |
| 361~376 | Work #1~ #16 valid/invalid | |
| 551~566 | (Simulation) Overall flow adjustment variable | |
| **General variable (V!)** | | |
| **Number** | **Count** | **Content** |
| 31~46 | Workpiece size ( L ) | |
| 61~76 | Workpiece size ( W ) | |
| 91~106 | Workpiece size ( H ) | |
| 121~136 | Pickup height | Shall be defined by the user |

## 4.2. Overall flow chart

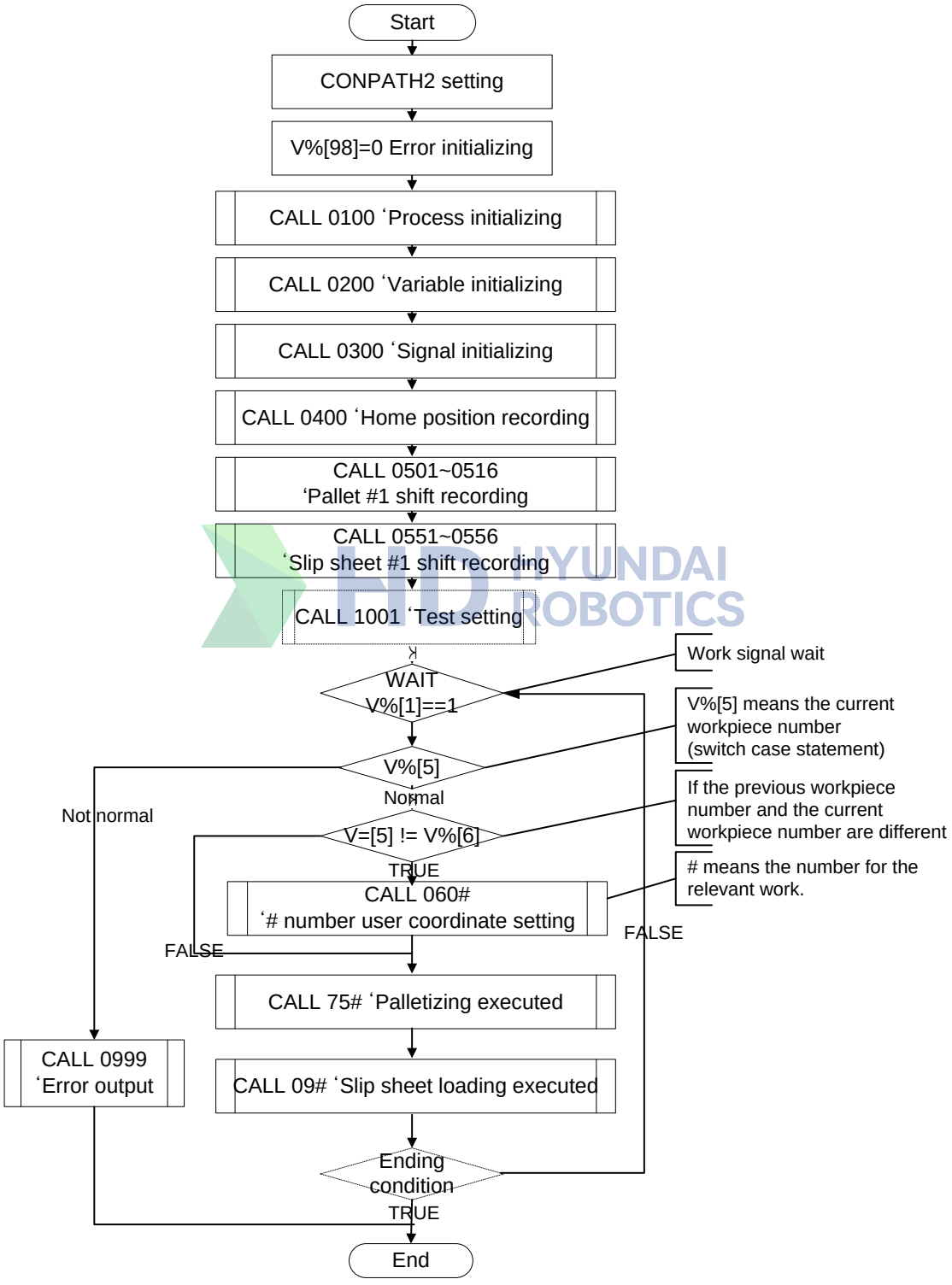



Figure 4.1 Standard program overall flow chart

## 4.3. Program configuration

Table 4-3 Job numbers and roles in the standard program

| Job Number | Role | Description |
|---|---|---|
| 1 | Main | Overall flow managing |
| 50 | Vacuum On | Records signals for the griper to hold objects |
| 51 | Vacuum Off | Records signals for the griper to release objects |
| 100 | Process parameter setting | |
| 200 | Initialization of variables | |
| 300 | Initialization of signals | |
| 400 | Home position and workpiece position pose program | Needed to record the position by using the pose constant in the defined pose variable. |
| 451~466 | Tool control program | Controls the positions of individual tools |
| 501~516 | Each pallet loading pattern shift variable program | To be created automatically by HRpal and HRpalware |
| 551~566 | Slip sheet shift variable program | To be created automatically by HRpal and HRpalware |
| 601~616 | Pallet coordinate creating program | Needed to create the user coordinate on the pallet and to record the origin of the work as well as the points on the X axis and X-Y plane |
| 701~716 | Pallet parameter setting | |
| 751~766 | Palletizing motion program | Executes palletizing by moving the robot |
| 801~816 | Slip sheet parameter setting | |
| 851~866 | Slip sheet motion program | Places a slip sheet by moving the robot |
| 999 | Error handling program | Program for indicating errors when they occur |
| 1001 | (Simulation) test setup program | To allow users to use simulated values to check whether the set values work normally. |
| 1002 | (Simulation) test ending condition check | To record the ending condition to check the cycle times |

### 4.3.1. Main program

The main program is divided into the following 4 sections.

(1) To initialize processes and variables
(2) To record tool control and shift variables
(3) To judge and execute palletizing conditions
(4) To process errors

When it is necessary to run processes by using the standard program, the user must run the main program at least once. This is because the main program processes signals and carries out initialization. Up to 16th lines in [Program 1 Main program configuration] are related to the basic initialization. If the initialization section is run at least once and the relevant data are saved, the job programs such as pallet movement and slip sheet movement can be run normally without additional processing.

**Program 1 Main program configuration**

```
Program File Format Version : 1.6   MechType: _MECHTYPE   TotalAxis: _TOTAL_AX   AuxAxis: _AUX_AX
1        "Main Job Program
2        '------------------------
3        CONTPATH 2
4        '------------------------
5        V%[98]=0 'JOB PROGRAM ERROR INITIALIZING
6        '------------------------
7        CALL 100 'Process initializing
8        CALL 200 'Variable initializing
9        CALL 300 'Signal initializing
10       CALL 400 'Home position initializing
11       '------------------------
12      CALL 451   '1 Process tool control recording
13      CALL 501   '1 Process pallet shift recording
14      ···
15
16      '------------------------
17      CALL 1001 'Simulation setting
18      V![8] = TIMER
19 100 WAIT V%[1] = 1            'START
20      '------------------------
21      SELECT V%[5]
22      CASE 1    'Work #1
23      IF V%[6]<>V%[5] THEN
24           CALL 601 'User CRD
25      ENDIF
26           CALL 751 '1 Process pallet moving
27           V%[6] = V%[5] 'Previous process saving
28      ···
29      CASE ELSE
30           V%[98]=1 "Process not registered
```

```
31            GOTO 200
32        END_SELECT
33        '------------------------
34        CALL 1002 'Simulation completion setting
35        IF V%[566]=9999 THEN 300
36        '------------------------
37        'Normal processing
38        GOTO 100
39        '------------------------
40        'Error Handling
41        '------------------------
42 200 CALL 999 'Error function
43 300 PRINT #0, "Total Cycle Time= " ; TIMER - V![8]
44        END
```

### 4.3.2. Vacuum On, Off

The Vacuum on and off programs (Job program #50 and #51) are used in the pallet moving program. When it comes to job programs that are created basically, they are defined in the job programs by using DO10 as a signal. When they are applied for real processes, the job programs shall only be changed by using proper signals for relevant processes.

### 4.3.3. Process parameter setting

The Process parameter setting program (Job program #100) is a job program used to decide whether to use the relevant process. The values of V% [361 ~ 376] are defined in 0 or 1. To enable it, 1 shall be assigned. To disable, 0 shall be assigned.
Thus, assigned parameter values can be used to check whether the relevant processes are enabled by monitoring them later.

### 4.3.4. Initialization of variables and signals

The Variable initialization program (Job program #200) is a job program used to designate the initial values of various variables that are used in the standard program. Most of the values are processed in the standard program internally. They are created automatically by HRpal or HRpalware.
However, in case of the pickup height in the 28th line, the values that are designated directly by the user will be used. Once the standard program is created, the user shall carry out the change manually (Figure 4.2). When it comes to the Print and Stop section of the #2, #3, #42, and #43 lines, deleting after changing the job program shall be carried out to run the robot.

