MOTOCALV EG
OPERATOR'S MANUAL

Upon receipt of the product and prior to initial operation, read this instruction thoroughly, retain for future reference.

YASKAWA

General Precautions

- Diagrams and photos in this manual are used as examples only and may differ from the actual delivered product.
- This manual may be modified when necessary because of improvement of the product, modification, or changes in specifications.
  Such modification is made as a revision by renewing the manual No.
- To order a copy of this manual, if your copy has been damaged or lost, contact your YASKAWA representative listed on the last page stating the manual No. on the front page.
- YASKAWA is not responsible for any modification of the product made by the user since that will void our guarantee.
- Software supplied with this manuals intended for use by licensed operators only and may only be used or copied according to the provisions of the license.
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CONTENTS

PREFACE

Outline of MOTOCALV EG

The MOTOCALV EG has been developed to improve positioning accuracy of YASKAWA's industrial robot MOTOMAN. The MOTOCALV EG is an application software for MS-Windows, which offers excellent operability on various types of personal computers.

Requirements for MOTOCALV EG Execution

OS	MS-Windows 2000/XP *1
Required Memory	128 Mbytes or more
Hardware disk Capacity	15 Mbytes or more
Screen	Screen supported by Windows (256 colors or more)

*1) MS-Windows 2000, MS-WindowsXP are trade marks of Microsoft Corporation, U.S.A.

MOTOCALV EG Setup

1. Turn ON the power to the personal computer and screen.
2. Start the Windows.
3. Insert the install CD-ROM to the CD-ROM drive.
4. Select the [Control Panel] of [Setting] from the [Start] button in the menu of task bar, then select the [Add/Delete Application].
5. Click the [Set-up] button and set "MOTOCALV-EG¥setup.exe" of the CD-ROM drive, following to the instructions displayed in the screen.
6. Clicking the [Complete] button starts the installation program. Follow the instructions displayed in the screen.
7. At the completion of setup, the [MOTOCALV EG] icon is displayed in the [Start]-[Program]-[Motoman]-[MOTOCALV EG].

1. TYPES OF CALIBRATION

The following types of calibrations are available for MOTOCALV EG.

1.1 Robot Calibration

Adjusts the absolute data and tool data, by teaching 5 postures each of 5 points (total 25 points) with robot. This calibration improves the absolute value accuracy of robot.

1.2 Tool Calibration

Adjusts tool data by teaching 7 postures at 1 point (total 7 points) with robot. This calibration calculates the exact tool data (robot control point).

1.3 Tool Posture Calibration

Adjusts tool data by teaching 1 posture at 1 point (total 1 point) with robot. This calibration calculates the exact tool positions (Rx, Ry, and Rz).

1.4 Workpiece Calibration

Recognizes the positional difference between each robot and workpiece, by comparing the job created by offline system and the job created with the actual robot. Then converts the position data by offline system into the data for the actual robot, using the difference above.

1.5 Layout Correction

The layout correction is composed of "Robot Layout Correction" and "Travel Axis Tilt Correction." "Robot Layout Correction" corrects the robot layout in the cell constructed by MotoSim EG for actual robot layout, by comparing the job created by offline system and the job created with the actual robot. "Travel Axis Tilt Correction" corrects the robot layout in the cell constructed by MotoSim EG for the actual robot layout, by calculating the positional difference between the travel axis and the robot positioned on the travel axis.

2. OPERATION

This chapter explains the operation method of each calibration by MOTOCALV EG.

2.1 Robot Calibration

2.1.1 Operation with Actual Robot

1) To perform robot calibration, prepare the data of tool to be mounted in advance.
The following three methods are available for tool data.
①Performs the tool calibration with the actual robot controller.
②Performs the tool calibration by MOTOCALV EG.
(Refer to Section 2.2 "Tool Calibration.")
③Uses the values of mechanical dimensions if specified in the drawing, etc.

2) Mount an end-pointed tool on the robot flange.
Use a tool with pointed-end part offset to the direction of X- or Y-axis on the tool coordinate. (Offset amount of approx. 200 mm is recommended.)

3) Using this tool, perform teaching of the job (job name: ROBOT) for 5 postures each of 5 points (total 25 points). The calibration job "ROBOT" is used for actual calculation by the calibration software.
The teaching method is explained below.

a) Using the same tool, perform teaching of 5 postures at each 5 point.
(Use MOVJ or MOVL for interpolation type. On base of the taught positions, X, Y, and Z will be calculated internally.)

Notes 1: For teaching of large-size robots of K60 and more, perform teaching with the wrist angle 45° or less, since the flexure by the robot arm weight may affect calibration, with the wrist posture largely inclined. For robot sizes below K60, incline the wrist 45° or more.
2: When the actual playback operation requires movement changing robot form, for example, the robot wrist axis rotating in reverse, perform teaching with the posture of that movement.

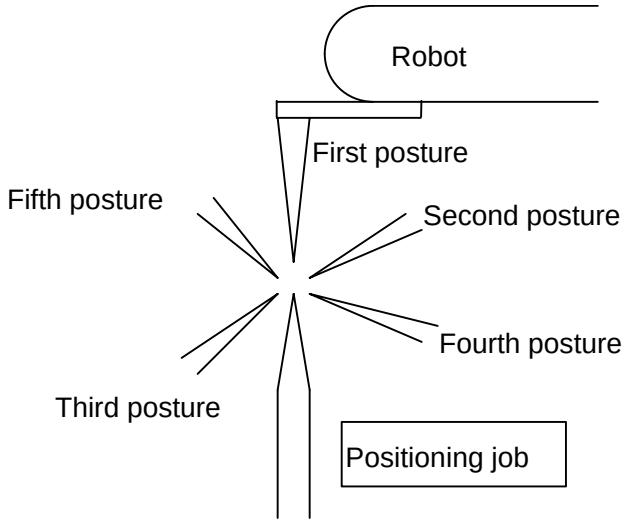


Fig. 2.1.1 Teaching the Same Point with 5 Postures

b) With operation a), perform teaching of 1 point at 5 different points.

The distance between each point should be kept to a minimum of 100 mm. If this condition is not kept, this function doesn't work right.

Perform teaching at five points from left upper side to right lower side with 5 postures each, so that the values of X, Y, and Z vary equally in a wide area of the robot front face, for teaching of correct calibration job. For robot postures at job teaching, refer to Appendix 1 "Examples of Robot Calibration."

<Example of Robot Calibration Job>

```
NOP
*1
MOVJ C0000 VJ=0.78 PL=0
MOVJ C0001 VJ=0.78 PL=0
MOVJ C0002 VJ=0.78 PL=0
MOVJ C0003 VJ=0.78 PL=0
MOVJ C0004 VJ=0.78 PL=0
*2
MOVJ C0005 VJ=0.78 PL=0
MOVJ C0006 VJ=0.78 PL=0
MOVJ C0007 VJ=0.78 PL=0
MOVJ C0008 VJ=0.78 PL=0
MOVJ C0009 VJ=0.78 PL=0
*3
MOVJ C0010 VJ=0.78 PL=0
MOVJ C0011 VJ=0.78 PL=0
MOVJ C0012 VJ=0.78 PL=0
MOVJ C0013 VJ=0.78 PL=0
MOVJ C0014 VJ=0.78 PL=0
*4
MOVJ C0015 VJ=0.78 PL=0
MOVJ C0016 VJ=0.78 PL=0
MOVJ C0017 VJ=0.78 PL=0
MOVJ C0018 VJ=0.78 PL=0
MOVJ C0019 VJ=0.78 PL=0
*5
MOVJ C0020 VJ=0.78 PL=0
MOVJ C0021 VJ=0.78 PL=0
MOVJ C0022 VJ=0.78 PL=0
MOVJ C0023 VJ=0.78 PL=0
MOVJ C0024 VJ=0.78 PL=0
END
```

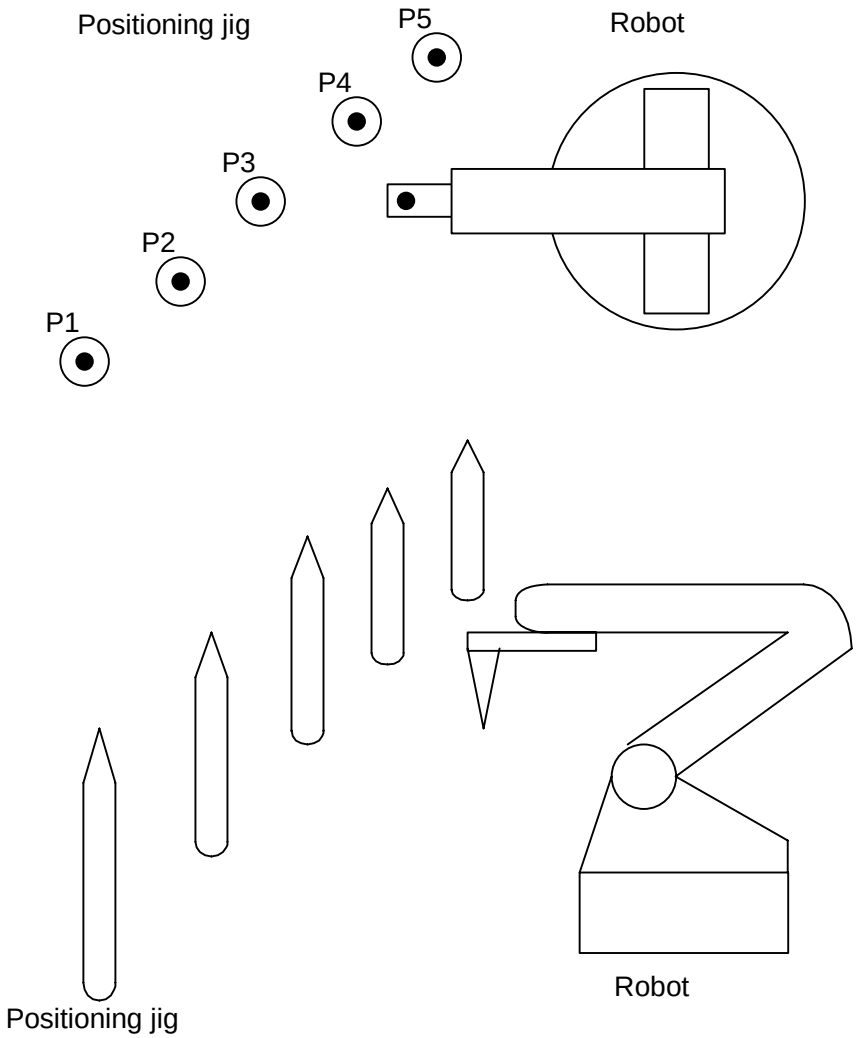


Fig. 2.1.2 Teaching 5 Points with 5 Postures

4) Save the following robot data from the robot controller to the floppy disk, using a device such as YASNAC FC2, etc.

File Name	Contents	Remarks
ALL.PRM	Robot parameter data	For ERC, PARAM.DAT
ABSO.DAT	Robot absolute data	
TOOL.CND	Tool data	For ERC, TOOL.DAT
ROBOT.JBI	Job of 5 postures each at 5 points for calibration	

Fig. 2.1.3 Data to be Saved to Floppy Disk

2.1.2 Operation on Personal Computer

1) Insert the above floppy disk. Double-click the [MOTOCALV EG] icon in the [Start]-[Program]-[Motoman]-[MOTOCALV EG] to start the program. The main screen, "MOTOCALV EG" is displayed for calibration programs.

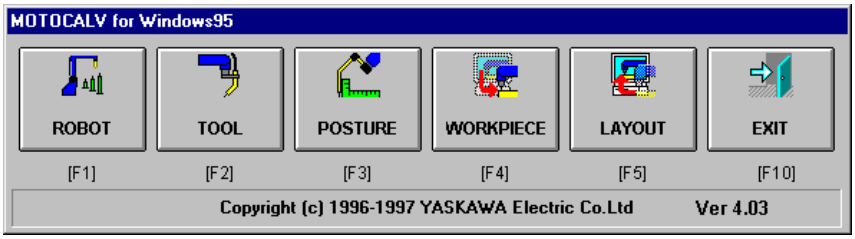


Fig. 2.1.4 Calibration Main Screen "MOTOCALV EG"

2) Click the [F1] (ROBOT) button to display the "Robot Calibration" screen.

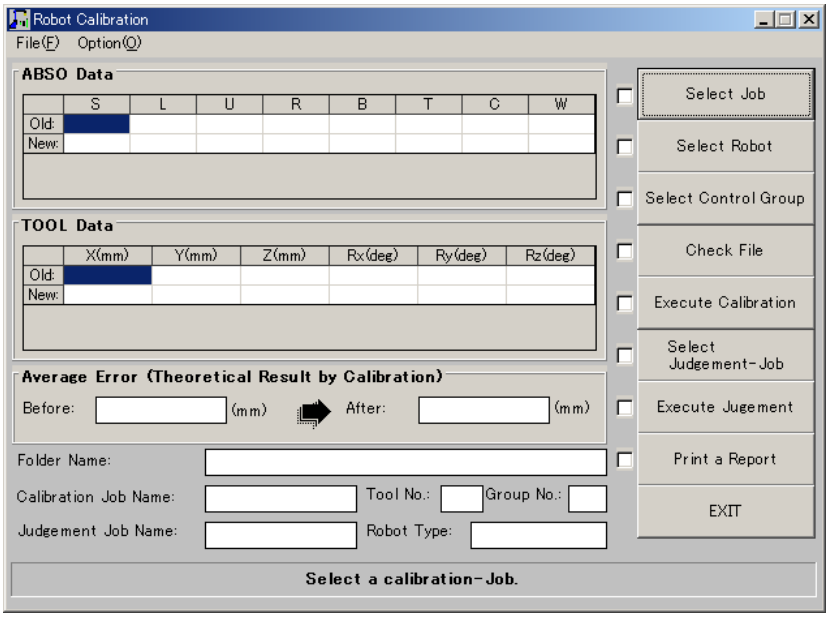


Fig. 2.1.5 "Robot Calibration" Screen

3) Click the [Select Job] button to display the [Select Job] dialog box. To select the robot calibration job file (Robot.JBI), click the [Open] button or double-click the file. (When the calibration job has been taught under a different job name, select the corresponding file.) Then the screen returns to the "Robot Calibration" screen.

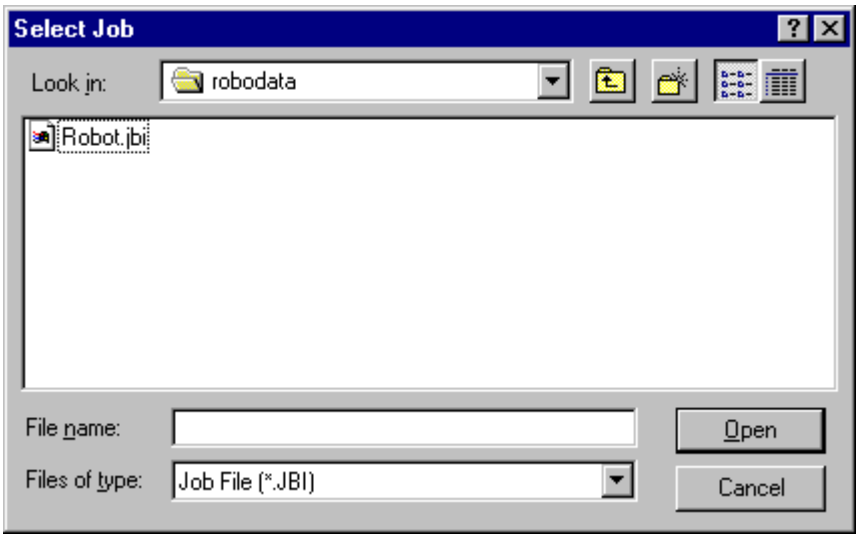


Fig. 2.1.6 [Select Job] Dialog Box

4) Click the [Select Robot] button to display the [Select Robot] dialog box. To select the robot type for robot calibration, click the [OK] button or double-click the corresponding type. If the corresponding type of robot is not on the list, select the "other robot type." Then the screen returns to the "Robot Calibration" screen.

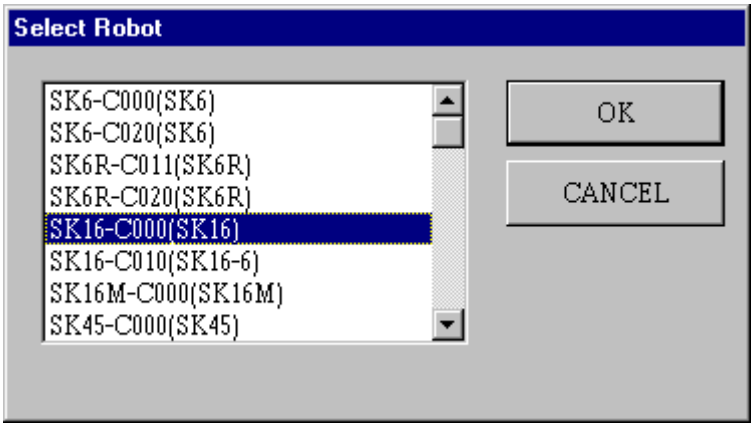


Fig. 2.1.7 [Select Robot] Dialog Box

5) Click the [Select Control Group] button to display the [Select Control Group] dialog box. To select the robot numger for robot calibration, click the [OK] button to return to the "Robot Calibration" screen

Fig. 2.1.8 [Select Control Group] Dialog Box

6) Click the [Check File] button to check the files necessary for calibration. (Verify that the corresponding files for parameter data, absolute data and tool data exist.)

When the corresponding files exist, the following message is displayed.

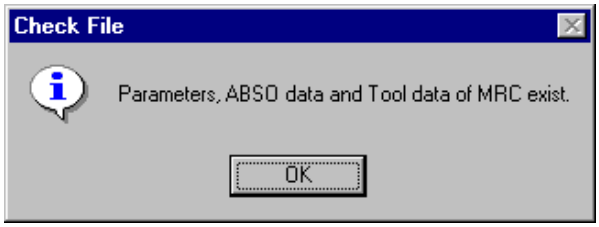


Fig. 2.1.9 "Check File" Confirmation Message

7) Click the [OK] button to return to the "Robot Calibration" screen. Click the [Execute Calibration] button to display the "Calculation" screen. Then calibration starts and the calculation process is displayed.

Clicking the [STOP] button stops the calculation to return to the "Robot Calibration" screen and the calculation result will not be written in the file (ABSO Data, TOOL Data).

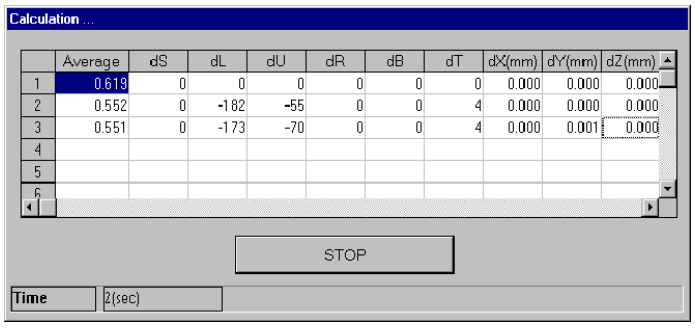


Fig. 2.1.10 "Calculation" Screen for Robot Calibration Calculation Process

When calculation is completed, the "Calculation finish" screen is displayed.