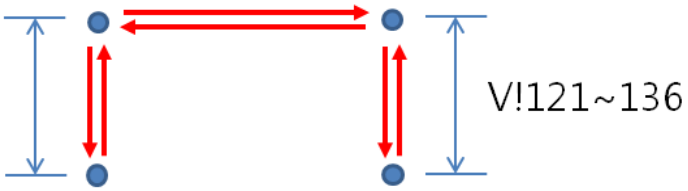



Figure 4.2 Meaning of V!121~136 variables

In addition, when the standard program is saved by using HRpalware, the data comments and various data monitoring lists for variables will be created automatically. When this function is used, it is possible to monitor the palletizing process directly from the teaching pendant.

**Program 2 Program for initializing variables**

```
Program File Format Version  1.6  Mech Type: _MECHTYPE  Total Axis: _TOTAL_AX  Aux Axis: _AUX_AX
1       "Initialize Variable
2       PRINT #0, "Change the values of variables and then delete Print or Stop."
3       STOP
4       V%[1]=0 'Start Signal
5       V%[5]=0 'Current Working Pallet Number
6       V%[6]=0 'Previous Working Pallet Number
7       V%[7]=1 'Package Number
8       V%[8]=1 'Previous Package Number
9       "Total package count
10      V%[121]=36 'Total Package #1
11      "Odd layer package count
12      V%[151]=9 'Odd Layer Package #1
13      " Even layer package count
14      V%[181]=9 'Even Layer Package #1
15      "Top layer package
16      V%[211]=9 'Top Layer Package #1
17      "Slip sheet count
18      V%[241] = 0 'Total Slip sheet #1
19      "First slip sheet insertion or not
20      V%[271]=0 'Slip sheet Stack First-layer #1
21      "Top slip sheet insertion or not
22      V%[301]=0 'Slip sheet Stack Top-layer #1
23      'Package length, width and height
24      V![31]=400 'Package Length #1
25      V![61]=300 'Package Width #1
26      V![91]=300 'Package Height #1
27      'Package pick height
28      V![121]=0 'Pickup Height #1
29      'Decision regarding workpiece counter resetting or not
30      'When the workpiece counter is reset, the slip sheet and layer counters will be reset together
31      FOR V%[3]=1 TO 16
32          IF V%[30+V%[3]] <> 0 THEN
33              PRINT #0, "1:Continue, 2: Reset
34              INPUT #0, V%[2]
35              IF V%[2]<>1 THEN
36                  V%[30+V%[3]]=0 'Workpiece counter reset
37                  V%[60+V%[3]]=0 'Slip sheet counter reset
38                  V%[90+V%[3]]=0 'Layer counter reset
39              ENDIF
40          ENDIF
41      NEXT
42      PRINT #0, "Change the values of variables and delete Print or Stop."
43      STOP
44      END
```

The Signal initializing program (Job program #300) is used to record the signals that shall be initialized before executing relevant programs. At the initial stage, there is nothing defined. Signals shall be recorded according to relevant processes.

### 4.3.5. Home position and workpiece position pose program

The Home position and workpiece position program (Job program #400) is a program for recording the home position of a specific process and the position to move to for the pickup operation. The pose variables of 6000's are used for designating the home positions while the pose variables of 6500's~ 6700's are used for designating pickup positions for individual processes. In each process, up to 5 different workpieces can be handled.

**Program 3 Job program for recording the home position, pickup position and slip sheet pickup position**

```
Program File Format Version : 1.6  MechType: _MECHTYPE  TotalAxis: _TOTAL_AX  AuxAxis: _AUX_AX
1       "Home, Package, Approach Position
2       PRINT #0,"Change the following positions to real work positions by using the pose constants."
3       STOP
4       P[6001]=P* 'Home Position #1
5       P[6001].CFG.CRD=1
6       P[6501]=P* 'Pickup Position #Work 1_1
7       P[6501].CFG.CRD=1
8       P[6551]=P* 'Pickup Position #Work 1_2
9       P[6551].CFG.CRD=1
10      P[6601]=P* 'Pickup Position #Work 1_3
11      P[6601].CFG.CRD=1
12      P[6651]=P* 'Pickup Position #Work 1_4
13      P[6651].CFG.CRD=1
14      P[6701]=P* 'Pickup Position #Work 1_5
15      P[6701].CFG.CRD=1
16      END
```



### 4.3.6. Tool control program

The Tool control programs (Job programs #451 ~ #466) are used for carrying out defining regarding the control of tools that are used to control jigs and positions. Whether to use tool control programs depend on individual processes, and the positions for using them may vary even when they are used. That is why their calling positions are not designated specifically. Considering this, the users need to prepare control programs to meet the needs of individual processes and designate the calling positions directly.

### 4.3.7. Loading pattern shift variable program for individual pallets

The Loading pattern shift variable programs for individual pallets (Job programs #501 ~ #516) and the Slip sheet shift variable programs (Job programs #551 ~ #566) are the programs where the loading patterns and the slip sheet shift values are saved). The patters created by using HRpal or HRpalware are saved automatically and the users can change the shift values directly.

The shift variables range from R1001 to R9999 and 500 pre-assigned values are designed to be used for each process. What is to be indicated as a note in each shift variable is Layer_Order. For example, 1_3 means the 3rd workpiece on the 1st layer.

**Program 4 Example of the program for creating a pallet loading pattern**

```
Program File Format Version : 1.6  MechType: _MECHTYPE  TotalAxis: _TOTAL_AX  AuxAxis: _AUX_AX
1       R2001=(0.000,0.000,0.000,0.000,0.000,0.000)U   '1_1
2       R2002=(-300.000,0.000,0.000,0.000,0.000,0.000)U   '1_2
3       R2003=(0.000,400.000,0.000,0.000,0.000,0.000)U   '1_3
4       R2004=(-750.000,-50.000,0.000,0.000,0.000,90.000)U   '1_4
5       R2005=(-50.000,750.000,0.000,0.000,0.000,90.000)U   '1_5
6       R2006=(-300.000,400.000,0.000,0.000,0.000,0.000)U   '1_6
7       R2007=(-800.000,300.000,0.000,0.000,0.000,0.000)U   '1_7
8       R2008=(-450.000,750.000,0.000,0.000,0.000,90.000)U   '1_8
9       R2009=(-800.000,700.000,0.000,0.000,0.000,0.000)U   '1_9
10      R2010=(-50.000,750.000,300.000,0.000,0.000,90.000)U   '2_1
11      R2011=(-50.000,450.000,300.000,0.000,0.000,90.000)U   '2_2
12      R2012=(-450.000,750.000,300.000,0.000,0.000,90.000)U   '2_3
13      R2013=(0.000,0.000,300.000,0.000,0.000,0.000)U   '2_4
14      R2014=(-800.000,700.000,300.000,0.000,0.000,0.000)U   '2_5
15      R2015=(-450.000,450.000,300.000,0.000,0.000,90.000)U   '2_6
16      R2016=(-350.000,-50.000,300.000,0.000,0.000,90.000)U   '2_7
17      R2017=(-800.000,300.000,300.000,0.000,0.000,0.000)U   '2_8
18      R2018=(-750.000,-50.000,300.000,0.000,0.000,90.000)U   '2_9
19      END
```

### 4.3.8. Pallet coordinate creating program

The shift data of the patterns created by HRpal or HRpalware are all recorded as relative shift values against the #1 package position. Accordingly, it is needed to create the user coordinate based on the #1 package loading position (or teaching position and marked with *) on the pallet and the relevant information is defined in the Pallet coordinate creating program (Job programs #601 ~ #616).
The user coordinate can be created by recording 3 coordinate values. The coordinate values to be recorded are as shown below (Program 5, Figure 4.3).

- P1 – Record the first package loading starting position, which is the coordinate origin at the same time.
- P2 – Set on point in the X axis based on #1 package.
- P3 – Set one point in the X-Y plane based on #1 package.

The user coordinate is basically defined based on the same method that is applied for the robot coordinate (right hand coordinate). When the user coordinate is defined in the manner of applying the right hand coordinate to the teaching position (* marked) shown on the HRpal or HRpalware screen, the operation will take place in the right manner.