Click the [EXIT] button and the calibration will be judged as "successful" or "failed" based on

the average error (theoretical value by calibration calculation). Then 2 types of "Message of Calibration Judgement" are displayed. Click the [OK] button to return to the "Robot Calibration" screen.

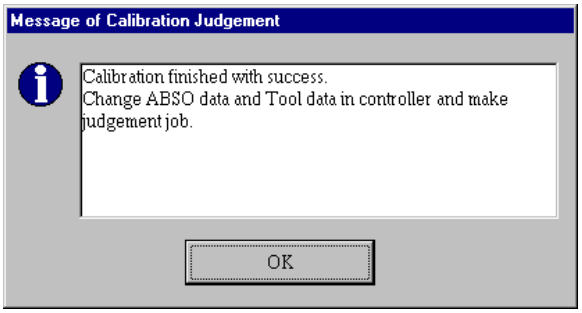


Fig. 2.1.11 Message for Successful Calibration

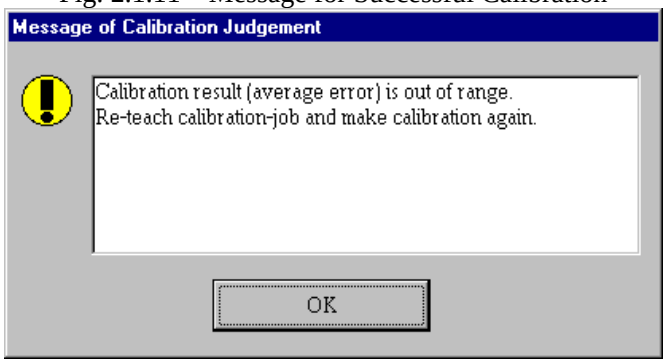


Fig. 2.1.12 Message for Failed Calibration

Notes 1: When a message for failed calibration is displayed, perform re-teaching of robot calibration from the step 3) of 2.1.1 "Operation with Actual Robot", and re-execute the process.

2: For some failed calibration jobs or robot types after re-teaching and re-executing the process, extend the calculation range for calibration job. For calculation range setting, contact your YASKAWA representative or YASKAWA Robot Service.

8) Click the [OK] button to return to the "Robot Calibration" screen. When a successful calibration result is obtained, stop the operation on personal computer once, and load the changed ABSO Data and TOOL Data to the actual robot, by using a device such as YASNAC FC2, etc.
(ABSO.DAT, TOOL.CND. For ERC, ABSO.DAT, TOOL.DAT)

9) After verifying that new ABSO Data and TOOL Data have been overwritten in the robot controller, turn OFF power to the robot controller and re-start.

10) Using the same tool as used for the calibration job (5 postures each at 5 points), perform teaching of the control point constant operation job (job name: P7-NEW, 7 postures at 1 point). This is called a judgement job.

For robot postures at job teaching, refer to Appendix 2 "Example of Tool Calibration."

Note: This operation checks how much robot accuracy is improved by changing the ABSO Data and TOOL Data by calibration job.

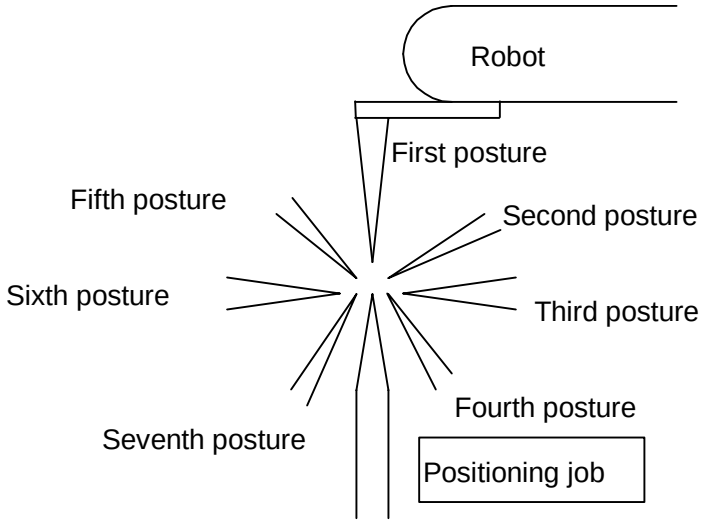


Fig. 2.1.13 Teaching the Same Point with 7 Postures

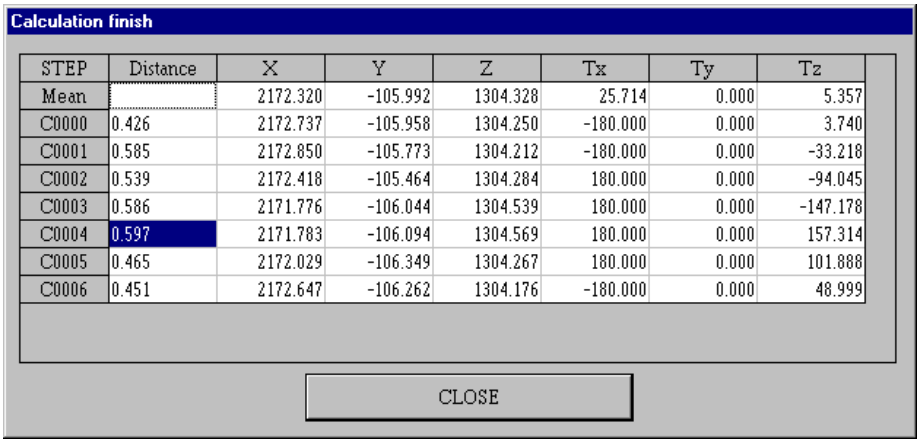
11) Save the job (P7-NEW.JBI) of 7 taught postures at 1 point, from the robot controller to the floppy disk.

12) Insert the above floppy disk from the robot controller to the personal computer drive, and execute the continued operation for robot calibration.

13) Click the [Select Judgement-Job] button to display the [Select Judgement-Job] dialog box. To select the created judgement job file (P7-NEW.JBI), click the [Open] button or double-click the file. Then the screen returns to the "Robot Calibration" screen.

Fig. 2.1.14 [Select Judgement-Job] Dialog Box

14) Click the [Execute Judgement] button to display the "Calculating" screen. The accuracy after calibration of the control point constant operation. The screen shows the X, Y, and Z coordinates and their average coordinates at each point of the judgement job. When calculation is completed, the "Calculation finish" screen is displayed.



STEP	Distance	X	Y	Z	Tx	Ty	Tz
Mean		2172.320	-105.992	1304.328	25.714	0.000	5.357
C0000	0.426	2172.737	-105.958	1304.250	-180.000	0.000	3.740
C0001	0.585	2172.850	-105.773	1304.212	-180.000	0.000	-33.218
C0002	0.539	2172.418	-105.464	1304.284	180.000	0.000	-94.045
C0003	0.586	2171.776	-106.044	1304.539	180.000	0.000	-147.178
C0004	0.597	2171.783	-106.094	1304.569	180.000	0.000	157.314
C0005	0.465	2172.029	-106.349	1304.267	180.000	0.000	101.888
C0006	0.451	2172.647	-106.262	1304.176	-180.000	0.000	48.999

Fig. 2.1.15 "Calculation finish" Screen for Judgement Job

Clicking the [CLOSE] button starts checking the maximum values of distance from the average coordinate to each point, and performs calibration judgement of control point constant operation after the adjustment of ABSO Data and TOOL Data. At completion of calibration process, the calibration will be judged as "successful" or "failed." Then 2 types of "Message of Calibration Judgement" are displayed. Click the [OK] button to return to the "Robot Calibration" screen.

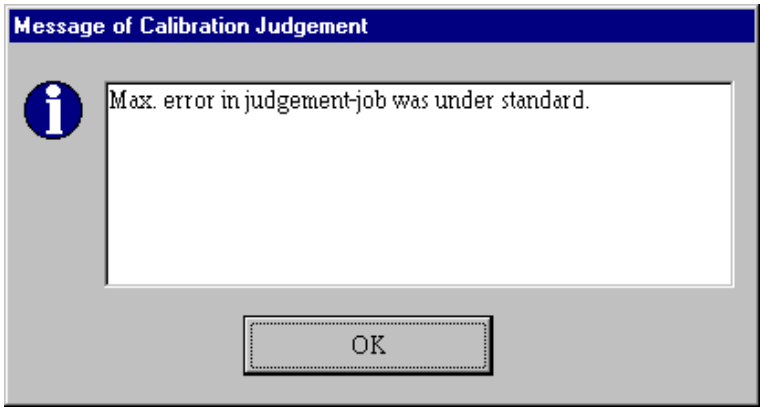


Fig. 2.1.16 Message for Successful Judgement

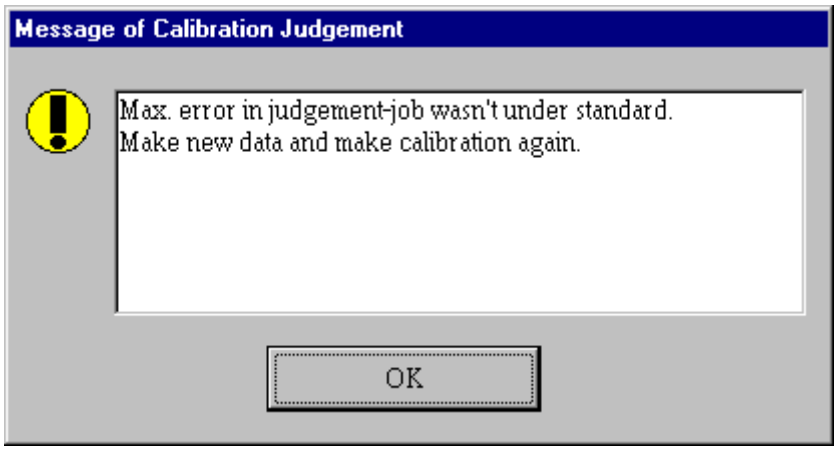


Fig. 2.1.17 Message for Failed Judgement

Note: When a failed judgement result message is displayed, perform re-teaching of calibration from step 9).

15) Click the [OK] button to return to the "Robot Calibration" screen. When a successful judgement message is displayed, click the [Print a Report] button to print out the report. The robot calibration operation is completed.

2.2 Tool Calibration

2.2.1 Operation with Actual Robot

1) To perform tool calibration, prepare the data of tool to be mounted in advance. Mount the tool on the robot flange. The following two methods are available for tool data, in addition to tool calibration method explained in this section.

① Performs the tool calibration with the actual robot.

②Uses the values of mechanical dimensions of the tool if specified in the drawing, etc.

2) Using this tool, perform teaching of the job (job name: TOOL) of 7 postures and more at 1 point. The calibration job "TOOL" is used for actual calculation by the calibration software. The teaching method is explained below.

a) Using the same tool, perform teaching of 7 postures at one point. (Use MOVJ or MOVL for interpolation type. On base of the taught positions, X, Y, and Z will be calculated internally.)

Notes 1: For teaching of large-size robots of K60 and more, perform teaching with the wrist angle 45° or less, since the flexure by the robot arm weight may affect calibration, with the wrist posture largely inclined. For robot sizes below K60, incline the wrist 45° or more.

2: When the actual playback operation requires movement as changing robot form, for example, the robot wrist axis rotating in reverse, perform teaching with the posture of that movement. For robot postures at job teaching, refer to Appendix 2 "Examples of Tool Calibration."

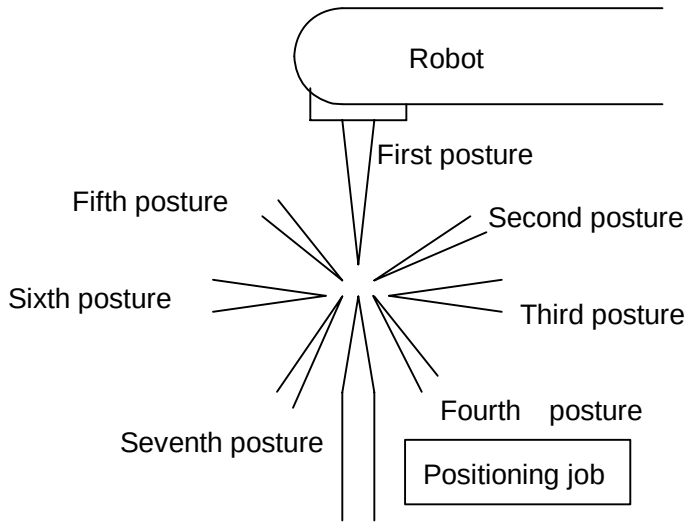


Fig. 2.2.1 Teaching the Same Point with 7 Postures

<Example of Tool Calibration Job>

NOP

MOVJ C000 VJ=0.78 PL=0

MOVJ C001 VJ=0.78 PL=0

MOVJ C002 VJ=0.78 PL=0

MOVJ C003 VJ=0.78 PL=0

MOVJ C004 VJ=0.78 PL=0

MOVJ C005 VJ=0.78 PL=0

MOVJ C006 VJ=0.78 PL=0

END

3) Save the following robot data from the robot controller to the floppy disk, using a device such as YASNAC FC2, etc.

File Name	Contents	Remarks
ALL.PRM	Robot parameter data	For ERC, PARAM.DAT
TOOL.CND	Tool data	For ERC, TOOL.DAT
TOOL.JBI	Job for tool calibration	7 postures or more at 1 point

Fig. 2.2.2 Data to be Saved to Floppy Disk

2.2.2 Operation on Personal Computer

1) Insert the above floppy disk. Double-click the [MOTOCALV EG] icon in the [Start]-[Program]-[Motoman]-[MOTOCALV EG] to start the program. (Refer to Fig. 2.1.4 Calibration Main Screen "MOTOCALV EG")

2) Click the [F2] (TOOL) button to display the "Tool Calibration" screen.

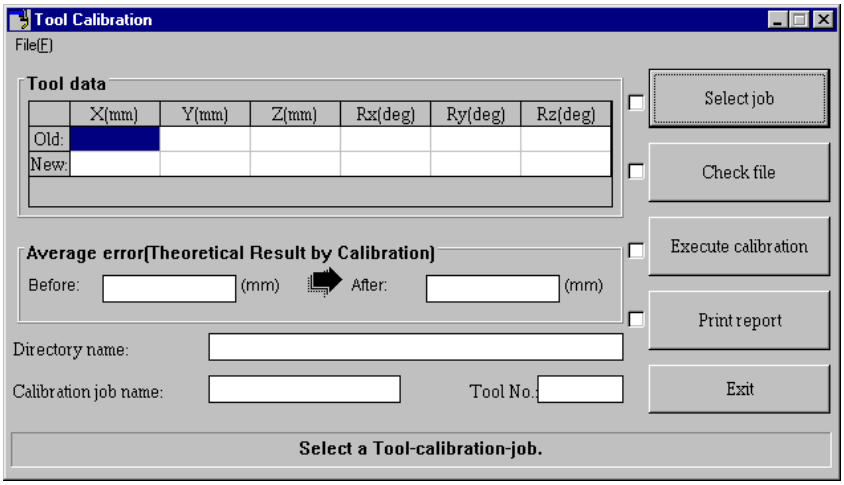


Fig. 2.2.3 "Tool Calibration" Screen

3) Click the [Select job] button to display the [Select job] dialog box. To select the tool calibration job file (TOOL.JBI), click the [Open] button or double-click the file. (When the calibration job has been taught under a different name, select the corresponding file.) Then the screen returns to the "Robot Calibration" screen.

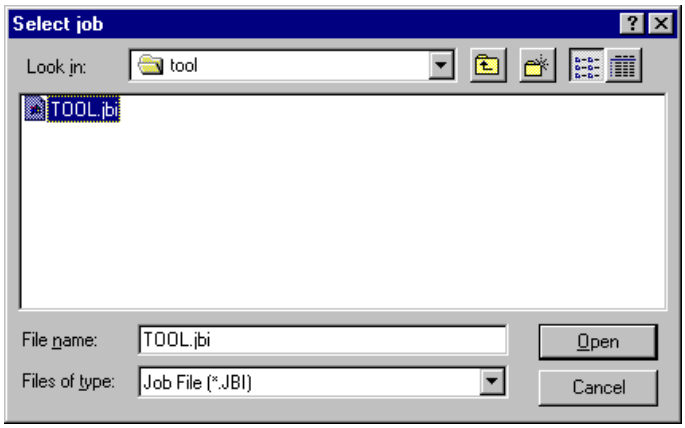


Fig. 2.2.4 [Select job] Dialog Box

4) Click the [Check File] button to check the files necessary for tool calibration.
(Verify that the corresponding files for parameter data and tool data exist.)
When the corresponding files exist, the following message is displayed.

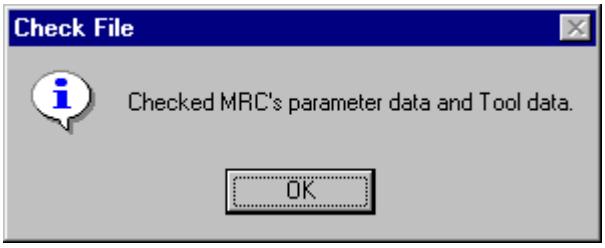


Fig. 2.2.5 "Check File" Confirmation Message

5) Clicking the [OK] button returns to the "Tool Calibration" screen. Click the [Execute Calibration] button to display the "Calculating" screen.
Then calibration starts and the calculation process is displayed.
Clicking the [STOP] button stops the calculation to return to the "Tool Calibration" screen and the calculation result will not be written in the file (Tool Data). When calculation is completed, the "Calculation finish" screen is displayed.

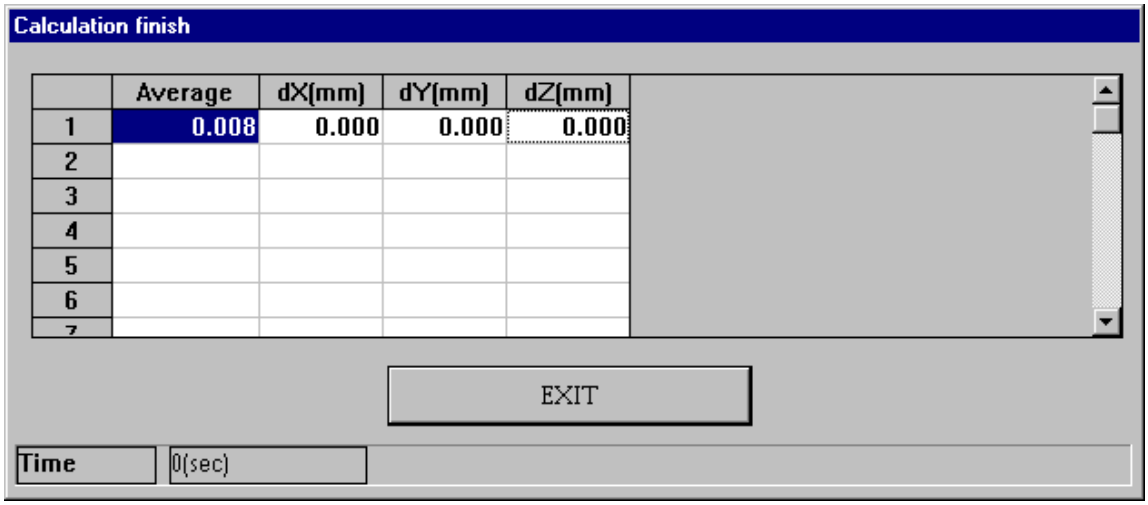


Fig. 2.2.6 "Calculation finish" Screen for Tool Calibration Calculation Process

6) Clicking the [EXIT] button returns to the "Tool Calibration" screen. Click the [Print a Report] button to print out the report.