**Program 5 Job program for recording the user coordinate**

```
Program File Format Version : 1.6  MechType: _MECHTYPE  TotalAxis: _TOTAL_AX  AuxAxis: _AUX_AX
1       "HHI User Coordinate Define Program
2       PRINT #0,"Record the user coordinates by using the pose constant. After completing, delete
                PRINT and STOP."
3       STOP
4       P1=P* 'Origin
5       P2=P* 'X-axis
6       P3=P* 'X-Y plane
7       MKUCRD 1,P1,P2,P3
8       SELUCRD 1
9       P4=P1
10      P4.CFG.CRD=4
11      END
```

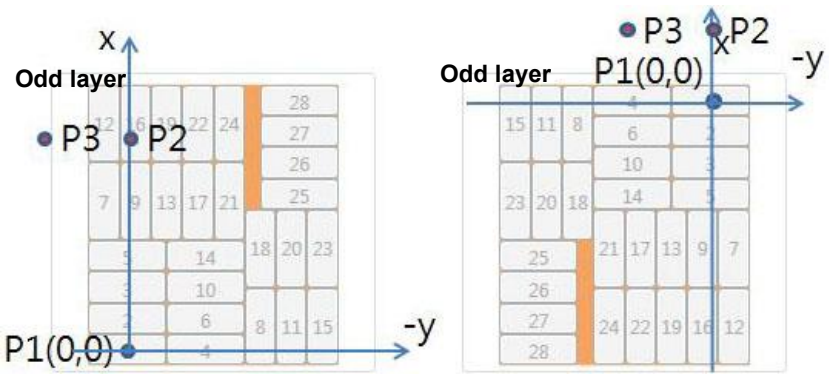



Figure 4.3 Example of the user coordinate recording

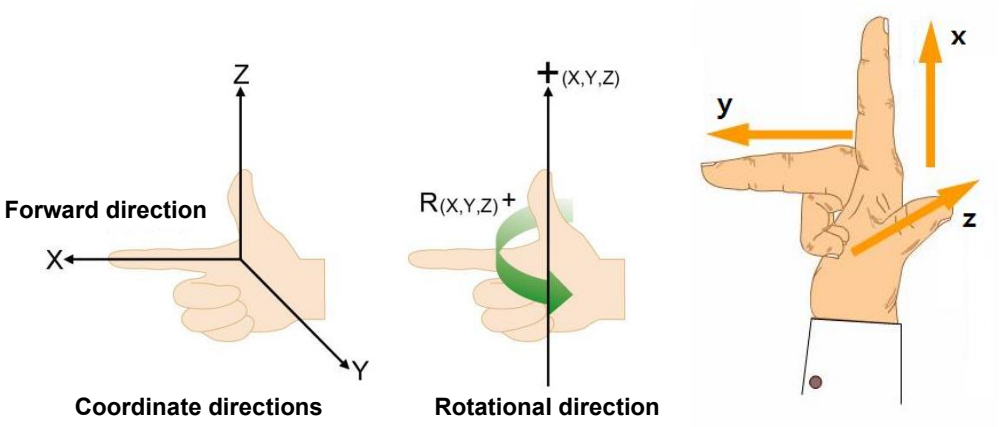



Figure 4.4 Right hand coordinate configuration

### 4.3.9. Pallet and slip sheet parameter setting

The Pallet and slip sheet parameters setting programs (Job program #701 ~ #716) are used for assigning shift variables to progress palletizing or for initializing variables necessary for palletizing. Basically, there is no need to change the variables of relevant job programs. However, if the step is to be added or changed, the relevant job program can be prepare by changing it.

**Program 6 Program for setting the pallet parameter**

```
Program File Format Version : 1.6  MechType: _MECHTYPE  TotalAxis: _TOTAL_AX  AuxAxis: _AUX_AX
1       'Palletize Parameter Setting #0
2       V%[98]=0 'Error Handling Variable
3       IF V%[31]=V%[121] THEN
4           V%[31]=0
5           V%[61]=0
6           V%[91]=0
7       ENDIF
8       P[1001]=P[6001] 'Home Position
9       P[1002]=P[6501 + ((V%[7]-1)*50)] + (0.000, 0.000, V![121], 0.000, 0.000, 0.000)R  'Near Package
10      P[1003]=P[6501 + ((V%[7]-1)*50)] 'Package Pos
11      P[1004]=P[1002] 'Pick up Pos
12      P[1006]=P4 + R[2001+V%[31]] 'Place Down
13      P[1005]=P[1006] + (0.000, 0.000, V![121], 0.000, 0.000, 0.000)R 'Near Place down
14      P[1007]=P[1005] 'Up
15      END
```

## 4.3.10. Palletizing and slip sheet motion program

The palletizing and slip sheet motion program is a combination of the Move statements that are needed to move the robot. The standard program needs 4 position values (package, pick up, near place down, and place down) to operate continuously. The 4 values are to be defined using the pickup height values designated in 4.3.5 Home position and workpiece position pose program, 4.3.8 Pallet coordinate creating program, and 4.3.4 Initialization of variables and signals. The home position means an initial position to move to when other workpiece enters or when there is a need to carry out noncontinuous operations, such as moving to insert slip sheet. When looking at the lines #3~#5, we can know that this will be executed only when there is a change.
If needed to add another via point somewhere between S4, UP, and S5 Near Place Down, it is necessary to add a new Move statement between S4 and S5.

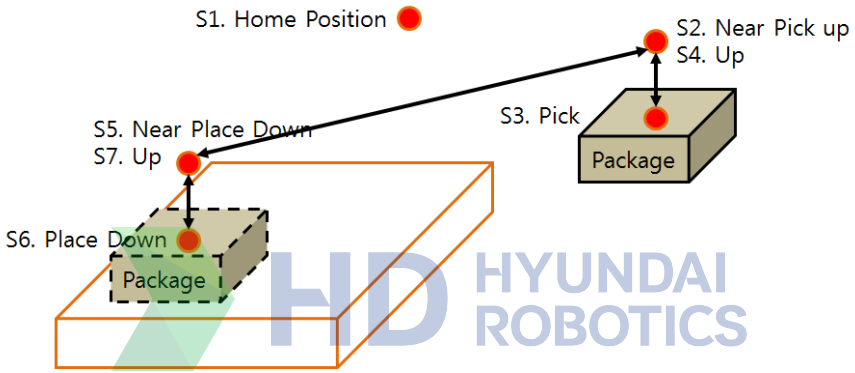



Figure 4.5 Palletizing motion position values

**Program 7 Program for pallet motion**

```
Program File Format Version : 1.6  MechType: _MECHTYPE  TotalAxis: _TOTAL_AX  AuxAxis: _AUX_AX
1       "Palletize Job Program
2         CALL 701 'Motion parameter setting
3       IF V%[6]<>V%[5] OR V%[7]<>V%[8] THEN
4   S1  MOVE P,P[1001],S=90%,A=1,T=0 'Home Position
5       ENDIF
6   S2  MOVE P,P[1002],S=90%,A=5,T=0 'Near Pick up
7   S3  MOVE L,P[1003],S=90%,A=0,T=0 'Pick
8       CALL 0051 'Vaccum On
9   S4  MOVE L,P[1004],S=90%,A=5,T=0 'Up
10  S5  MOVE P,P[1005],S=90%,A=5,T=0 'Near place down
11  S6  MOVE L,P[1006],S=90%,A=0,T=0 'Place down
12      CALL 0050 'Vaccum Off
13      V%[31] = V%[31] + 1 'Count increase
14      V%[8] = V%[7] 'Previous package, slip sheet number saving
15  S7  MOVE L,P[1007],S=90%,A=5,T=0 'Up
16      END
```

## 4.4. Standard program basic usage

Most part of the standard program is configured automatically and can be run when the user changes some sections only. What needs to be changed includes variable setting and position recording. When the relevant sections are changed if needed, the robot will move automatically, making it possible to check the motion of the robot very quickly.

### 4.4.1. Variable setting

In the standard program created automatically in HRpal and HRpalware, the variables, V!121~136, shall be changed by the user. The variables are related to deciding whether to pick up or place down and the relevant heights of picking up and placing down.
Other variables can be changed by the user when necessary. Refer to [4.1. Variable configuration] for more details.

### 4.4.2. Position recording

There are 2 main basic positions that shall be recorded in the standard program. The first one is the pose variable that indicates the package position, and the second one is the variable that is needed to create the user coordinate on the pallet.

(1) Pose recording related to the pickup position

The variable related to the package position is defined in the 0400.JOB file. The workpiece pickup position, slip sheet pickup position, and home position are defined for each process. The user can move the robot to a desired position by using the teaching pendant directly with the robot or through simulation program, and change the relevant pose variable to a pose constant value (Program 3).
When a package is to be used for a loading pattern, teaching for the home position and the pickup position #1 shall only be carried out. If multiple packages are to be used, teaching for all relevant pickup positions shall be carried out.

(2) Defining the user coordinate on the pallet

The shift data of the patterns created by HRpal or HRpalware are all recorded as relative shift values against the #1 package position. Accordingly, it is needed to create the user coordinate based on the #1 package loading position (or teaching position and marked with *) on the pallet, and the relevant information is defined in the Pallet coordinate creating programs (Job programs #601 ~ #616).
Refer to [4.3.8 Pallet coordinate creating program] for more details.

HYUNDAI ROBOTICS

# 5 Simulation Example

The simulation section describes how to carry out palletizing and depalletizing in simulation by using HRpal and HRSpace3. The purpose of this example is to ensure that the user configures the shapes of the pallet and box to carry out teaching for positions, and change the standard program and check whether the operation takes place properly. However, this example excludes the transportation of a package in simulation because such simulation includes more complicate processes.

In this example, the simulation is carried out as shown below in Figure 5.1 in which one pallet and one package are used for simulation. Then, the depalletizing simulation can be executed by making a simple change in the same environment configuration.

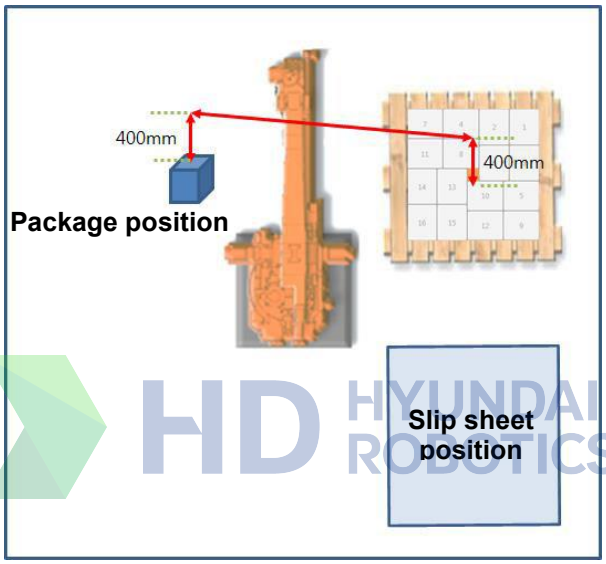



Figure 5.1 Palletizing configuration example

## 5.1. Environment configuration

(1) Robot
HP160

(2) Pallet
Size: 1,100 x 1,100 x 150 mm, weight: 10 kg, live weight: 600 kg

(3) Package
Size 300 x 250 x 300 (10 kg)

(4) Slip sheet
1100x1100x1 mm (0.1kg)

(5) Auto loading order
Starting from the right bottom

(6) Layer count setting
3 layers to be inputted directly

(7) Checking regarding slip sheet insertion or not
Slip sheet to be inserted into all layers (No slip sheet insertion for the top layer)

## 5.2. Pattern creating progressing in stages

(1) First, execute HRpal V1.0 and press the Pallet button.

(2) Input 'pallet' into the pallet name section, and input 1,100, 1,100, 150, 10, and 600 in to the length, width, height, weight, and weight capacity sections individually in sequence (Figure 5.2).

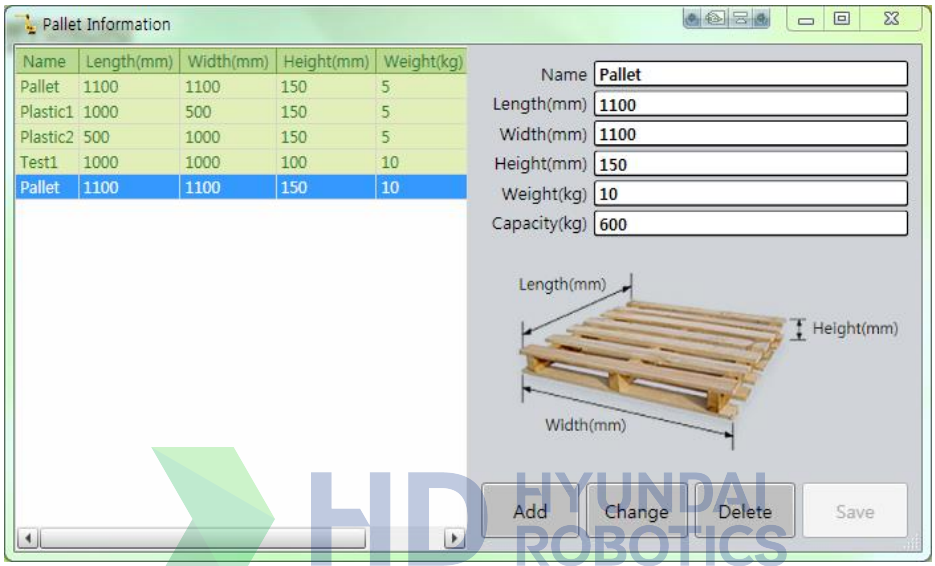



Figure 5.2 Pallet information input

(3) Input the relevant package and slip sheet information by taking into consideration the above environment configuration (Figure 5.3, Figure 5.4).

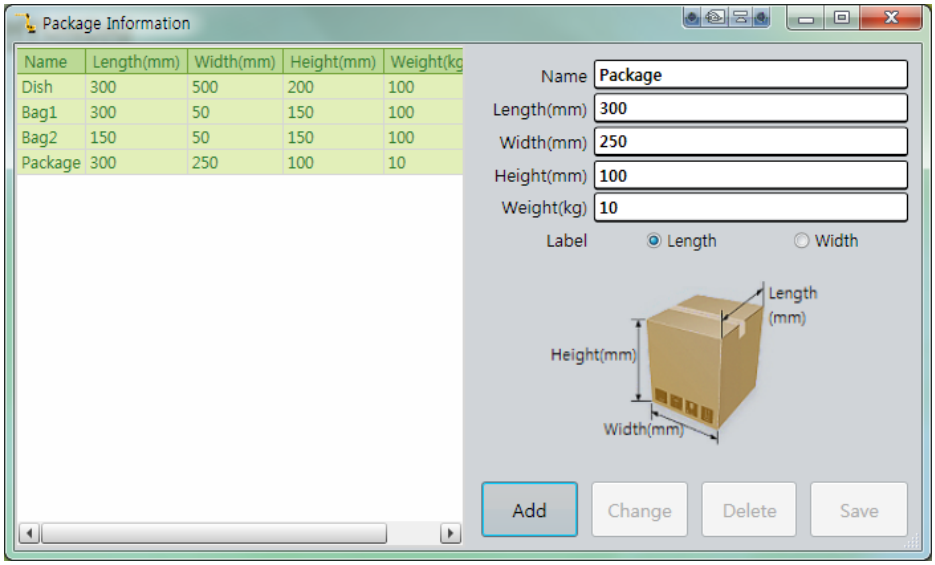



Figure 5.3 Package information input

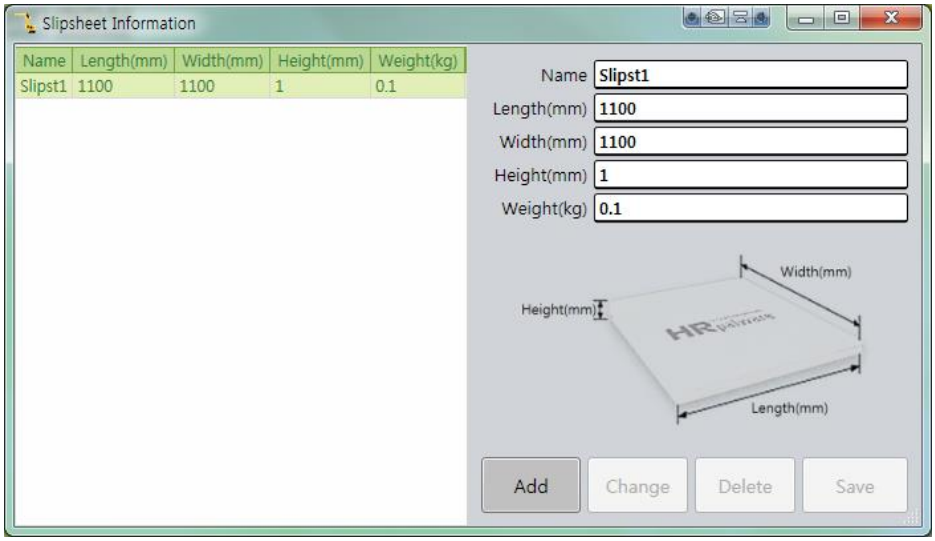



Figure 5.4 Slip sheet information input

(4) Press the Pattern Create button to create a pattern based on the inputted information.

(5) Input the necessary information to create a pattern by referring to (Figure 5.5) shown below.