7) Load the changed tool data to the actual robot, by using a device such as YASNAC FC2, etc. After loading, confirm that the new tool data has been overwritten in the robot controller.
(TOOL.CND. For ERC, TOOL.DAT)

The tool calibration operation is completed.

2.3 Tool Posture Calibration

2.3.1 Operation with Actual Robot

1) To perform tool posture calibration, prepare the data of tool to be mounted in advance.
The following three methods are available for tool data.

①Performs the tool calibration with the actual robot.

②Performs the tool calibration by MOTOCALV EG.
(Refer to Section 2.2 "Tool Calibration.")

③Uses the values of mechanical dimensions if specified in the drawing, etc.

2) Mount a tool on the robot flange, and using this tool, perform teaching of the job (job name: TOOLPS) for 1 posture at 1 point. This calibration job "TOOLPS" is used for actual calculation by the calibration software.
The teaching method is explained below.

a) Use a level or other instruments to set the desired posture by moving the robot along the coordinate axis, then teach the point.
(Use MOVJ or MOVL for interpolation type. On base of the taught positions, X, Y, and Z will be calculated internally.)

Note: For example of arc weld torch, when the direction of welding wire is to be the same direction of Z-axis on the tool coordinate, place the tool in such a posture that the weld torch is positioned horizontally, and teach this position.

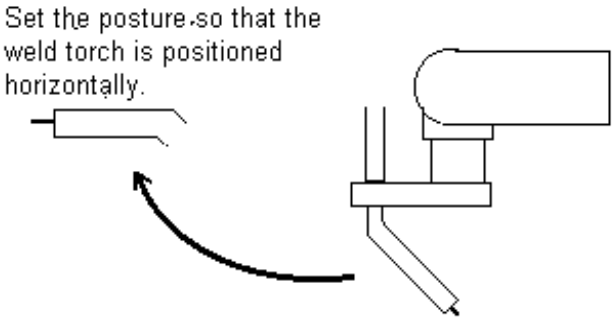


Fig. 2.3.1 One Point Teaching

＜Example of Tool Posture Calibration Job＞

```
NOP
MOVJ C000 VJ=0.78 PL=0
END
```

3) Save the following robot data from the robot controller to the floppy disk, using a device such as YASNAC FC2, etc.

File Name	Contents	Remarks
ALL.PRM	Robot parameter data	For ERC, PARAM.DAT
TOOL.CND	Tool data	For ERC, TOOL.DAT
TOOLPS.JBI	Job for tool posture calibration	1 posture at 1 point

Fig. 2.3.2 Data to be Saved to Floppy Disk

2.3.2 Operation on Personal Computer

1) Insert the above floppy disk. Double-click the [MOTOCALV EG] icon in the [Start]-[Program]-[Motoman]-[MOTOCALV EG] to start the program. (Refer to Fig. 2.1.4 Calibration Main Screen "MOTOCALV EG")

2) Click the [F3] (POSTURE) button to display the "Tool Posture Calibration" screen.

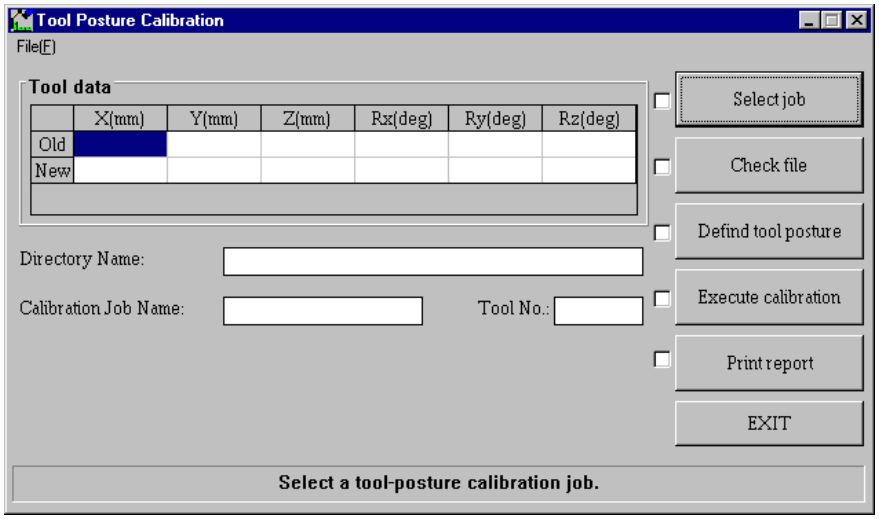


Fig. 2.3.3 "Tool Posture Calibration" Screen

3) Click the [Select job] button to display the [Select job] dialog box. To select the tool posture calibration job file (TOOLPS.JBI), click the [Open] button or double-click the file. (When the calibration job has been taught under a different job name, select the corresponding file.) Then the screen returns to the "Tool Posture Calibration" screen.

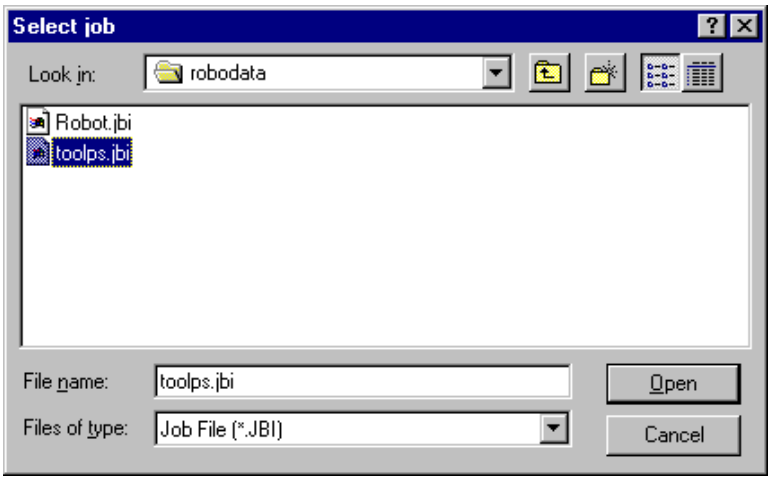


Fig. 2.3.4 [Select job] Dialog Box

4) Click the [Check File] button to check the files necessary for tool posture calibration. (Verify that the corresponding files for parameter data and tool data exist.)
When the corresponding files exist, the following message is displayed.

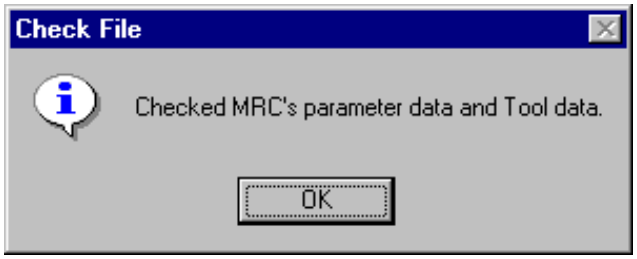


Fig. 2.3.5 "Check File" Confirmation Message

5) Click the [OK] button to return to the "Tool Posture Calibration" screen. Click the [Define tool posture] button to display the "Tool Posture Settings" screen. Then click the [Rx-], [Rx+], [Ry-], [Ry+], [Rz-], and [Rz+] buttons as many times as needed, to set the taught posture with actual robot. Then click the [OK] button to return to the "Tool Posture Calibration" screen.

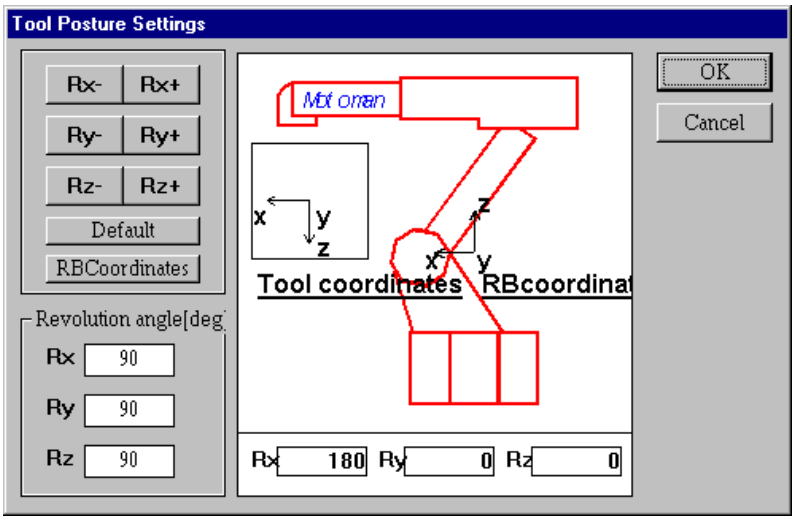


Fig. 2.3.6 "Tool Posture Settings" Screen

6) Click the [Execute Calibration] button to execute the calibration.

7) Click the [Print a Report] button to print out the report.

8) Load the changed tool data to the actual robot, by using a device such as YASNAC FC2, etc. After loading, confirm that the new tool data has been overwritten in the robot controller. (TOOL.CND. For ERC, TOOL.DAT)

The tool posture calibration operation is completed.

2.4 Workpiece Calibration

The workpiece calibration is composed of "Workpiece calibration" and "Job conversion." "Workpiece calibration" calculates the positional difference between each robot and workpiece, by comparing the job created by offline system and the job created with the actual robot. Then "Job conversion" converts the position data by offline system into the data for the actual robot, using the difference above.

2.4.1 Workpiece Calibration

■ Teaching of personal computer reference point teaching job

Perform teaching of personal computer reference point teaching job by MotoSim EG.

Job name: WORK

Teaching method:

Using the same tool, teach the workpiece reference points. Decide 3 or more reference points. (5 points are recommended. When higher accuracy is required, teach more points.) Teach the first 3 points to form a triangle largely covering the robot working envelope for the workpiece. The order of teaching and number of teaching points should be the same as for the robot controller reference point teaching job explained in "■ Teaching of robot controller reference point teaching job (Operation with actual robot)" below. For interpolation type, use MOVJ or MOVL. On base of the taught positions, X, Y, and Z will be calculated internally. (It is recommended that reference point teaching be performed without changing the robot posture, to maintain accuracy of tool data (robot control point)).

＜Workpiece calibration: Example of personal computer reference point job＞

```
NOP
MOVL C0000 V=46.0 PL=0
MOVL C0001 V=46.0 PL=0
MOVL C0002 V=46.0 PL=0
MOVL C0003 V=46.0 PL=0
MOVL C0004 V=46.0 PL=0
END
```

■ Teaching of robot controller reference point teaching job (Operation with actual robot)

Perform teaching of robot controller reference point teaching job with actual robot.

Job name: WORKREF

Teaching method:

Using the same tool, teach the workpiece reference points. Decide 3 or more reference points. (5 points are recommended. When higher accuracy is required, teach more points.) Teach the first 3 points to form a triangle largely covering the robot working envelope for the workpiece. The order of teaching and number of teaching points should be the same as for the personal computer reference point teaching job explained in "■ Teaching of personal computer reference point teaching job" in the previous page. Any interpolation type can be used. (For teaching reference points, it is recommended that reference point teaching be performed without changing the robot posture to maintain accuracy of tool data (robot control point)).

＜Workpiece calibration: Example of robot controller reference point job＞

```
NOP
MOVL C0000 V=46.0 PL=0
MOVL C0001 V=46.0 PL=0
MOVL C0002 V=46.0 PL=0
MOVL C0003 V=46.0 PL=0
MOVL C0004 V=46.0 PL=0
END
```

Save the following robot data from the robot controller to the floppy disk, using a device such as YASNAC FC2, etc.

File Name	Contents	Remarks
ALL.PRM	Robot parameter data	For ERC, PARAM.DAT
TOOL.CND	Tool data	For ERC, TOOL.DAT
WORKREF.JBI	Job for workpiece calibration	3 points or more

Fig. 2.4.1 Data to be Saved to Floppy Disk

■ Calibration operation

1) Insert the above floppy disk to the personal computer drive. Double-click the [MOTOCALV EG] icon in the [Start]-[Program]-[Motoman]−[MOTOCALV EG] to start the program. (Refer to Fig. 2.1.4 Calibration Main Screen "MOTOCALV EG")

2) Click the [F4] (WORKPIECE) button to display the "Workpiece Calibration" screen.

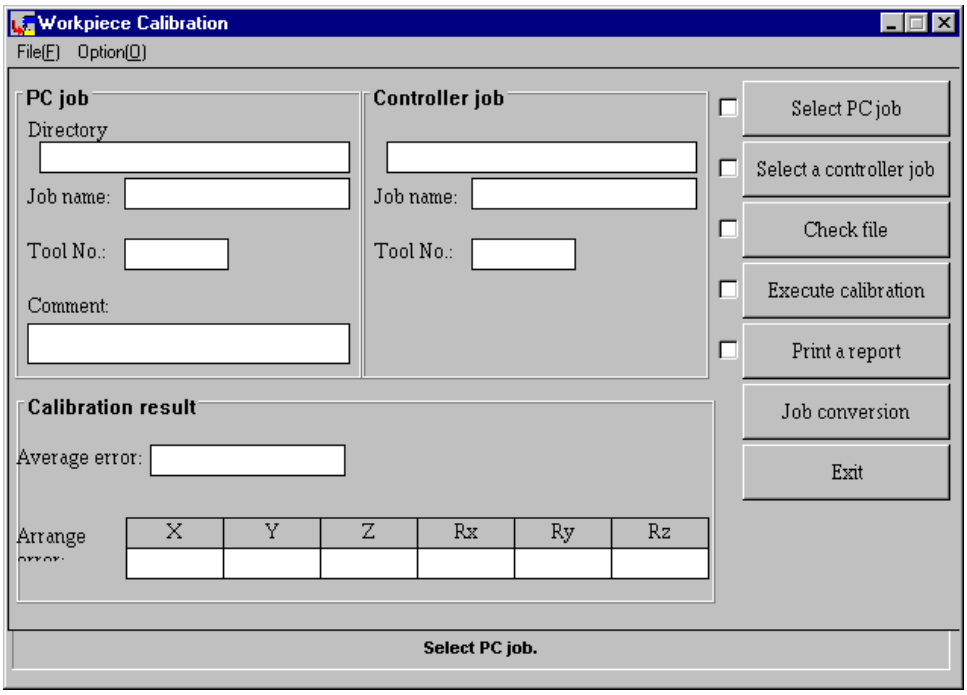


Fig. 2.4.2 "Workpiece Calibration" Screen

3) Click the [Select PC job] button to display the [Select PC job] dialog box. To select the file of personal computer reference point job for calibration (WORK.JBI), click the [Open] button or double-click the file. (When the reference point job has been taught under a different name, select the corresponding file.) Then the screen returns to the "Workpiece Calibration" screen.

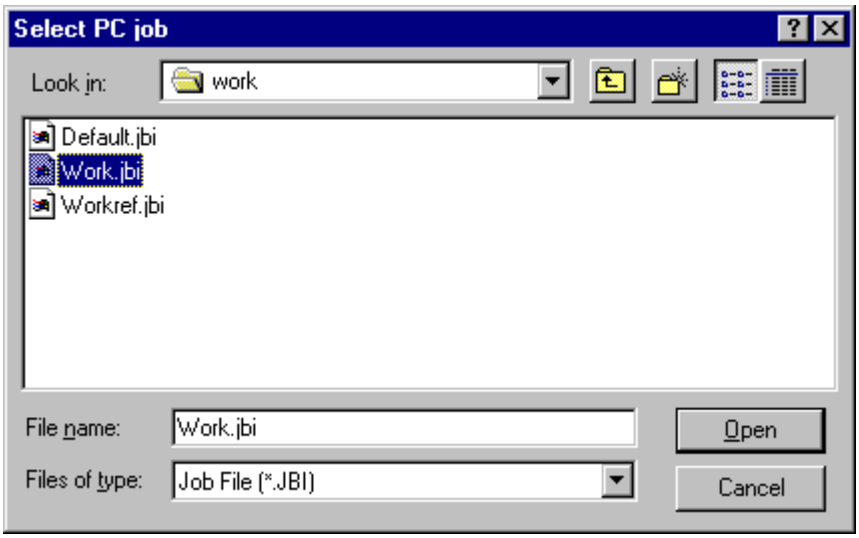


Fig. 2.4.3 [Select PC job] Dialog Box

4) Click the [Select a robot controller job] button to display the [Select a robot controller job] dialog box. To select the file of robot controller reference point job saved in the floppy disk for calibration (WORKREF.JBI), click the [Open] button or double-click the file. (When the reference point job has been taught under a different name, select the corresponding file.) Then the screen returns to the "Workpiece Calibration" screen.

Fig. 2.4.4 [Select a robot controller job] Dialog Box

5) Click the [Check File] button to check the files necessary for workpiece calibration. (Verify that the corresponding files for parameter data and tool data exist.)
When the corresponding files exist, the following message is displayed.

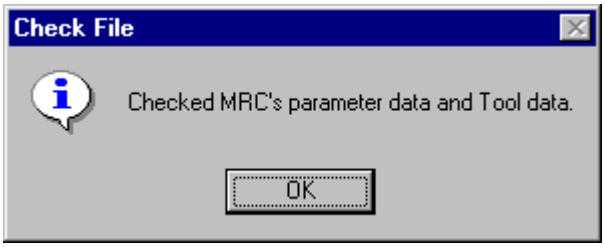


Fig. 2.4.5 "Check File" Confirmation Message

6) Click the [OK] button to return to the "Workpiece Calibration" screen.

Note: If no comment is required, it is not necessary to write in.

7) Click the [Execute Calibration] button to display the "Calculating" screen. Input a comment to be written in the personal computer job (WORK.JBI).
Then calibration starts and the calculation process is displayed.

Note: As calculation result, the conversion constant are written in personal computer reference point job (WORK.JBI) and robot controller reference point job (WORKREF.JBI), as a comment statement. The matrix to convert the personal computer job to the robot controller job is written in WORK.JBI, and the matrix to convert the robot controller job to the personal computer job in WORKREF.JBI, respectively. They are written in form of a comment statement, with X, Y, Z, Rx, Ry, Rz values based on the robot wrist motion.