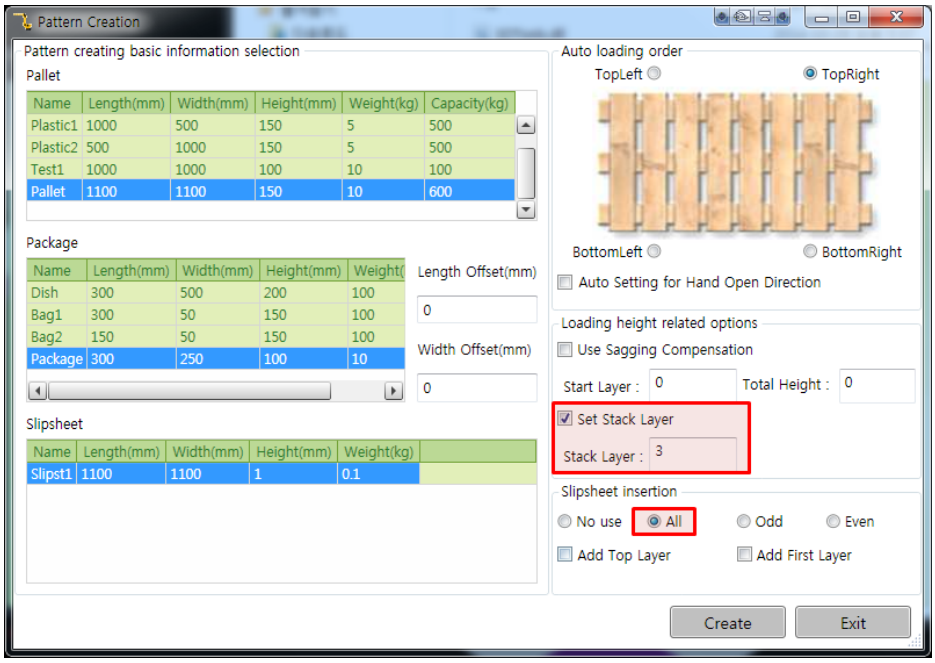



Figure 5.5 Pattern creating

(6) Select the best pattern among the thus created ones, press the Save button, name the pattern as 4 x 4, and press the OK button to save it before ending the window (Figure 5.6).

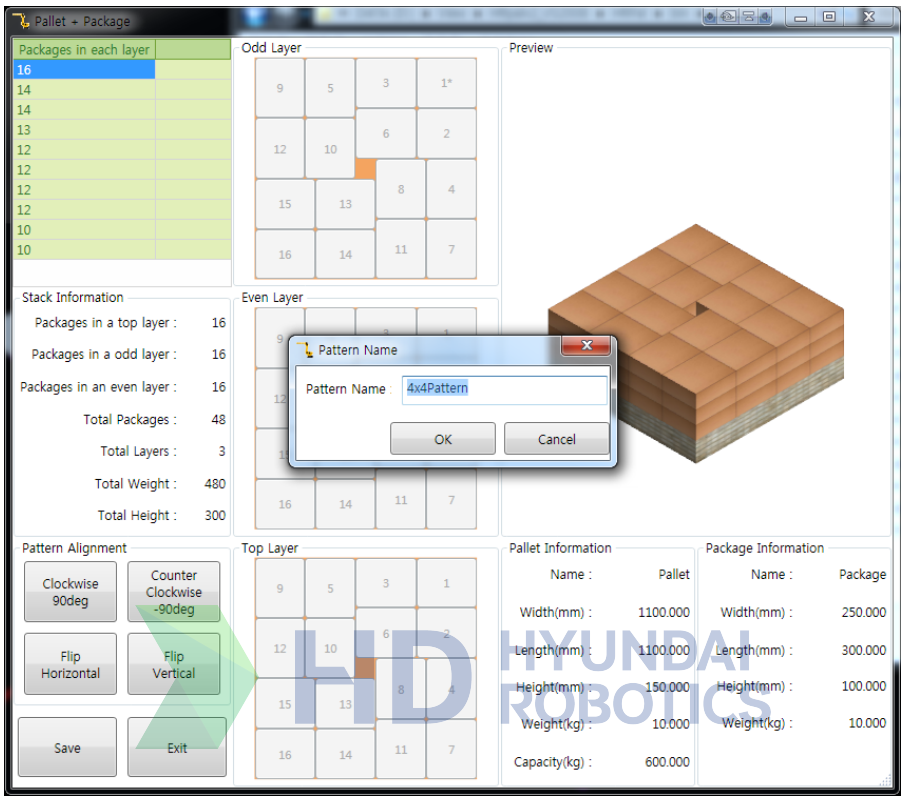



Figure 5.6 Pattern saving

(7) To create a job program and the HRSpae3 project file for the created pattern, it is needed to enter the pattern managing menu and designate the register number for the relevant pattern (Figure 5.7).

(8) Check the reference positions that need to be taught to the robot (Figure 5.7). (* position)

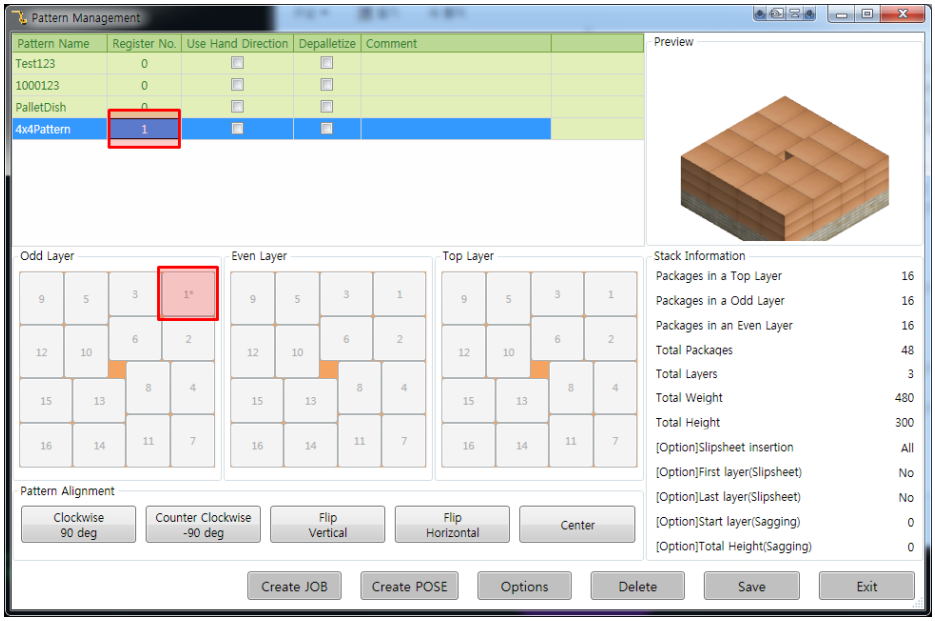



Figure 5.7 Register number designation and teach position checking

(9) Press the Job Create button and select a folder where the user wants to create a job program and HRSpace3 project file (Figure 5.8). Here, the HRSpace Simulation folder is created on the background screen for the use.

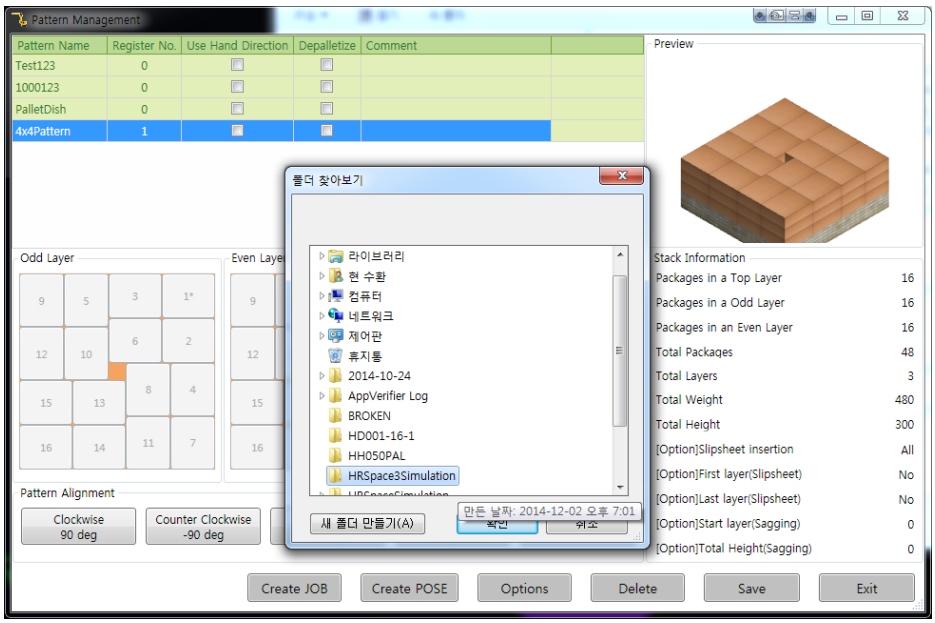



Figure 5.8 Job creating

## 5.3. HRSpace3 environment setting and simulation execution

### 5.3.1. Layout arrangement and job program loading

(1) After going through [5.2 Pattern creating progressing in stages], it is possible to check that files are crated as shown below in (Table 5-1). To carry out simulation, the contents of 0200.JOB, 0400.JOB, and 0601.JOB shall be changed.

Table 5-1 Roles of created job programs and whether to be changed by the user

| File name | Role | Whether to be changed by the user |
|---|---|---|
| 0001.JOB | Main program | |
| 0050.JOB | Vacuum on | |
| 0051.JOB | Vacuum off | |
| 0100.JOB | Process parameter setting | |
| 0200.JOB | Initialization of variables | o |
| 0300.JOB | Initialization of signals | |
| 0400.JOB | Home position and workpiece position pose program | o |
| 0451.JOB | Tool control program | |
| 0501.JOB | Pallet loading pattern shift variable | |
| 0551.JOB | Slip sheet shift variable | |
| 0601.JOB | Pallet coordinate creating program | o |
| 0701.JOB | Pallet parameter setting | |
| 0751.JOB | Basic palletizing program | |
| 0801.JOB | Slip sheet parameter setting | |
| 0851.JOB | Slip sheet insertion program | |
| 0999.JOB | Error handling program | |

| | | |
|---|---|---|
| 1001.JOB | (Simulation) test setup | |
| 1002.JOB | (Simulation) test ending condition check | |
| Result.hrs | HRSpace3 Project File | |

(2) First, when the created Result.hrs file is opened, the following screen will be shown (Figure 5.9)

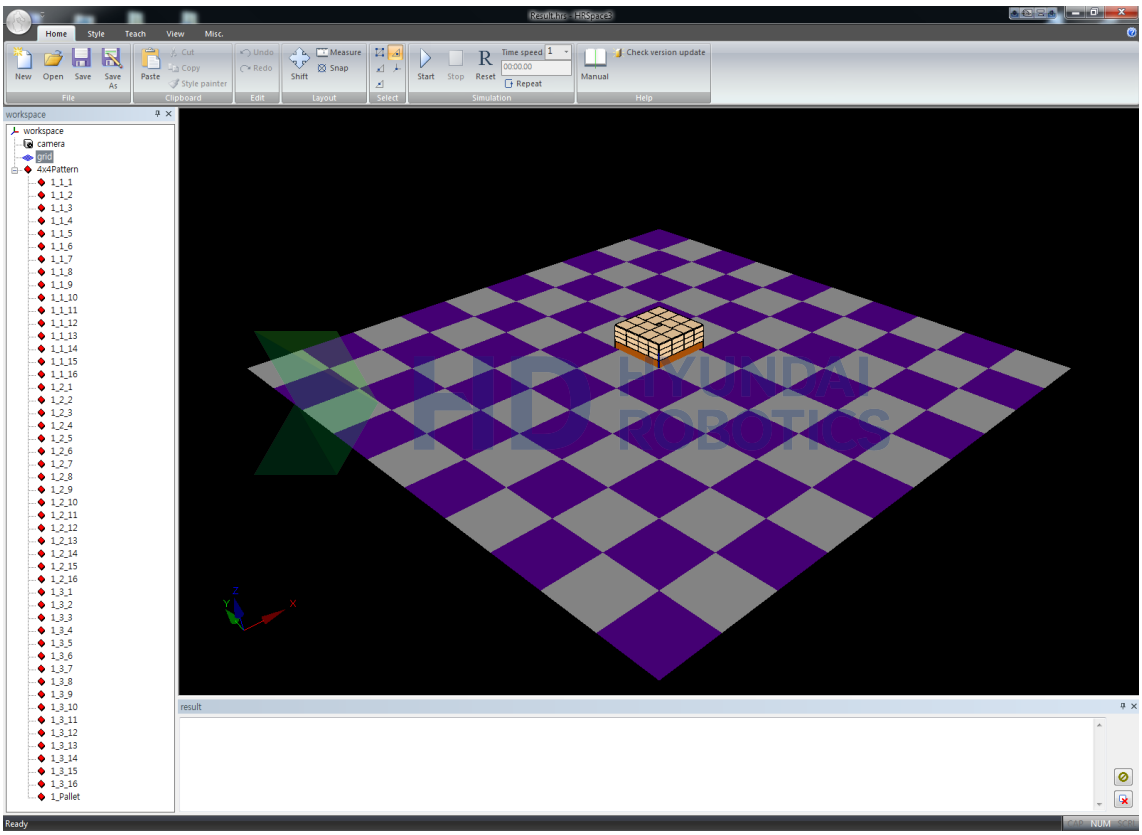



Figure 5.9 HRSpace3 project created by HRpal

(3) After adding the HP160 robot to the workspace tree by referring to Figure 5.1 Palletizing configuration example (Figure 5.10), arrange the position properly by using the home tap shift function.

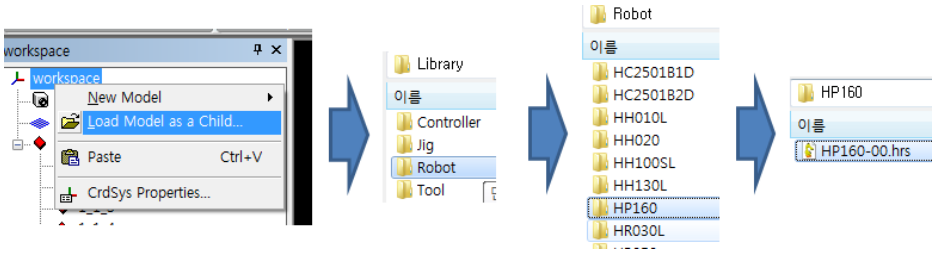



Figure 5.10 HP160 robot adding

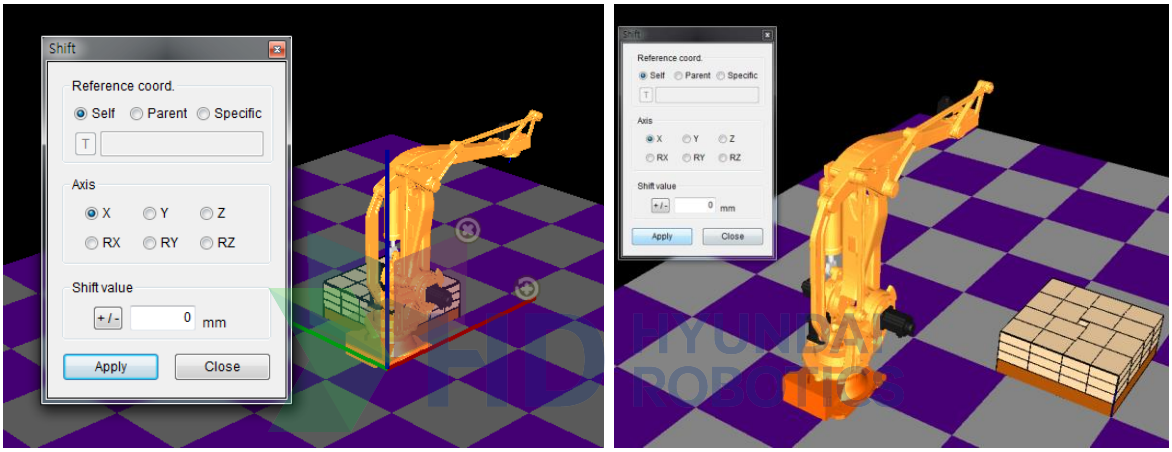



Figure 5.11 Shifting function

(4) To check surely that the robot moves the object correctly, copy the 1_1_1 model in the 4 x 4 pattern and paste it into the tap under the robot tree. After that, change the position (relative) values in the model property section to 0, 0, 0, changing the shape into one that looks like the robot holding the object (Figure 5.12).

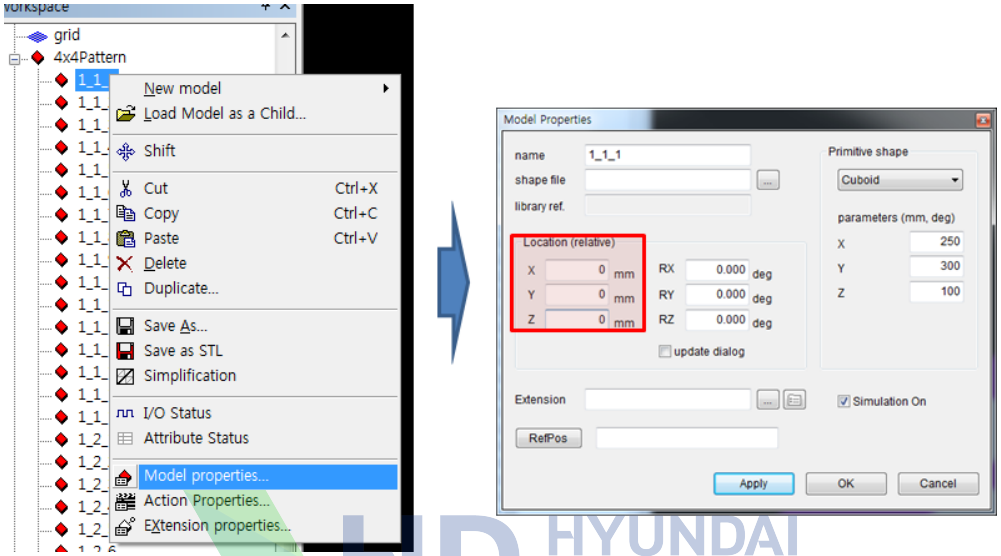



Figure 5.12 Changing the shape into one that looks like the robot holding an object

(5) When the arrangement is completed, save the file. Then, you can see that a robot folder is created in the folder.