Clicking the [STOP] button stops the calculation to return to the "Workpiece Calibration" screen and the calculation result will not be written in the file (personal computer reference point job, robot controller reference point job). When calculation is completed, the "Calculation finish" screen is displayed.

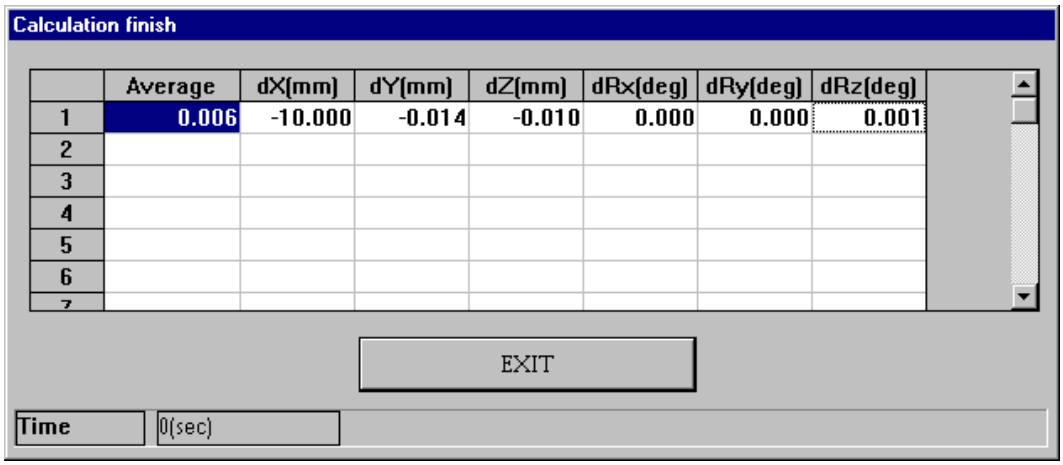


Fig. 2.4.6 "Calculation finish" Screen for Workpiece Calibration Calculation Process

＜Example of personal computer reference point job after calibration＞

```
NOP
'WKCOM COMMENT
'WKCAL(0.029)=21.053,-27.353,37.566,1.999,1.999,2.002
MOVL C0000 V=46.0 PL=0
MOVL C0001 V=46.0 PL=0
MOVL C0002 V=46.0 PL=0
MOVL C0003 V=46.0 PL=0
MOVL C0004 V=46.0 PL=0
END
```

Notes 1: The unit system for X, Y, and Z is distance (mm).

2: The unit system for Rx, Ry, and Rz is angle (degree).

8) Click the [Print a report] button to print out the report.

■ Calibration operation for multi stations

For multi stations, perform the procedure 3) to 7) indicated in "■ Calibration operation" to each stations for the number of station times.

2.4.2 Job Conversion

1) Click the [job conversion] button to display the "Workpiece Calibration" screen for job conversion.

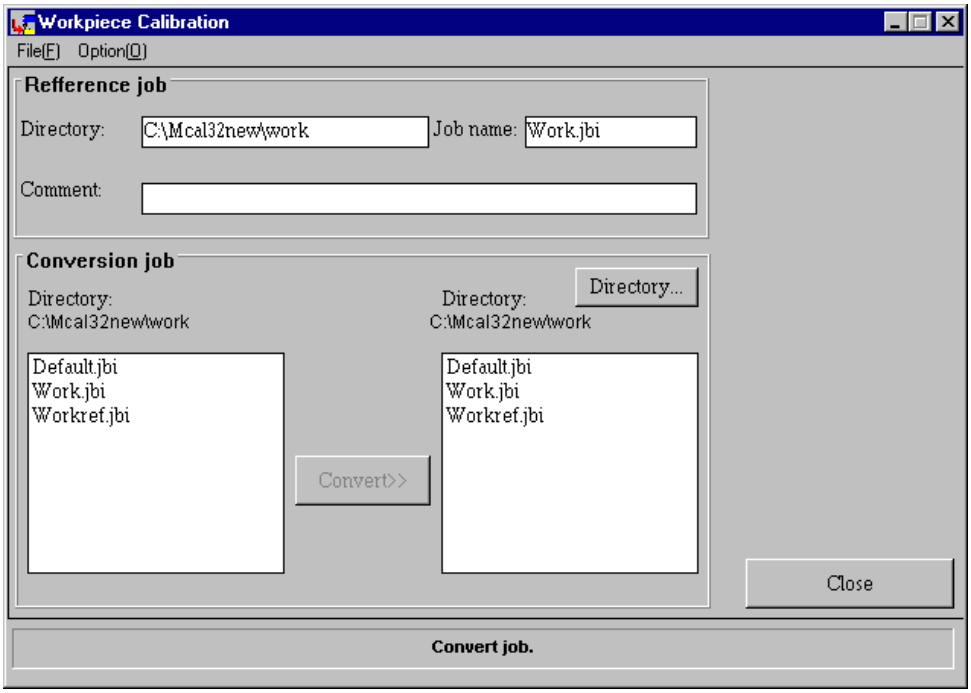


Fig. 2.4.7 "Workpiece Calibration" Screen for Job Conversion

Reference job is a job where the positional differences between personal computer and actual robot are written. And the personal computer reference point job (WORK.JBI) selected in the "Workpiece Calibration" screen is taken over to this screen, and displayed.

2) Select the job to convert from the list box on the left. More than one job can be selected.

Note: The directory should be the same as for the personal computer job (WORK.JBI) (The directory will be fixed and cannot be changed).

3) Click the [Directory…] button to specify the conversion destination directory.

Note: For the conversion destination directory, the conversion destination directory of the previous conversion is displayed as default.

4) Click the [Convert>>] button to execute the job conversion.

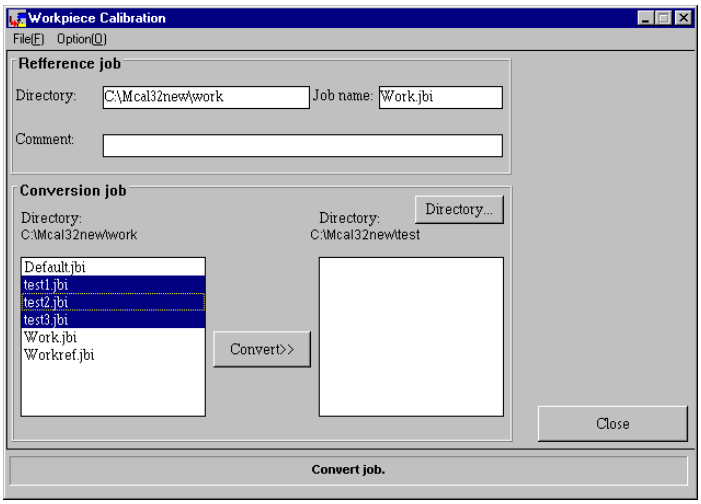


Fig. 2.4.8 "Workpiece Calibration" Screen after Job Conversion

5) If there are jobs to be deleted from conversion source and destination, select the jobs from each list box, then select [Delete Job (D)] from the [File (F)] menu to delete the jobs.

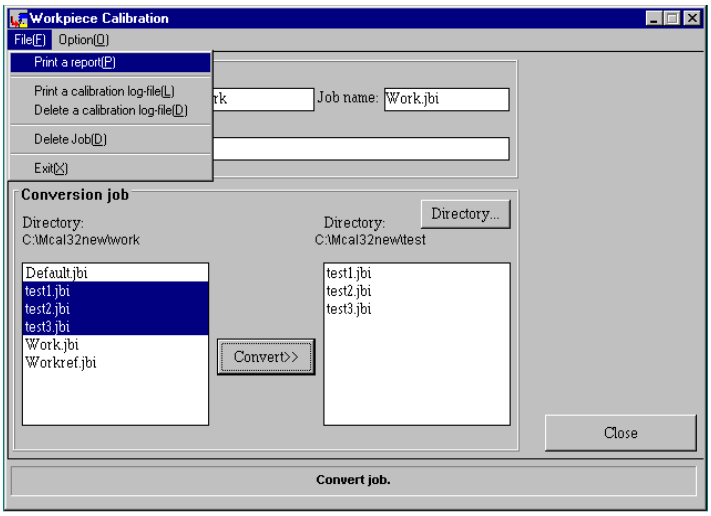


Fig. 2.4.9 "Workpiece Calibration" Screen after Job Conversion (at Selecting from File Menu)

6) When conversion is completed, click the [Close] button to return to the "Workpiece Calibration" screen.

7) Load the converted job to the actual robot, using a device such as YASNAC FC2, etc.

Note: For the converted job, the converted amount is written as default in comment. If this comment exceeds 32 characters, the job cannot be loaded to the robot controller. In this case, remove the check mark on [Output of conversion job comment disabled] of the option menu, to set the mode not to write comment in the job.

The workpiece calibration operation is completed.

■ Job conversion for multi stations

1) Click the [job conversion] button to display the “Workpiece Calibration” screen for job conversion.

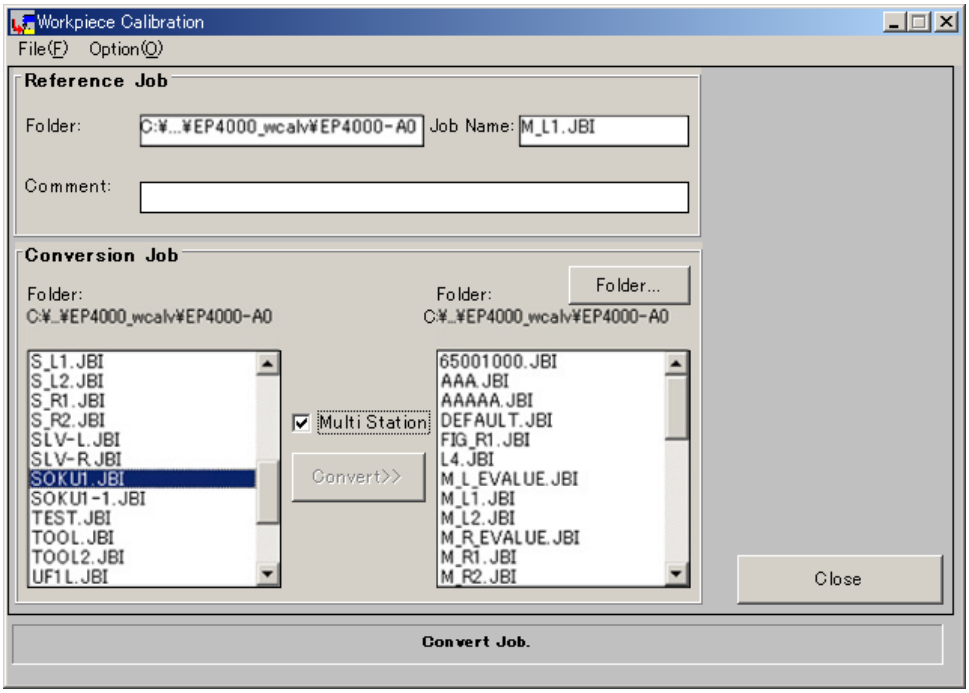


Fig. 2.4.10 “Workpiece Calibration” Screen for Job Conversion

Reference job is a job where the positional differences between personal computer and actual robot are written. And the personal computer reference point job (M_L1.JBI) selected in the “Workpiece Calibration” screen is taken over to this screen, and displayed.
Tick the [Multi Station] check box.

2) Select the job to convert from the list box on the left. More than one job cannot be selected.

Note: The directory should be the same as for the personal computer job (M_L1.JBI) selected. (The director will be fixed and cannot be changed.)

3) Click the [Directory…] button to specify the conversion destination directory.

Note: For the conversion destination directory, the conversion destination directory of the previous conversion is displayed as default.

4) Click the [Convert>>] button to execute the job conversion.

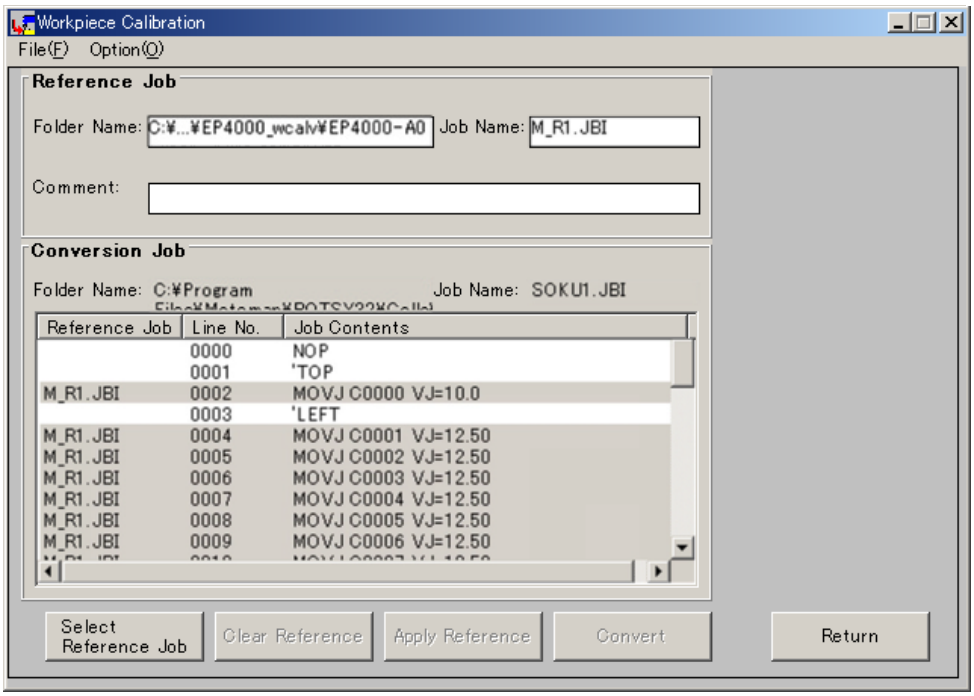


Fig. 2.4.11 “Workpiece Calibration” Screen for Calibration Job

Each steps of the job are selected default jobs. The default jobs are the latest correction jobs set before and decide by which correction job the step is to be converted. If necessary, change the correction job of each step by following the procedure indicated below.

① Click the [Select Reference Job] button to change the correction job.
② Select the step whose correction job was changed.
③ Click the [Apply Reference] button to change the reference job.
④ Either repeat the procedure ① to ③ above, or select several steps at a time to convert the reference jobs.
⑤ For the points of air cut or the steps you do not want to move, click the [Clear Reference] button and confirm that the step does not possess any reference job to prevent the step from being converted.
⑥ Click the [Convert] button to convert the job.

5) If there are jobs to be deleted from conversion source and destination, select the jobs from each list box, then select [Delete Job (D)] from the [File (F)] menu to delete the jobs.

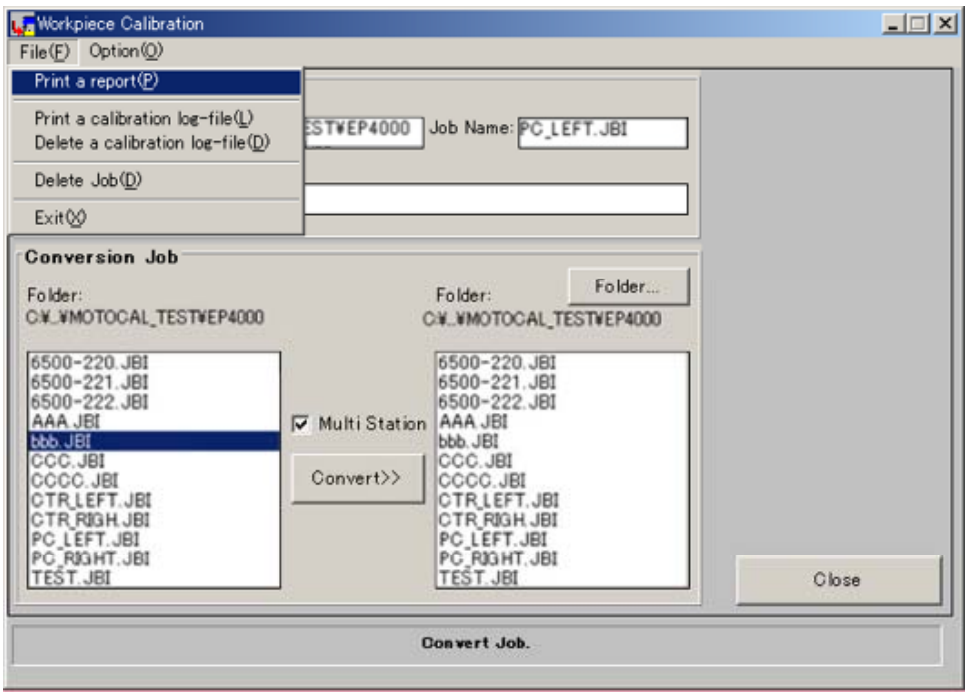


Fig. 2.4.12 “Workpiece Calibration” Screen for Job Conversion When Selecting form the File Menu

6) When conversion is completed, click the [Close] button to return to the “Workpiece Calibration” screen.

7) Load the converted job to the actual robot, using a device such as YASNAC FC2, etc.

Note: For the converted job, the converted amount is written as default in comment. If this comment exceeds 32 characters, the job cannot be loaded to the robot controller. In this case, remove the check mark on [Output of conversion job comment disabled] of the option menu, to set the mode not to write comment in the job.

2.5 Layout Correction

The layout correction is composed of "Robot Layout Correction" and "Travel Axis Correction." "Robot Layout Correction" corrects the robot layout in the cell constructed by ROSTY for actual robot layout, by comparing the job created by offline system and the job created with the actual robot. "Travel Axis Tilt Correction" corrects the robot layout in the cell constructed by ROSTY for the actual robot layout, by calculating the positional difference between the travel axis and the robot positioned on the travel axis.

Note: The above layout correction should be performed after having executed the robot calibration and tool calibration. Otherwise, proper operation cannot be performed.

2.5.1 Robot Layout Correction

■ Teaching of personal computer reference point teaching job

Perform teaching of the personal computer reference point teaching job by using MoToSim EG.

Job name: RTSJOB

Teaching method:

Using the same tool, teach the workpiece reference points. Decide 3 points to form a triangle largely covering the robot working envelope for the workpiece. When the robot is on the travel axis, move the travel axis and teach 3 points to form a triangle as above. The order of teaching and number of teaching points should be the same as for the robot controller reference point teaching job explained in "■ Teaching of robot controller reference point teaching job (Operation with actual robot)" below. Any type of interpolation can be used.

<Robot layout correction: Example of personal computer reference point job>

```
NOP
MOVL C0000 V=46.0 PL=0
MOVL C0001 V=46.0 PL=0
MOVL C0002 V=46.0 PL=0
END
```

■ Teaching of robot controller reference point teaching job (Operation with actual robot)

Perform teaching of robot controller reference point teaching job with actual robot.