(6) Move all the job programs created by HRpal to the robot folder. Then, load the job programs on the virtual controller by using the update function in the VRC folder of the virtual controller tool (Figure 5.13).

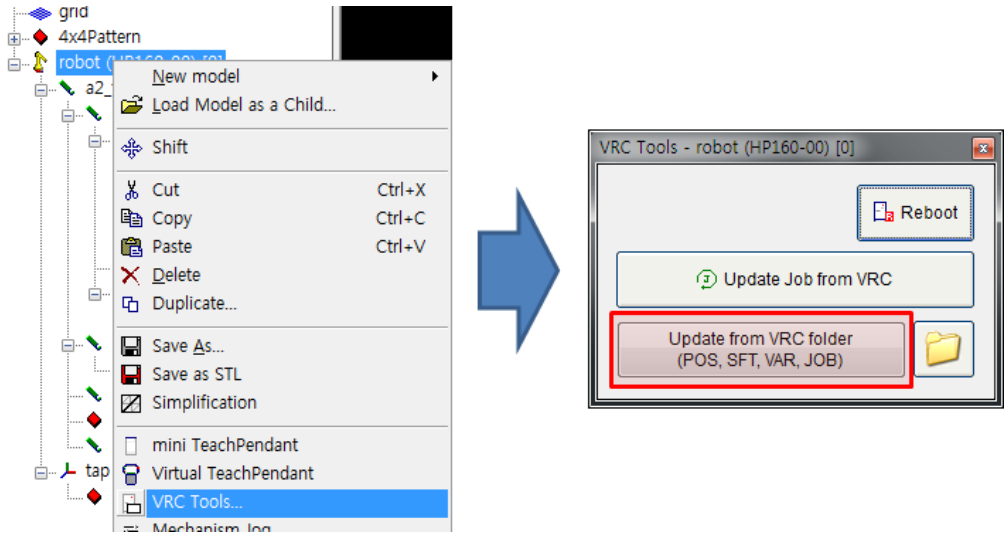


Figure 5.13 How to reflect the standard job program in the virtual controller

### 5.3.2. Job program changing and position recording

(1) Looking at Figure 5.1 Palletizing configuration example, the user can know that the package pickup and place down heights are limited to 400 mm. The relevant information is defined in 0200.JOB and change the variable value of V![121] to 400 by using the virtual teaching pendant or the text edit function (Figure 5.14).

```
V%[7]=1 'Package Number
V%[8]=1 'Previous Package Number
V%[121]=48 'Total Package #1
V%[151]=16 'Odd Layer Package #1
V%[181]=16 'Even Layer Package #1
V%[211]=16 'Top Layer Package #1
V%[241] = 2 'Total Slipsheet #1
V%[271]=0 'Slipsheet Stack First-layer #1
V%[301]=0 'Slipsheet Stack Top-layer #1
V![31]=300 'Package Length #1
V![61]=250 'Package Width #1
V![91]=100 'Package Height #1
V![121]=400 'Pickup Height #1
'Check reset work counter
FOR V%[3]=1 TO 16
```

Figure 5.14 0200.JOB V![121] value changing

(2) Change the above information. Then, save the 0200.JOB file in a folder by using the save function as shown in Figure 5.15.

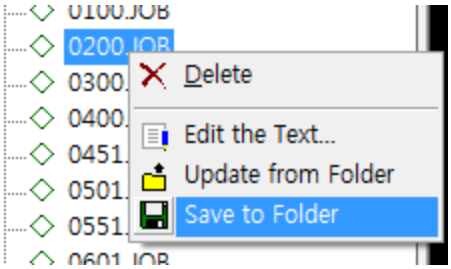



Figure 5.15 How to change information through a virtual teaching pendant and reflect it in a file

(3) Change the 0400.JOB file to record the home position and the package position. The pose variables that shall be changed include P6001, P6501, and P7001, meaning the home position, pickup position, and slip sheet pickup position, respectively.

```
Robot:HP160-00, 4axes, 0steps
''Home, Package, Approach Position
PRINT #0,"Please record below position variable
STOP
P[6001]=P* 'Home Position #1
P[6001].CFG.CRD=1
P[6501]=P* 'Pickup Position #Work 1_1
P[6501].CFG.CRD=1
P[6551]=P* 'Pickup Position #Work 1_2
P[6551].CFG.CRD=1
P[6601]=P* 'Pickup Position #Work 1_3
P[6601].CFG.CRD=1
P[6651]=P* 'Pickup Position #Work 1_4
P[6651].CFG.CRD=1
P[6701]=P* 'Pickup Position #Work 1_5
```

Figure 5.16 0400.JOB file configuration

(4) First, to record the home position, press the Motor On button using the virtual teaching pendant and move the robot to a proper position while in the manual mode. For the sake of convenience in teaching, carry out teaching using an orthogonal coordinate (Figure 5.17).

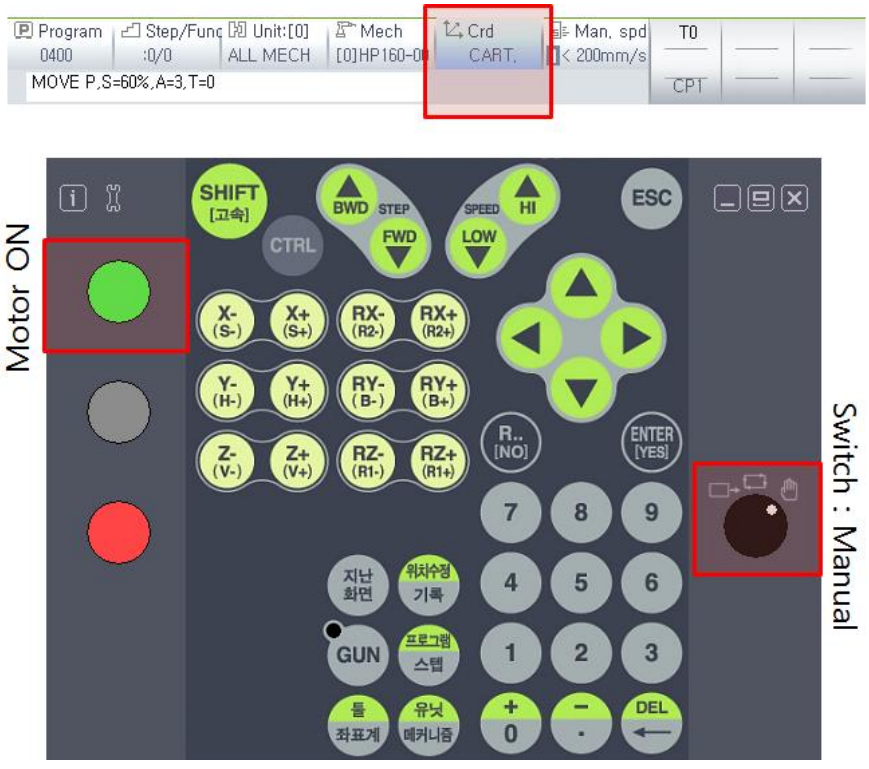


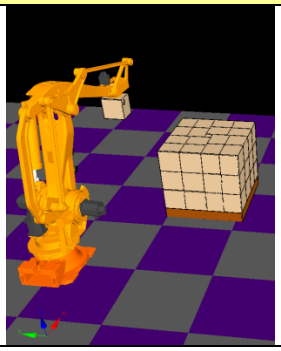
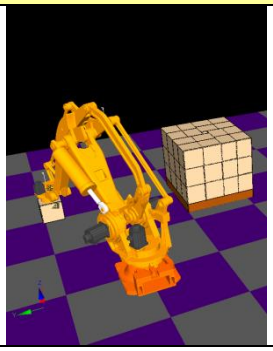
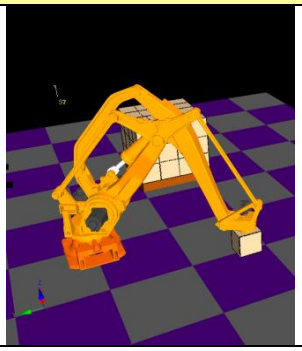
Figure 5.17 Motor on, mode switch changing, and coordinate changed position

(5) Move the robot to a desired position and change the robot's position from P* to the current position by using variable → pose → pose constant as shown in Figure 5.18.


Figure 5.18 Position recording by using pose constant

(6) The remaining 3 poses (P6501, P7001) shall be recorded using the same method shown above. For your information, in this example, the following postures are recorded and used.