Job name: CTRLJOB

Teaching method:

Using the same tool, teach the workpiece reference points. Decide 3 points to form a triangle largely covering the robot working envelope for the workpiece. When the robot is on the travel axis, move the travel axis and teach 3 points to form a triangle as above.

The order of teaching and number of teaching points should be the same as for the personal computer reference point teaching job explained in "■ Teaching of personal computer reference point teaching job" above. Any type of interpolation can be used.

<Robot layout correction: Example of robot controller reference point job>

```
NOP
MOVL C0000 V=46.0 PL=0
MOVL C0001 V=46.0 PL=0
MOVL C0002 V=46.0 PL=0
END
```

Save the following robot data from the robot controller to the floppy disk, using a device such as YASNAC FC2, etc.

File Name	Contents	Remarks
ALL.PRM	Robot parameter data	For ERC, PARAM.DAT
TOOL.CND	Tool data	For ERC, TOOL.DAT
CTRLJOB.JBI	Job for robot layout correction	3 points

Fig. 2.5.1 Data to be saved to Floppy Disk

■ Calibration operation

1) Insert the above floppy disk to the drive of personal computer. Double-click the [MOTOCALV EG] icon in the [Start]-[Program]-[Motoman]-[MOTOCALV EG] to start the program. (Refer to Fig. 2.1.4 Calibration Main Screen "MOTOCALV EG")

2) Click the [F5] (LAYOUT) button to display the "Layout Correction" screen.

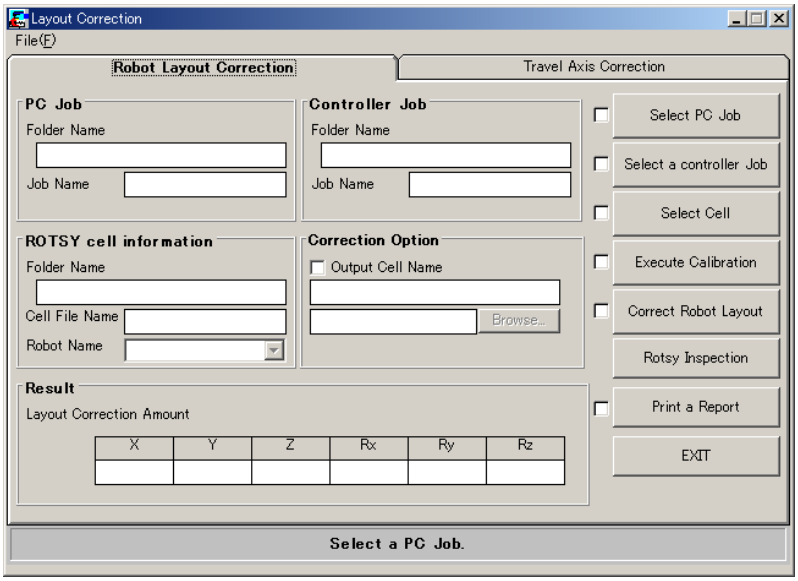


Fig. 2.5.2 “Layout Correction” Screen for Robot Layout Correction

3) Click the [Select PC job] button to display the [Select PC job] dialog box. To select the file of personal computer reference point job for calibration (RTSJOB.JBI), click the [Open] button or double-click the file. (When the reference point job has been taught under a different job name, select the corresponding file.) Then the screen returns to the "Layout Correction" screen.

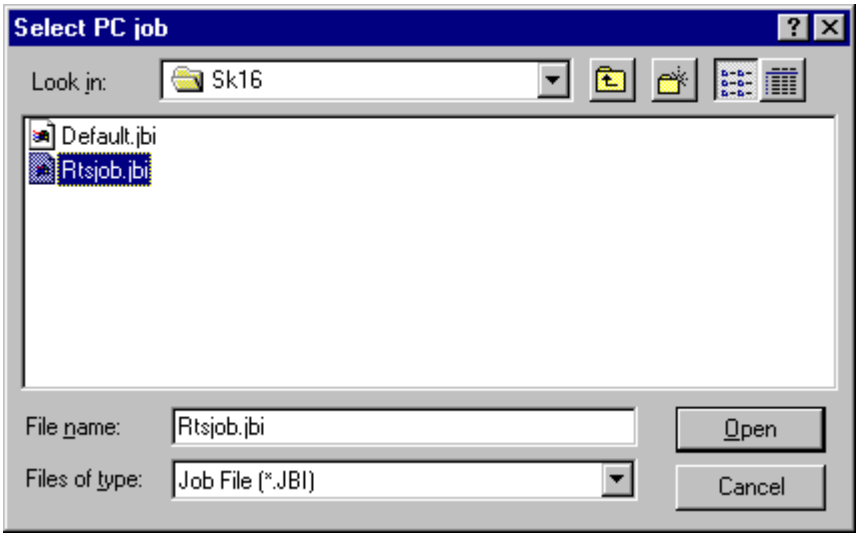


Fig. 2.5.3 [Select PC job] Dialog Box

4) Click the [Select a robot controller job] button to display the [Select a robot controller job] dialog box. To select the file of robot controller reference point job for calibration (CTRLJOB.JBI), click the [Open] button or double-click the file. (When the reference point job has been taught under a different job name, select the corresponding file.) Then the screen returns to the "Layout Correction" screen.

Fig. 2.5.4 [Select a robot controller job] Dialog Box

5) Click the [Select Cell] button to display the "Select Cell" dialog box. To select the corresponding cell file, click the [Open] button or double-click the corresponding file. Then the screen returns to the "Layout Correction" screen.

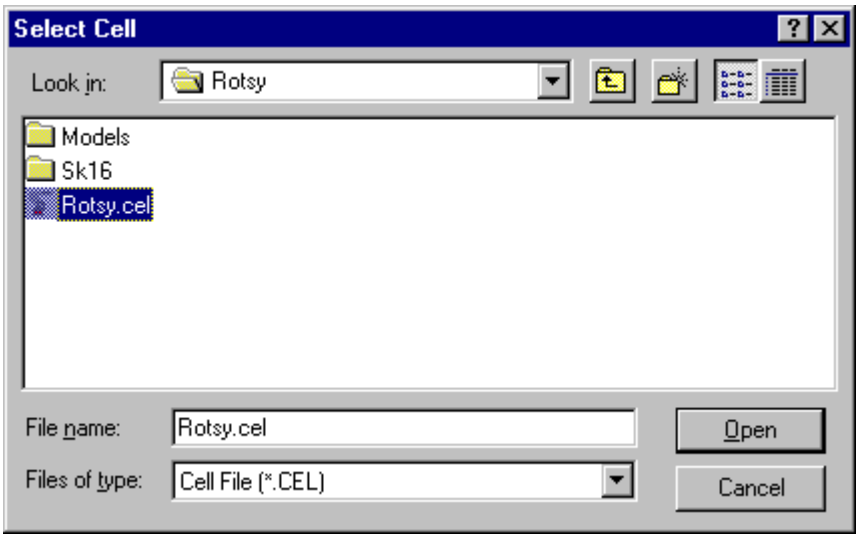


Fig. 2.5.5 [Select Cell] Dialog Box

If two or more robots are registered in the cell, the following message is displayed. Verify the selected robot name.

Fig. 2.5.5-1 Cell Check Message

If no robots are registered in the cell, the following message is displayed.

Fig. 2.5.5-2 Cell Check Message

6) If two or more robots are registered in the cell, click [Robot Name] combo box to select the robot.

7) Click the [Execute Calibration] button to execute the robot layout correction. When calibration is completed, the layout correction amounts are displayed in "Layout Correction" screen.

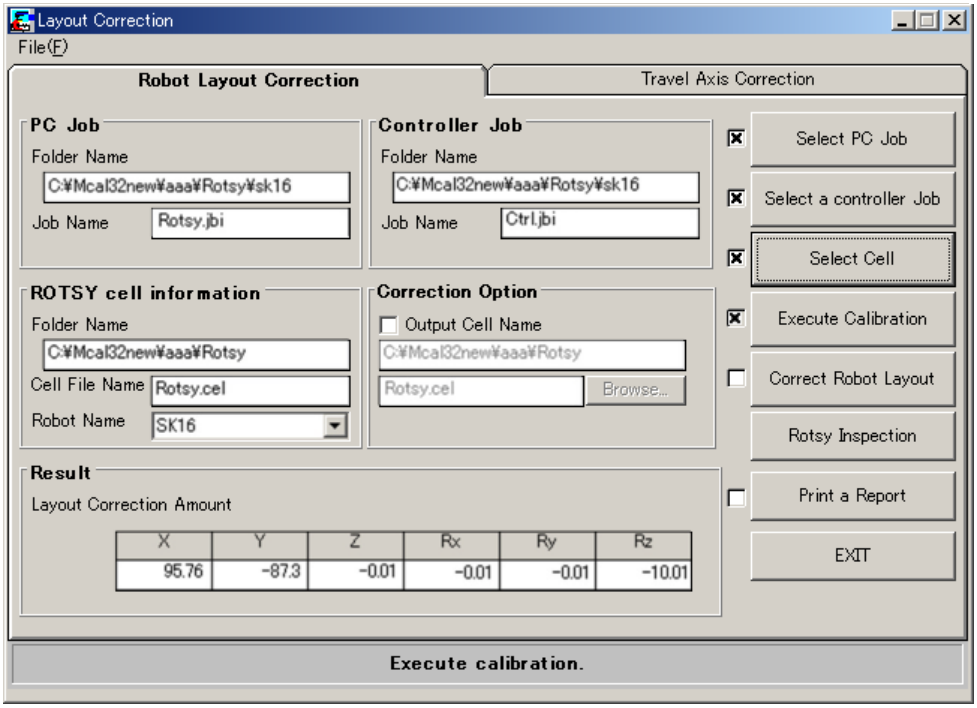


Fig. 2.5.6 "Layout Correction Amount" Screen for Robot Layout Correction

8) Click the [Correct Robot Layout] button to correct the robot layout on the cell. To create a new cell after correction without overwriting on the cell before, check the mark in the check box "Output Cell Name" of "Correction Option," and input a new cell name to be created.

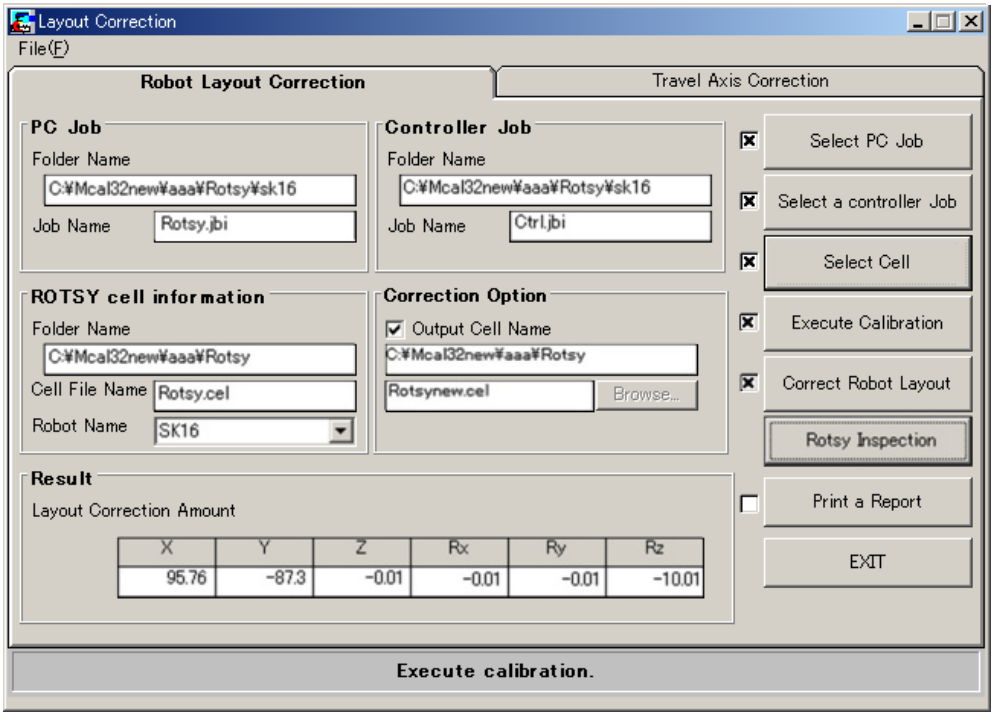


Fig. 2.5.7 "Layout Correction" Screen for Robot Layout Correction

9) Click the [MoToSim EG Inspection] button to inspect the robot layout correction in the cell of MoToSim EG.

10) Click the [Print a Report] button to print out the report.

The robot layout correction is completed.

2.5.2 Travel Axis Correction

■ Operation with actual robot

1) Prior to calibration, mount a end-pointed tool on the robot flange and perform tool calibration to obtain tool data.

2) Using this tool, perform teaching of the job for 3 travel axis movements at 3 points (total 9 points).

Note: Where the positional angle difference between the robot and the travel axis is considerably large, calibration is not possible.

a) Teach the same point with 3 postures using the same tool, moving along the travel axis. Any type of interpolation can be used.

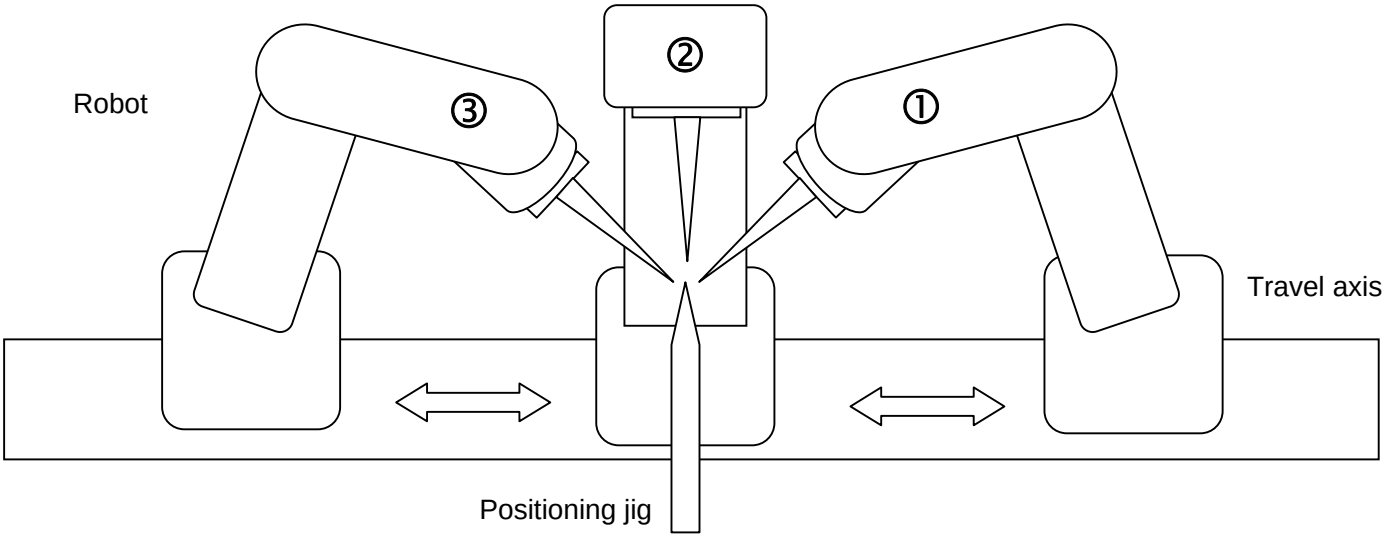


Fig. 2.5.8 Teaching the Same Point with 3 Postures by Moving Travel Axis

b) Teach the job at step a) at different 3 points (each point should be separated 100 mm or more).

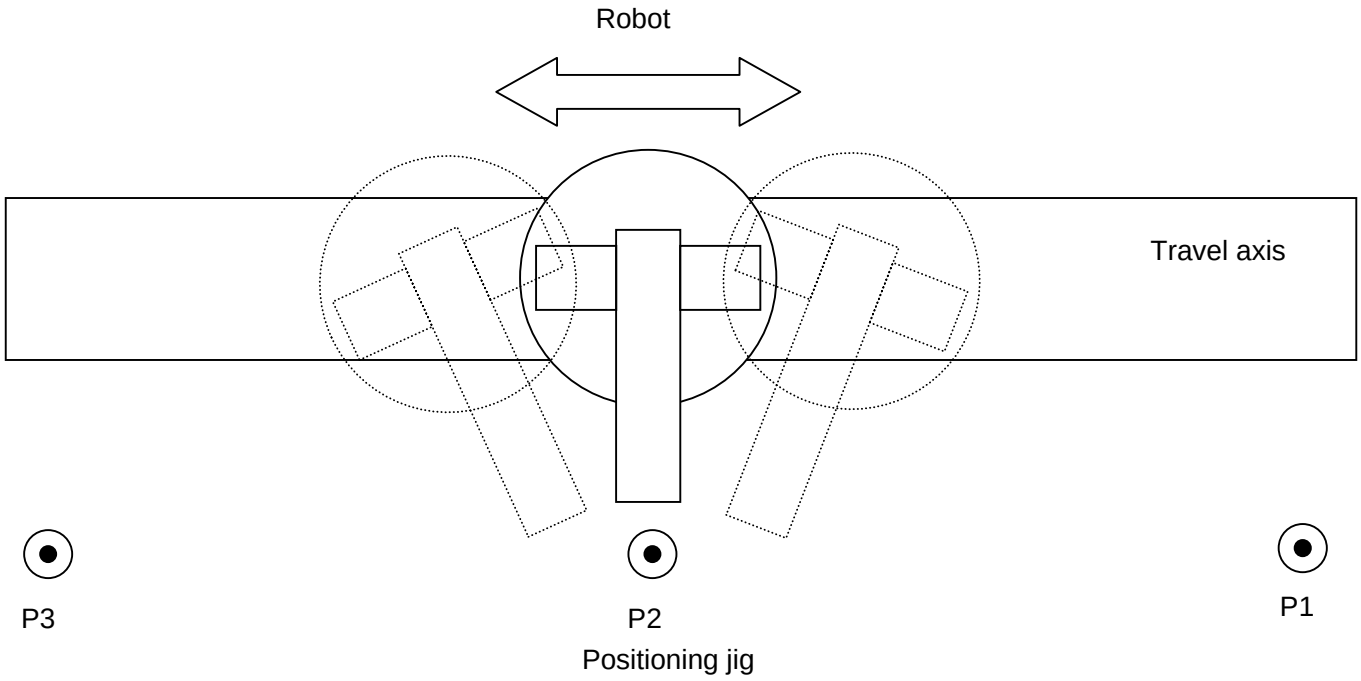


Fig. 2.5.9 Teaching 3 Points with 3 Postures by Moving Travel Axis

<Example of Travel Axis Tilt Correction Job>

```
NOP
*1
MOVJ C0000 VJ=0.78 PL=0
MOVJ C0001 VJ=0.78 PL=0
MOVJ C0002 VJ=0.78 PL=0
*2
MOVJ C0003 VJ=0.78 PL=0
MOVJ C0004 VJ=0.78 PL=0
MOVJ C0005 VJ=0.78 PL=0
*3
MOVJ C0006 VJ=0.78 PL=0
MOVJ C0007 VJ=0.78 PL=0
MOVJ C0008 VJ=0.78 PL=0
END
```

3) Save the following robot data from the robot controller to the floppy disk, using a device such as YASNAC FC2, etc.

File Name	Contents	Remarks
ALL.PRM	Robot parameter data	For ERC, PARAM.DAT
TOOL.CND	Tool data	For ERC, TOOL.DAT
CTRLJOB.JBI	Travel axis tilt correction job	9 points

Fig. 2.5.10 Data to be Saved to Floppy Disk

■ Calibration operation

1) Insert the above floppy disk to the personal computer drive. Double-click the [MOTOCALV EG] icon in the [Start]-[Program]-[Motoman]-[MOTOCALV EG] to start the program. (Refer to Fig. 2.1.4 Calibration Main Screen "MOTOCALV EG")

2) Click the [F5] (LAYOUT) button to display the "Layout Correction" screen, then click the [Travel Axis Correction] tab to display the screen for travel axis tilt correction.

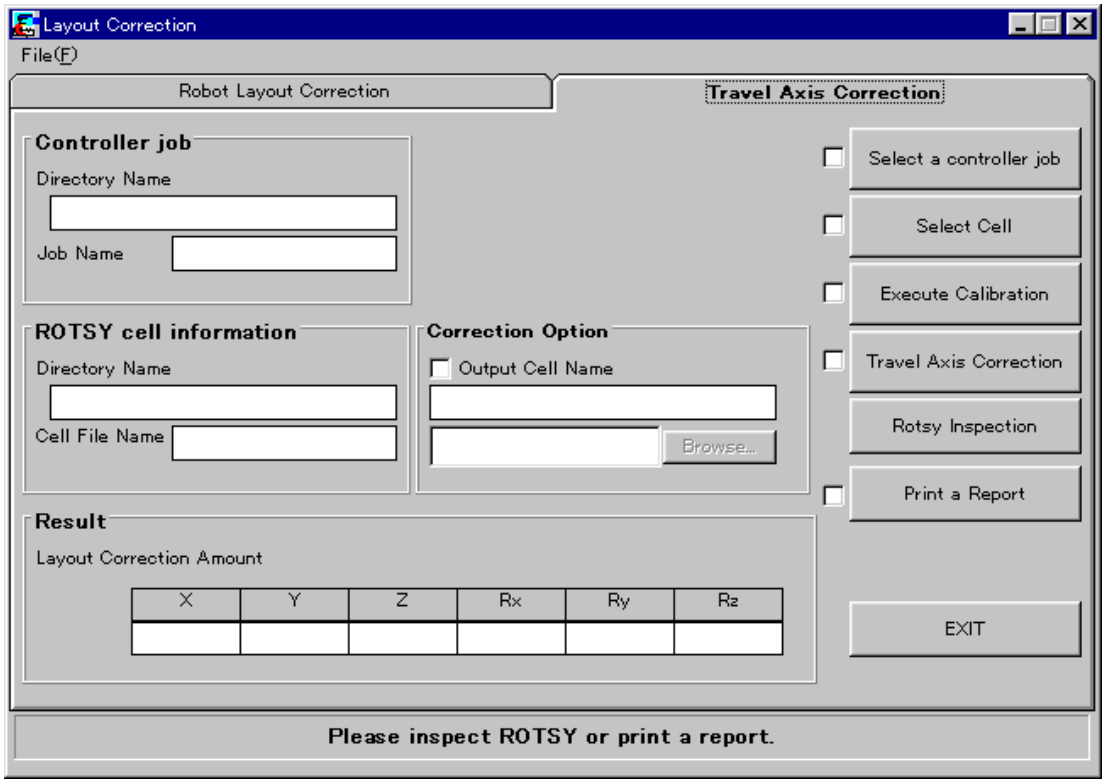


Fig. 2.5.11 "Layout Correction" Screen for Travel Axis Tilt Correction

3) Click the [Select a robot controller job] button to display the [Select a robot controller job] dialog box. To select the file of robot controller reference point job for calibration (CTRLJOB.JBI), click the [Open] button or double-click the file. (When the reference point job has been taught under a different job name, select the corresponding file.) Then the screen returns to the "Layout Correction" screen.

Fig. 2.5.12 [Select a robot controller job] Dialog Box

4) Click the [Select Cell] button to display the [Select Cell] dialog box. To select the corresponding cell file, click the [Open] button or double-click the corresponding file. Then the screen returns to the "Layout Correction" screen.

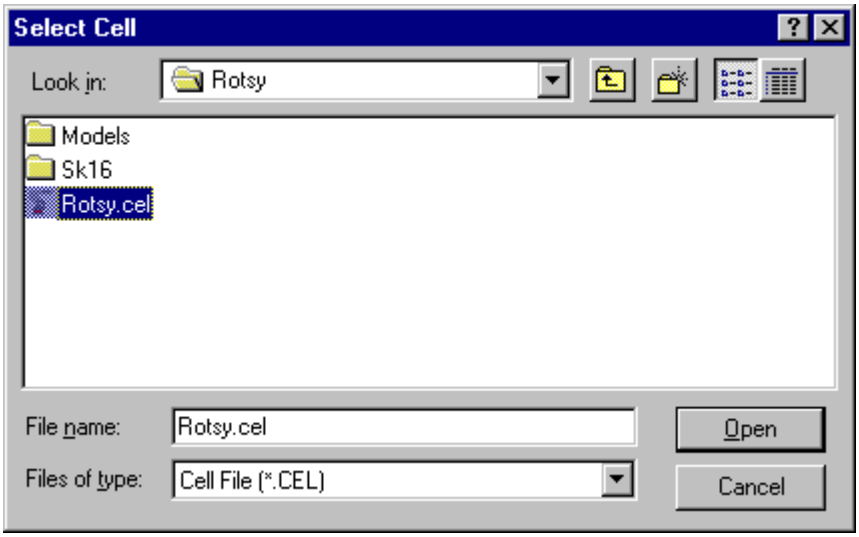


Fig. 2.5.13 [Select Cell] Dialog Box

If two or more robots are registered in the cell, the following message is displayed. Travel axis tilt cannot be corrected for the cell in which two or more robots are registered.
Create a cell in which only one robot is registered, then correct the travel axis tilt.

Fig. 2.5.13-1 Cell Check Message

If the robot registered in the cell is not incorporated with the travel axis, the following message is displayed.

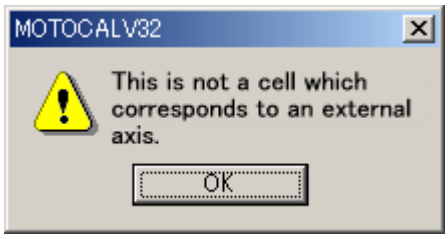


Fig. 2.5.13-2 Cell Check Message

5) Click the [Execute Calibration] button to execute the travel axis tilt correction. When calibration starts, the "Calculating" screen is displayed to show the calculation process.

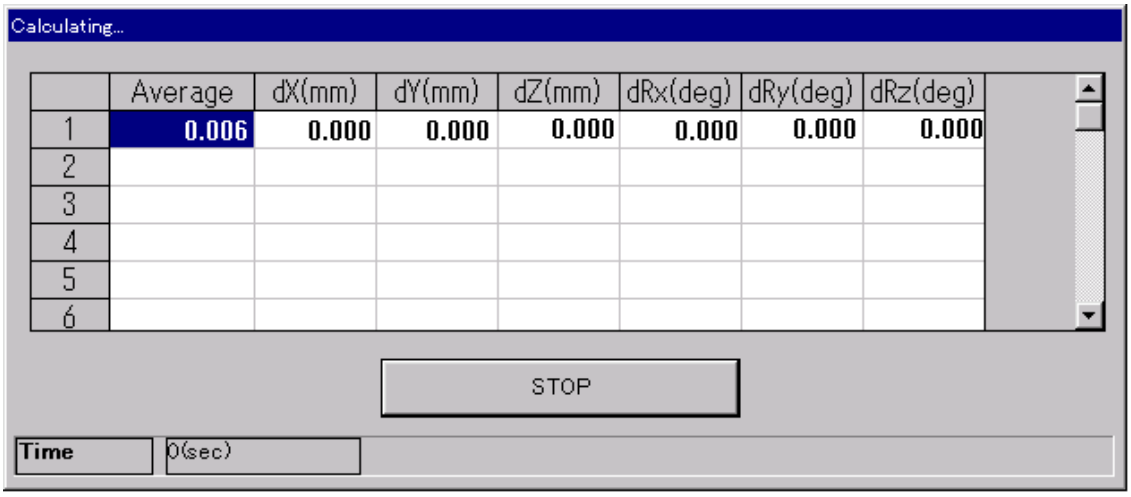


Fig. 2.5.14 "Calculating" Screen for Travel Axis Tilt Correction Calculation Process

Clicking the [STOP] button stops the calculation to return to the screen for travel axis tilt correction. When calibration is completed, the layout correction amounts are displayed in "Layout Correction" screen.

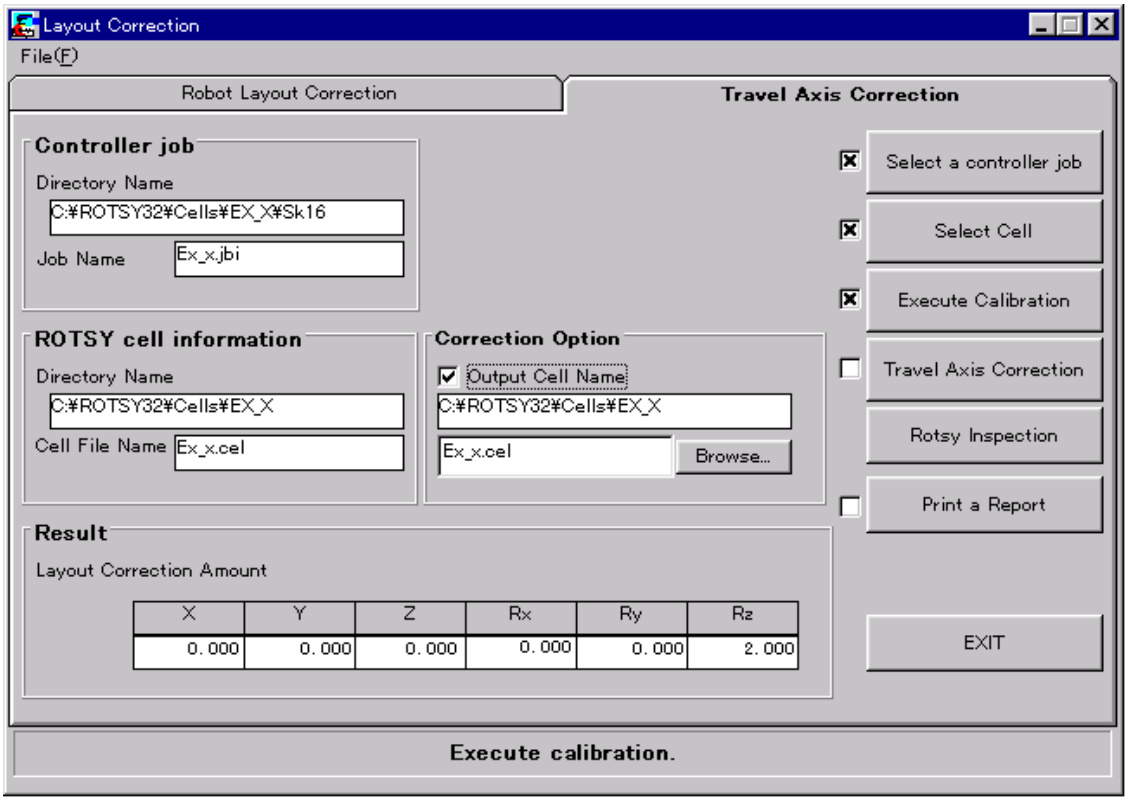


Fig. 2.5.15 "Layout Correction" Screen for Travel Axis Tilt Correction Amounts

6) Click the [Travel Axis Correction] button to reflect the positional difference between the robot and travel axis with actual robot, to the robot and travel axis in the cell. To create a new cell after correction without overwriting on the cell before, check the mark in the check box "Output Cell Name" of "Correction Option", and input a new cell name to be created.

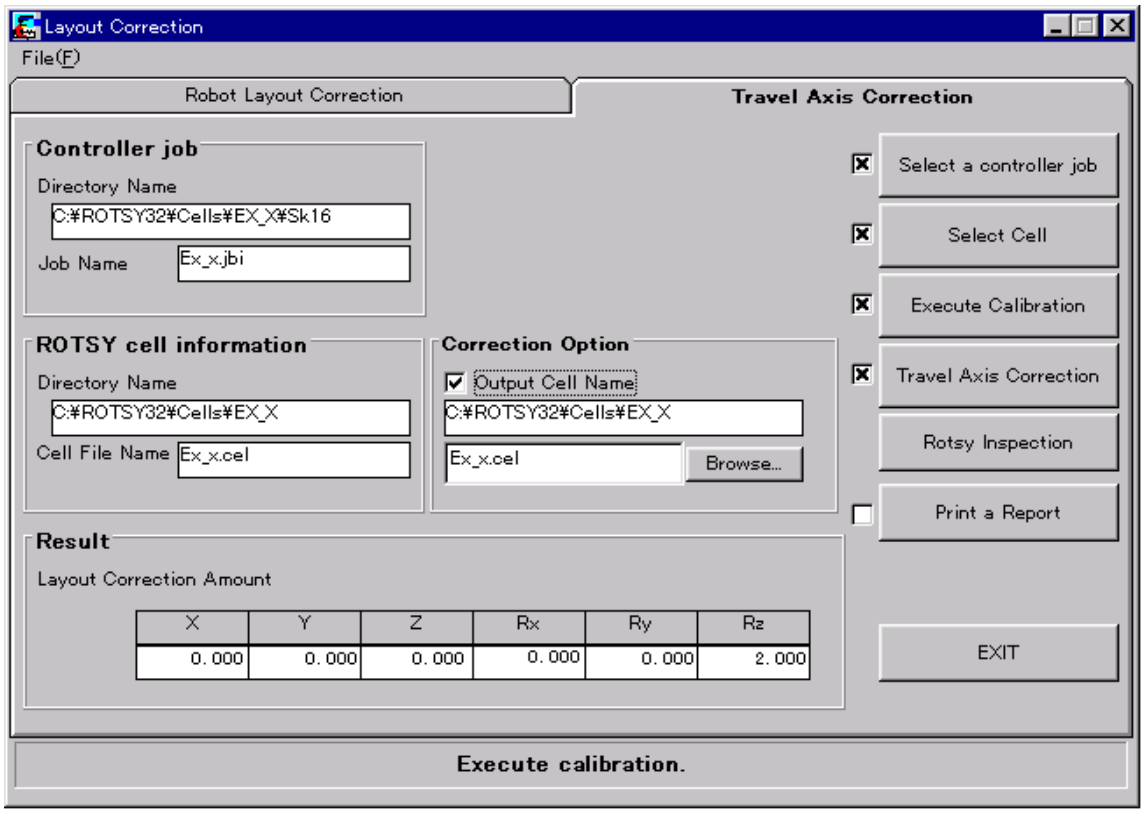


Fig. 2.5.16 "Layout Correction" Screen for Travel Axis Tilt Correction

7) Click the [MoToSim EG Inspection] button to inspect the travel axis tilt correction in the cell of MoToSim EG.

8) Click the [Print a Report] button to print out the report.

The travel axis tilt correction operation is completed.

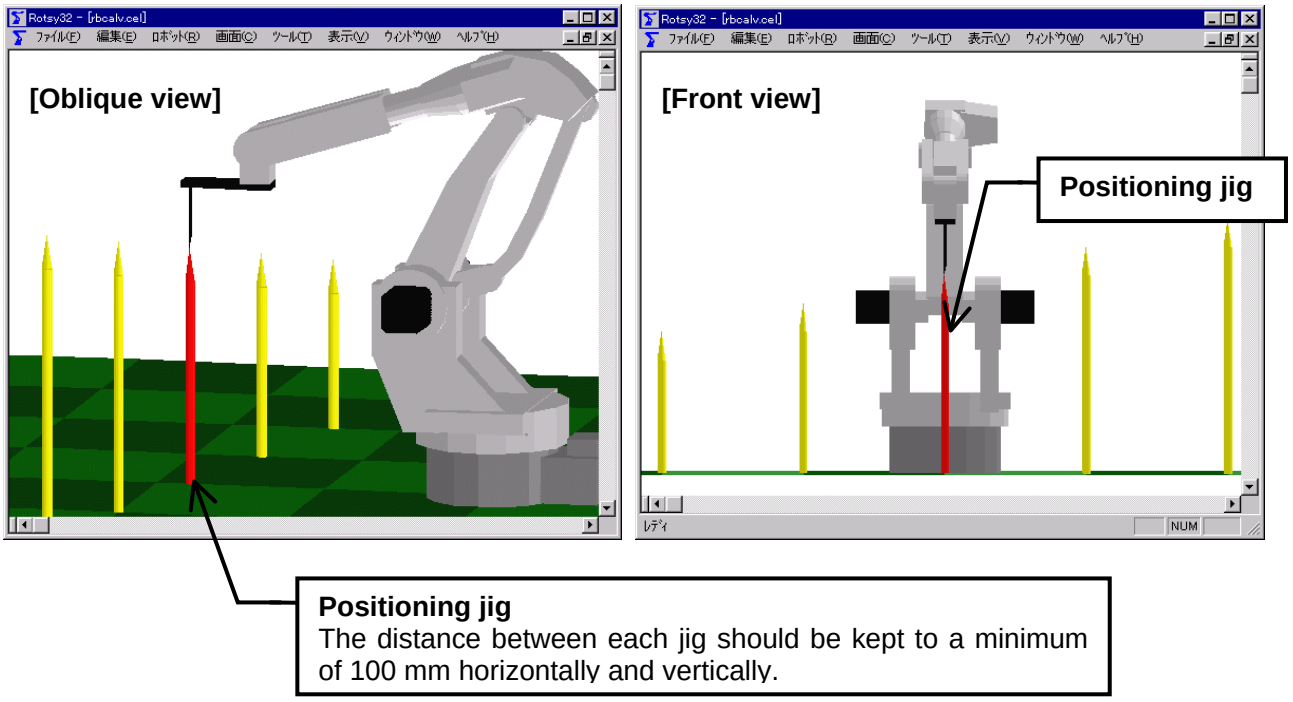
APPENDIX

Appendix 1. Examples of Robot Calibration

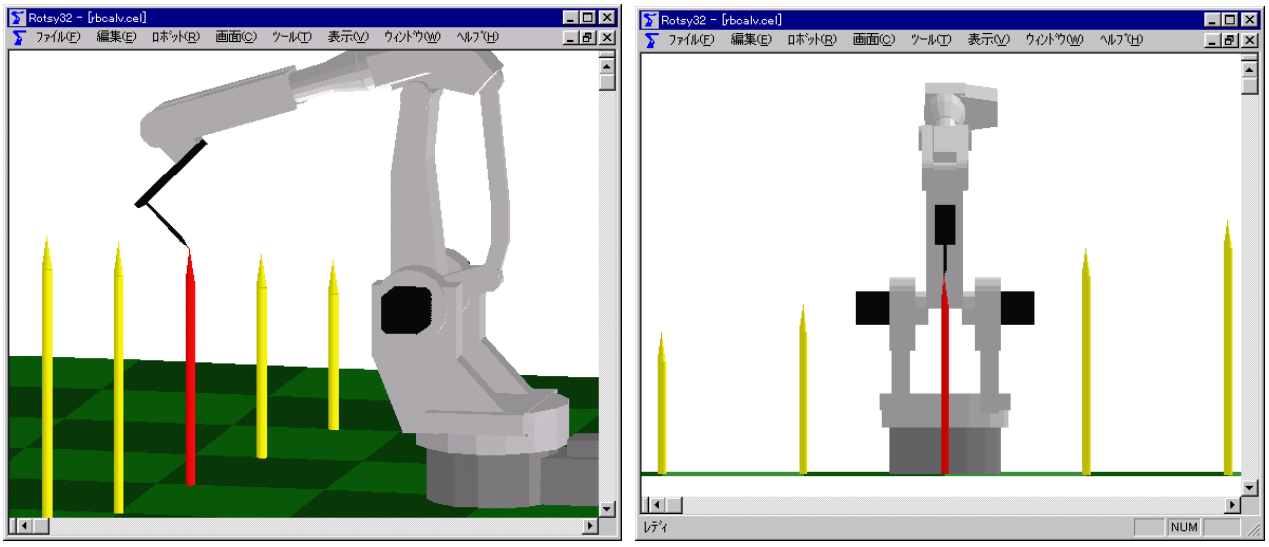
5 posture examples at one point are shown below. Perform teaching of these 5 postures each at 5 points (total 25 points).