Table 5-2 Shapes and coordinate values of the home position, pickup position, and slip sheet pickup position used in the example

| Home position | Pickup position | Slip sheet pickup position |
|---|---|---|
|  |  |  |
| (-2.717,80.127,-2.705,-2.716)A | (23.098,44.396,-8.083,23.099)A | (-119.867,50.580,-21.423,-119.863)A |

(7) In the next step, the pallet coordinate shall be recorded to place down the package. For this, the 3 points, P1, P2 and P3 in 0600.JOB shall be recorded and used.

(8) The position for which work teaching shall be carried out is #1 position in Figure 5.7 Register number designation and teaching position check. In HRSpace3, the position is the white colored package shown in Figure 5.19.

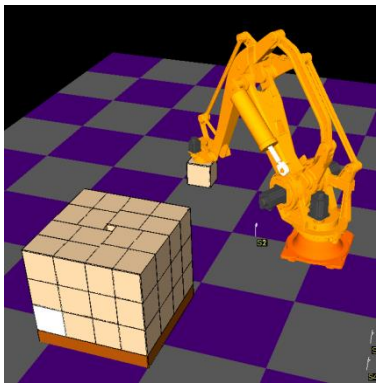
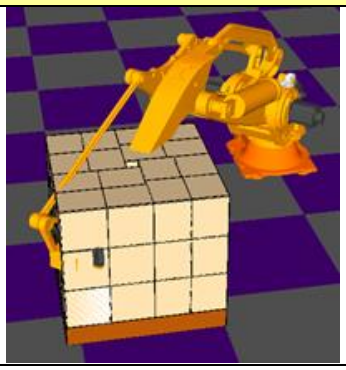
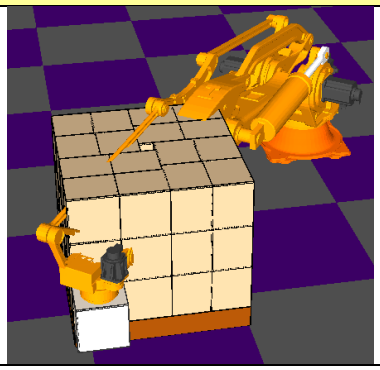
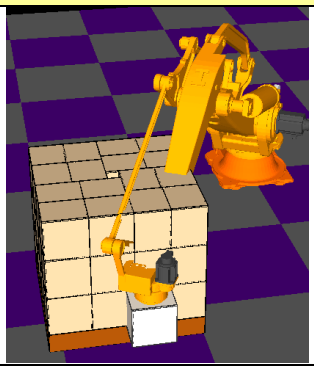


Figure 5.19 P1 teaching point position (white colored package, 1_1_1)

(9) Carry out teaching by placing P1 on the package position correctly only by moving it on the orthogonal coordinate without rotation. Teaching shall be carried out exactly in the same manner used in Figure 5.18 Position recording by using pose constant.

(10) After P1 teaching is carried out, P2 can be recorded by moving slightly in the X+ direction on the orthogonal coordinate. P2 can be recorded by moving slightly in the Y+ direction.
(*)In the example, the same positions as shown in Table 5.3 Examples of P1, P2 and P3 position recording

Table 5-3 Examples of P1, P2 and P3 position recording

| P1 | P2 | P3 |
|---|---|---|
|  |  |  |
| (-41.373,22.353,43.769,-41.3689)A | (-38.439,6.302,74.822,-38.434)A | (-29.795,28.510,31.846,-29.790)A |

When the 0001.JOB program is operated automatically from the virtual teaching pendant after teaching is completed, there will be a section in which stopping would occur when the Stop command is carried out in the middle of processing. You can delete or ignore it and continue to press the Start button to

progress. Then, you can check whether palletizing has been executed normally.

## 5.4. Depalletizing

Because of the difference in loading and placing down boxes, the palletizing and depalletizing operations differ in the loading/operation pattern as the unloading order is used instead of the loading order related to pattern. In this example, let's take a look on how to change the simulation examples shown so far into ones that are appropriate for depalletizing work.

(1) For the next step, carry out depalletizing in the same environment. Check the depalletizing section for the pattern created previously in the pattern managing function of HRpal (Figure 5.20).

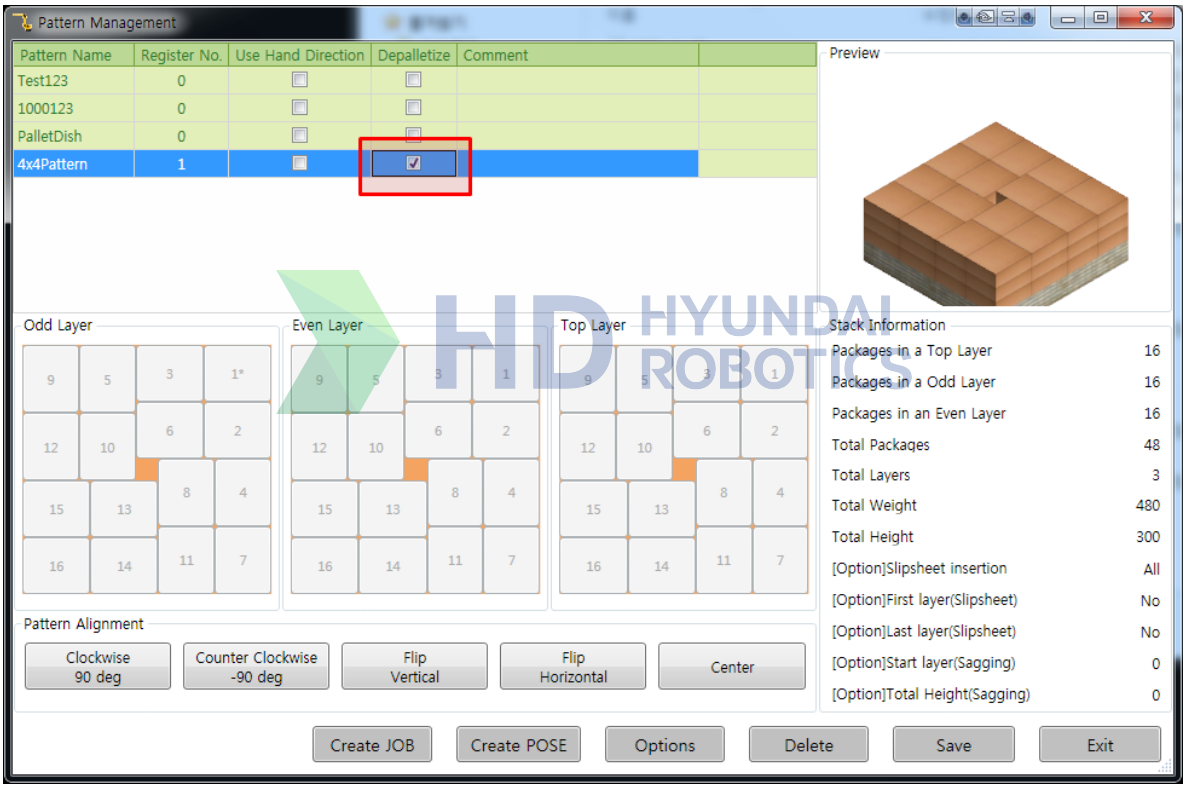



Figure 5.20 Depalletizing option check

(2) Create job programs by applying the same method used in Figure 5.8 Job creating. In this case, it is necessary to save data in the HRSpace Depallet Simulation folder differently from the previous process.

(3) Because the depalletizing process uses the same environment that is used for the palletizing process, the existing job programs can be used. Table 5-4 shown below lists the job programs in which the palletizing and depalletizing operations differ. Users just need to change the programs in which they differ.

Table 5-4 List of programs in which the palletizing and depalletizing operations differ when the depalletizing option is checked

| File name | Role | Difference from palletizing |
|---|---|---|
| 0001.JOB | Main program | |
| 0050.JOB | Vacuum on | |
| 0051.JOB | Vacuum off | |
| 0100.JOB | Process parameter setting | |
| 0200.JOB | Initialization of various variables | |
| 0300.JOB | Initialization of various signals | |
| 0400.JOB | Home position and workpiece position pose program | |
| 0451.JOB | Tool control program | |
| 0501.JOB | Pallet loading pattern shift variable | Different |
| 0551.JOB | Slip sheet shift variable | Different |
| 0601.JOB | Pallet coordinate creating program | |
| 0701.JOB | Pallet parameter setting | Different |
| 0751.JOB | Basic palletizing program | |
| 0801.JOB | Slip sheet parameter setting | Different |
| 0851.JOB | Slip sheet insertion program | |
| 0999.JOB | Error handling program | |
| 1001.JOB | (Simulation) test setup | |
| 1002.JOB | (Simulation) test ending condition check | |



(4) Copy the content of the previously created HRSpace Simulation folder to the HRSpace Depallet Simulation folder. By referring to the above Table 5-4, copy the 0501.JOB, 0551.JOB, and 0701.JOB files and paste them in the HRSpace Depallet Simulation/robot folder.

(5) After that, carry out simulation. Then, it can be checked that depalletizing, instead of palletizing, is carried out.

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