- **For SK and SV**

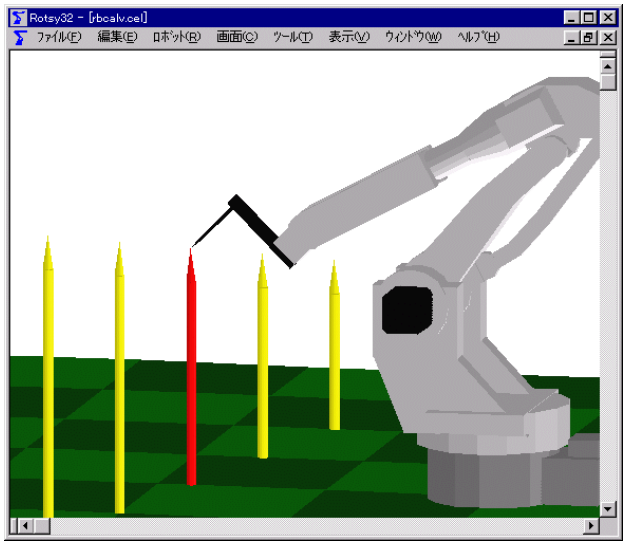
《First Posture》

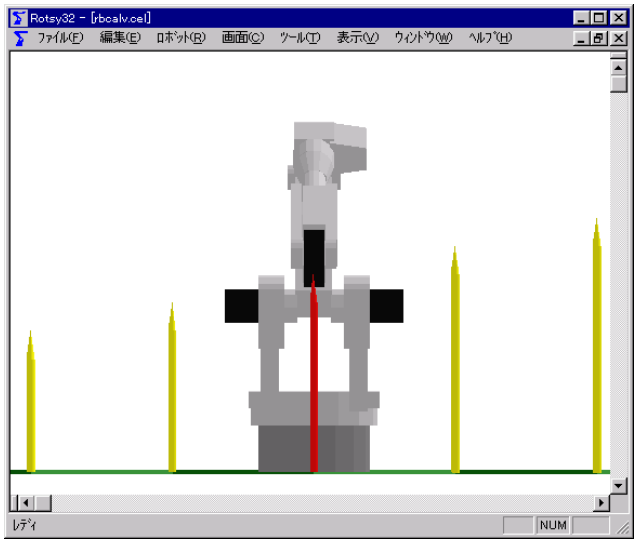


《Second Posture》

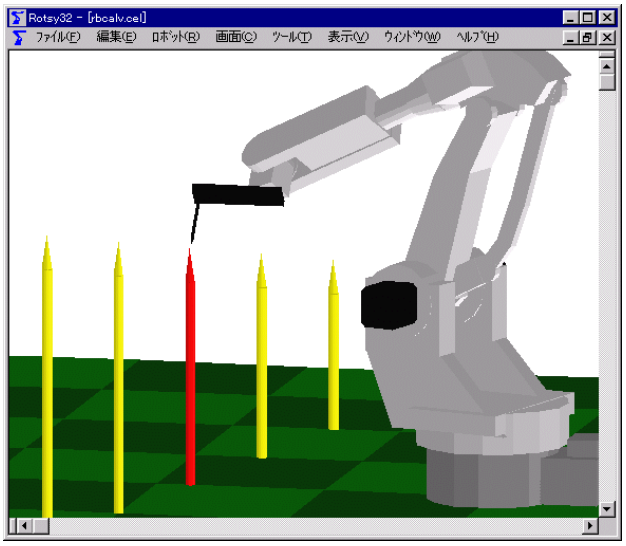


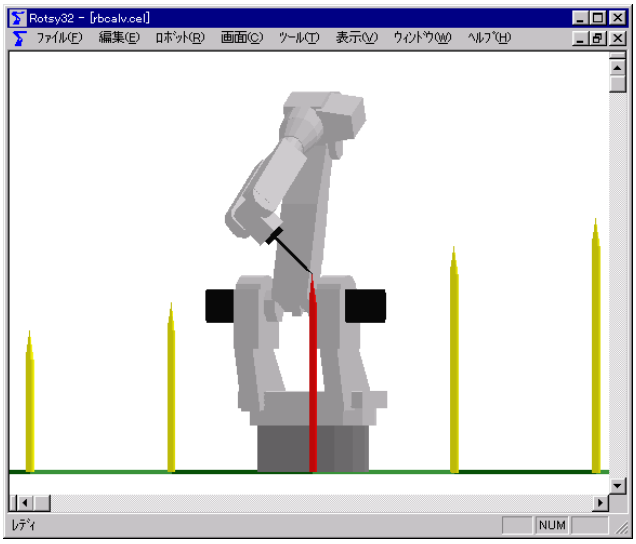
《Third Posture》



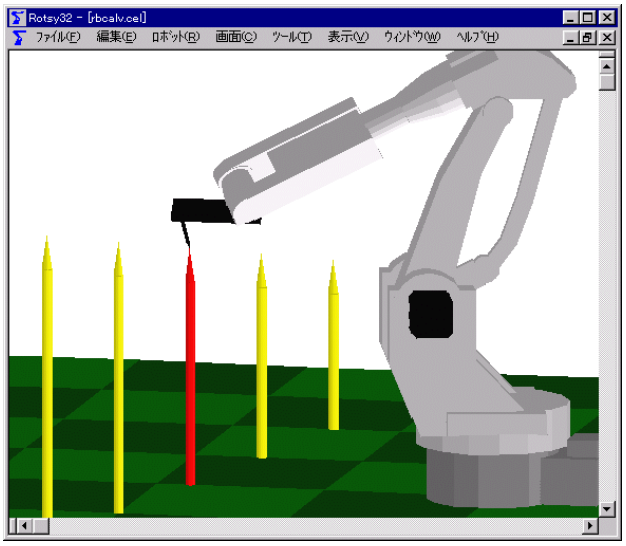


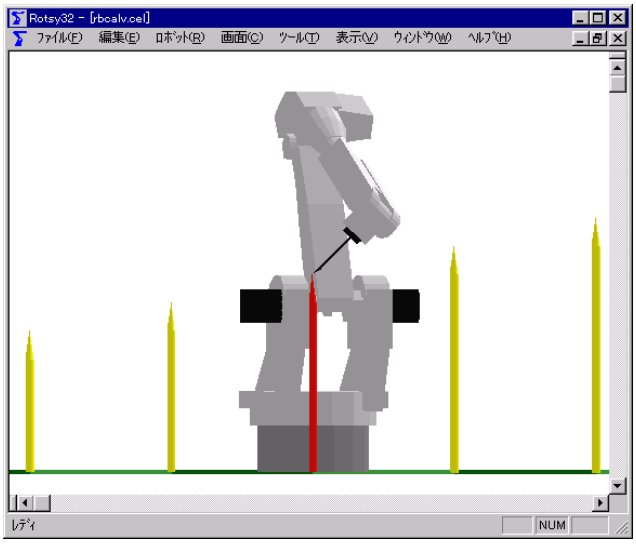
《Fourth Posture》





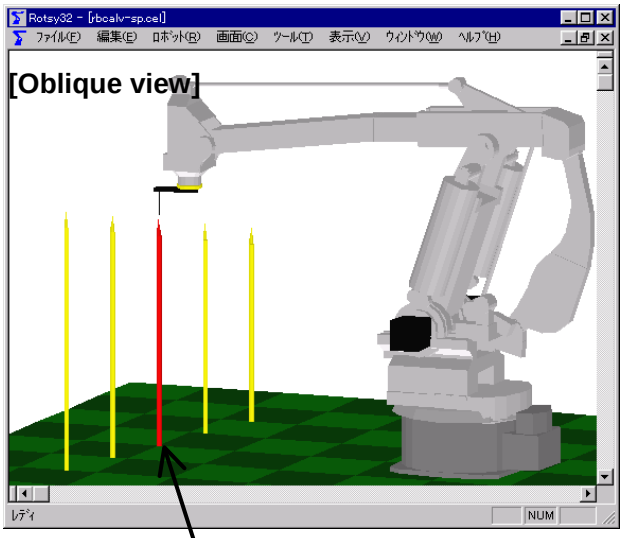
《Fifth Posture》

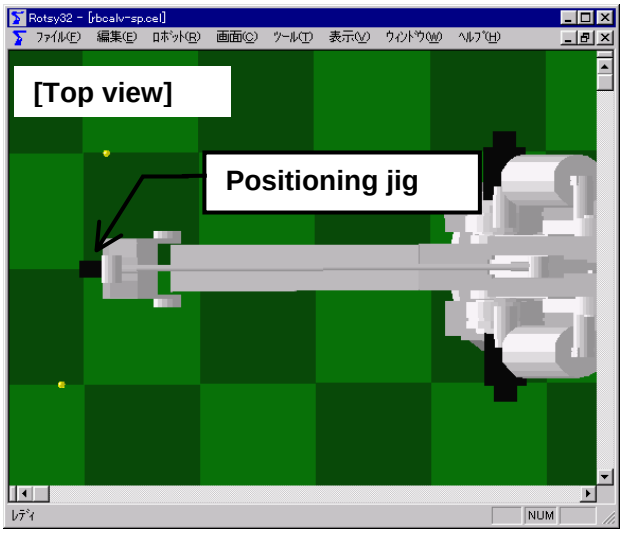




- **For SP100**

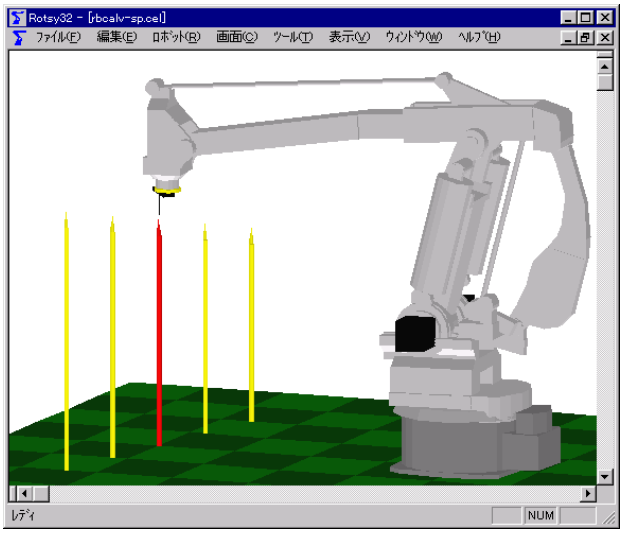
《First Posture》

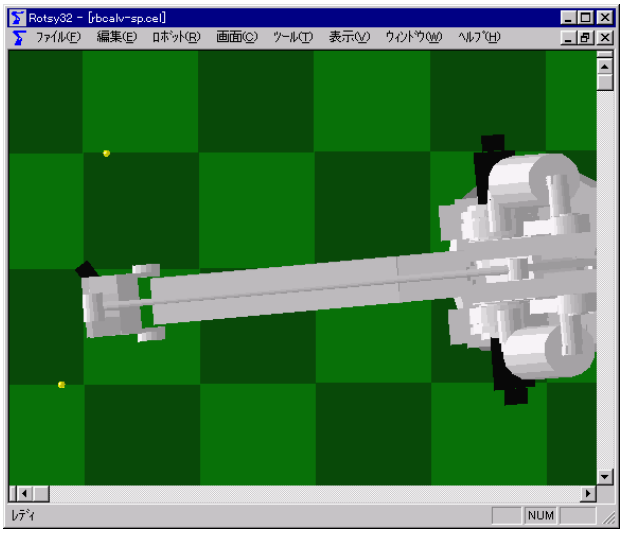




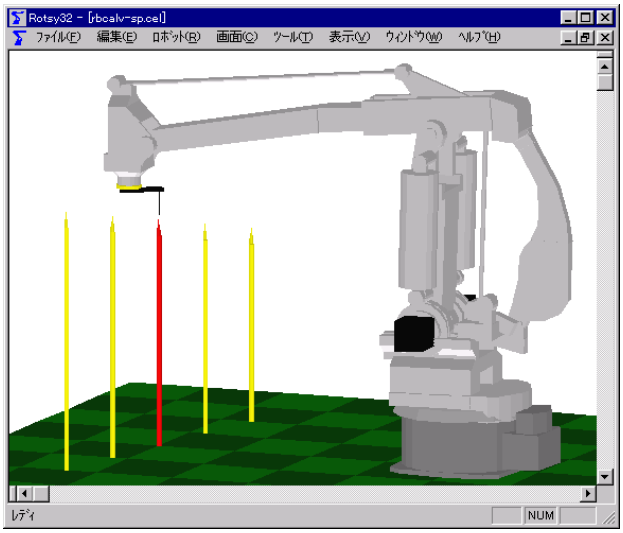
Positioning jig
The distance between each jig should be kept to a minimum of 100 mm horizontally and vertically.

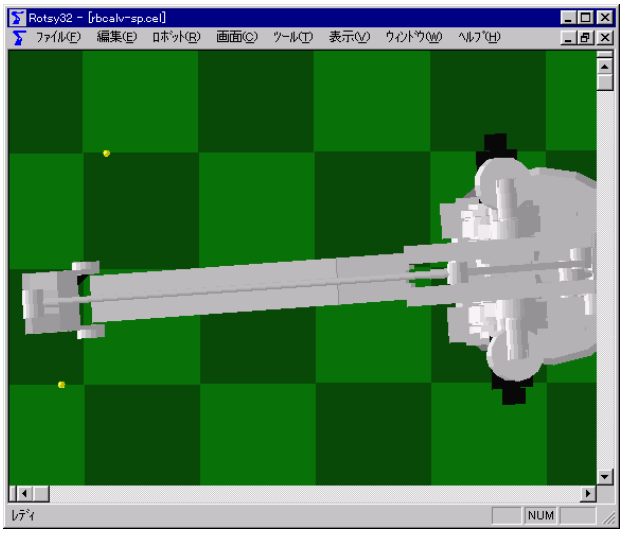
《Second Posture》



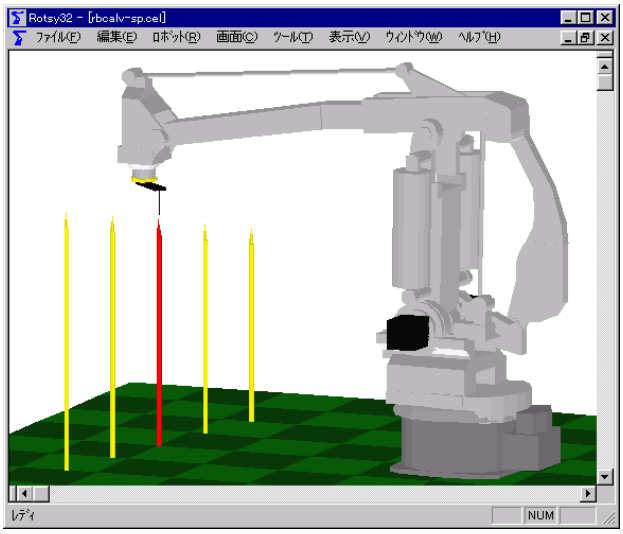


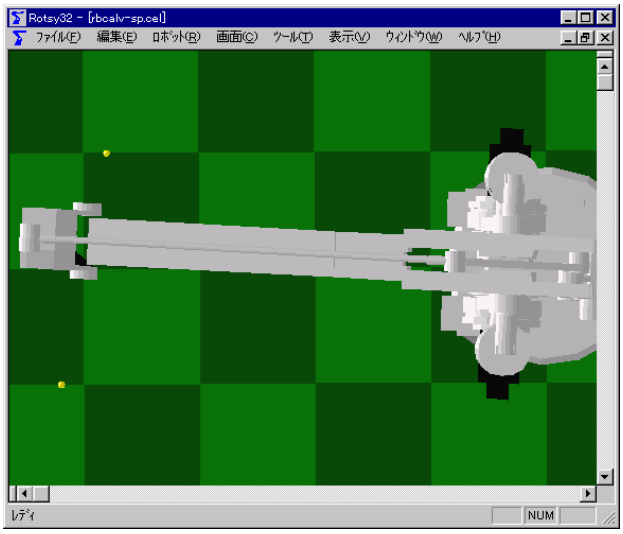
《Third Posture》



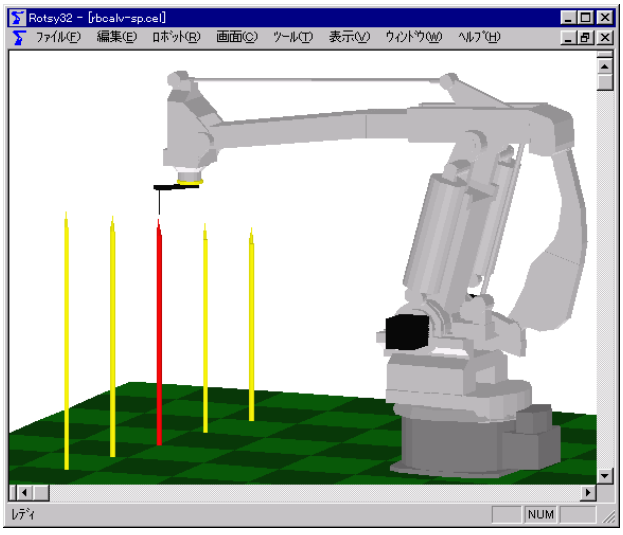


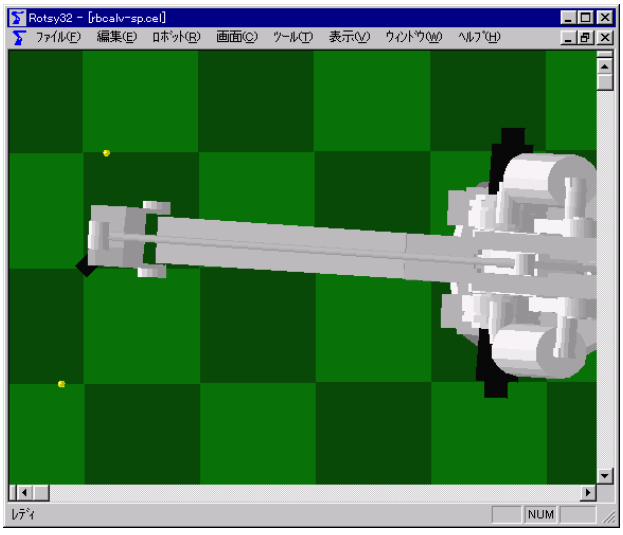
《Fourth Posture》





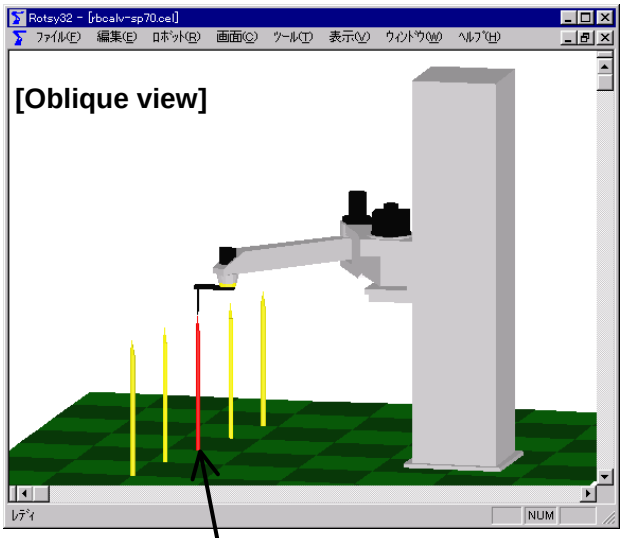
《Fifth Posture》

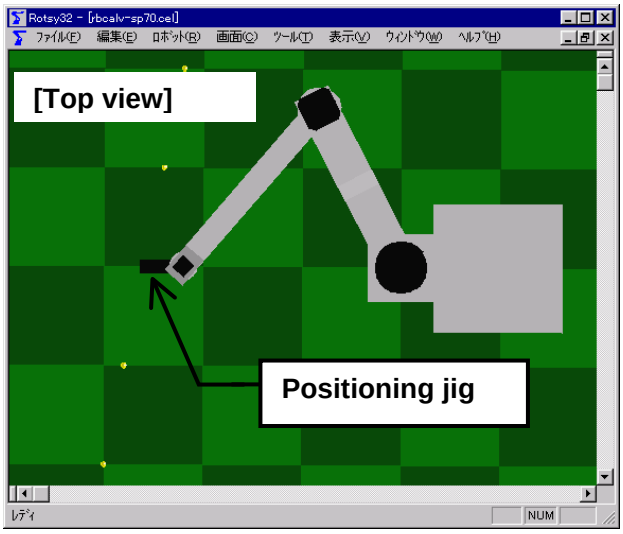




- **For SP70**

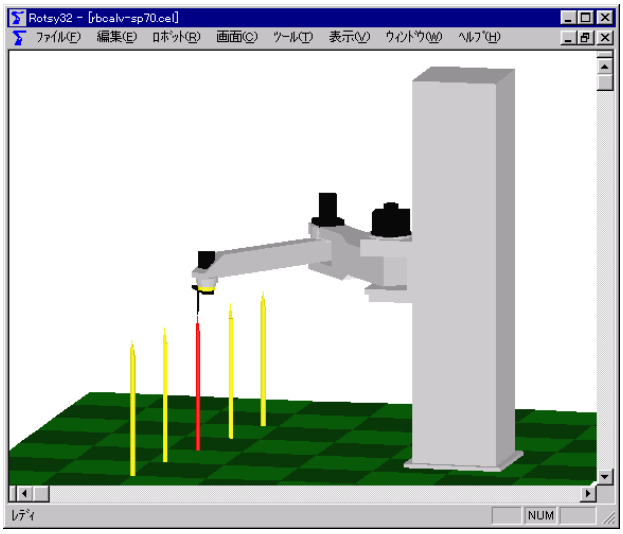
《First Posture》

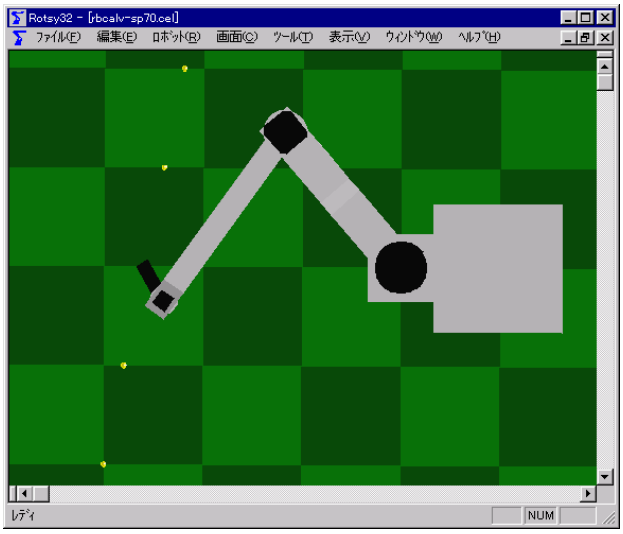




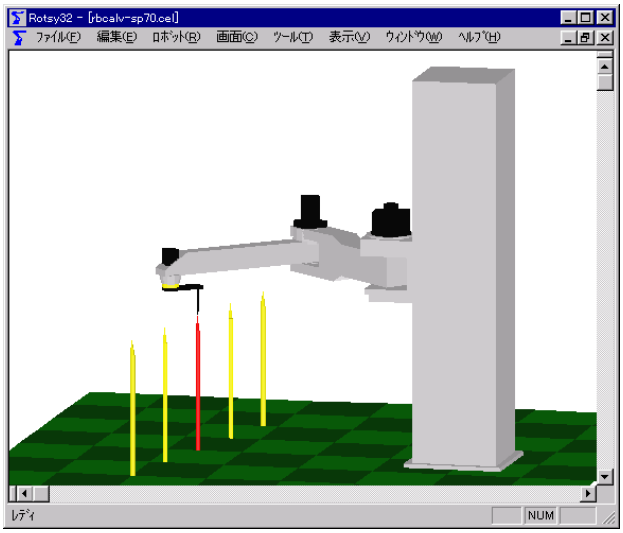
Positioning jig
The distance between each jig should be kept to a minimum of 100 mm horizontally and vertically.

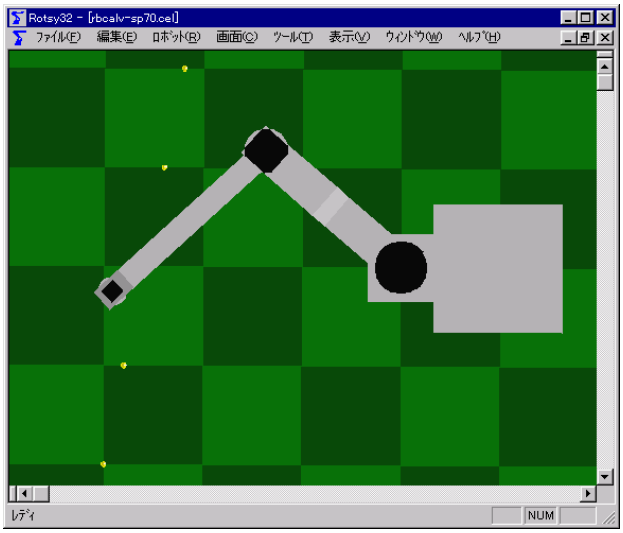
《Second Posture》



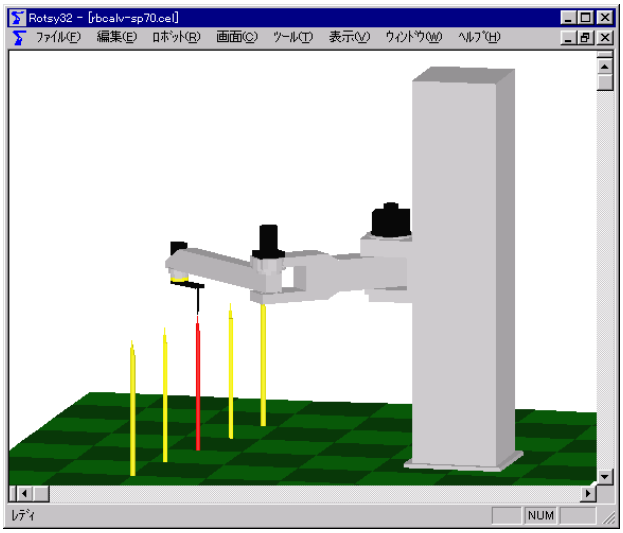


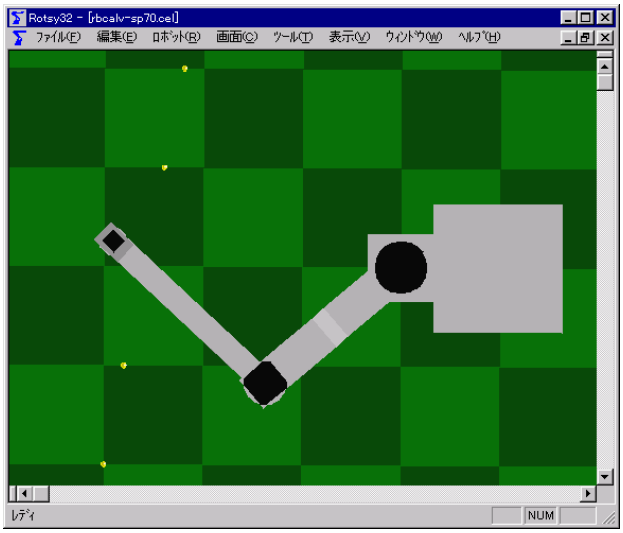
《Third Posture》



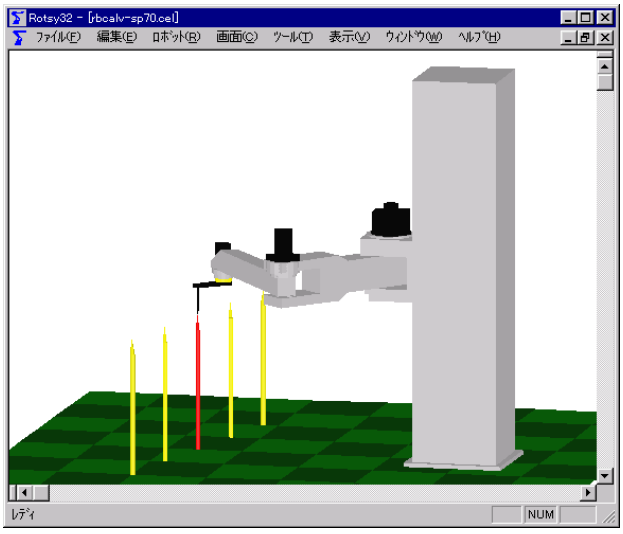


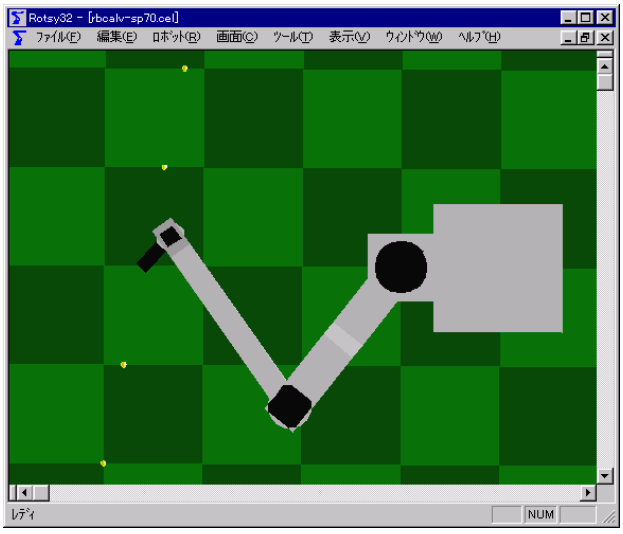
《Fourth Posture》





《Fifth Posture》

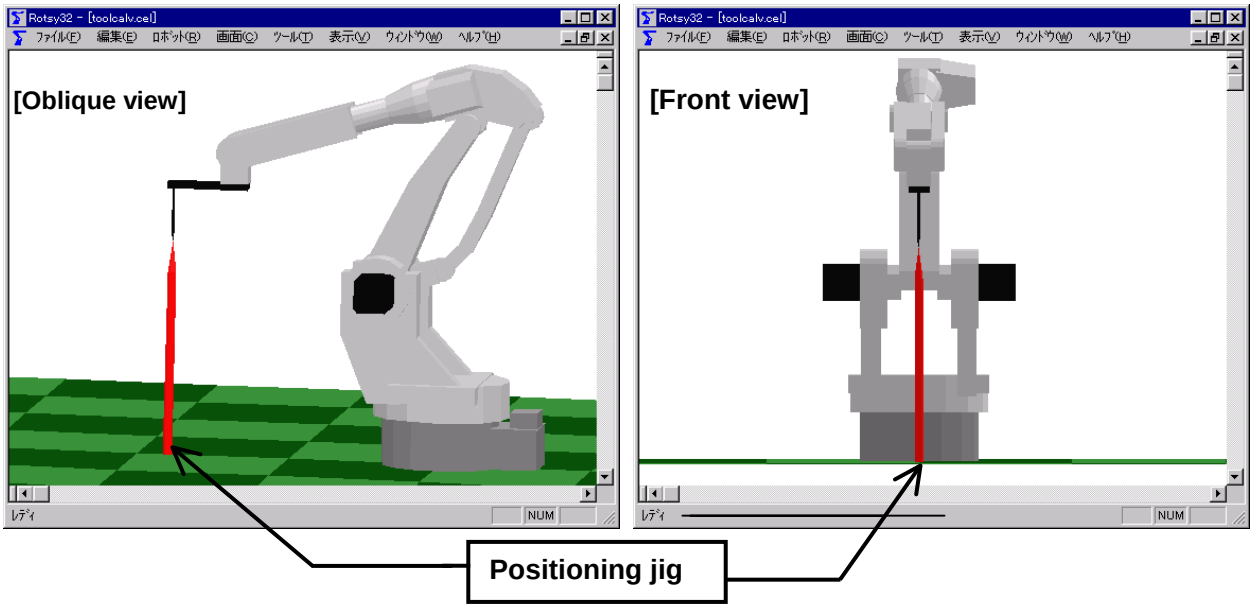




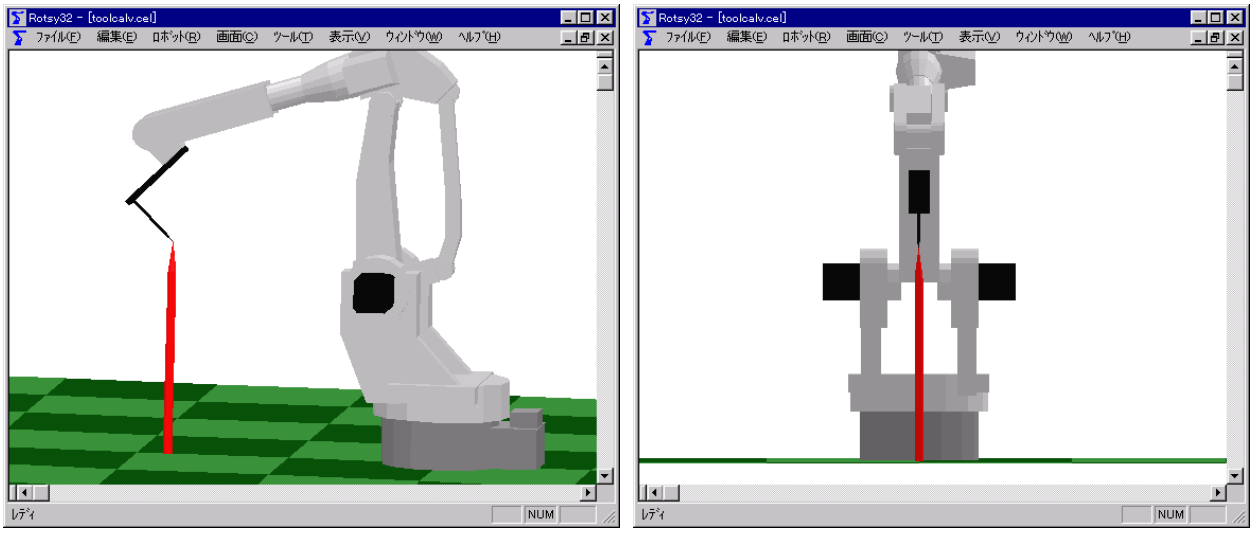
Appendix 2. Examples of Tool Calibration

- **For SK and SV**

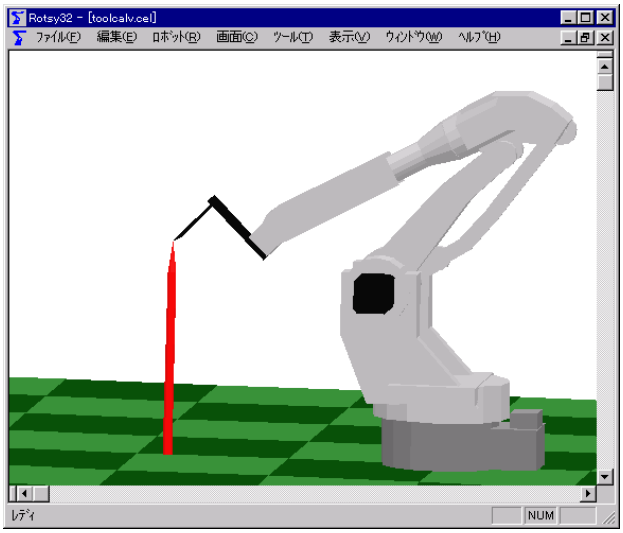
《First Posture》

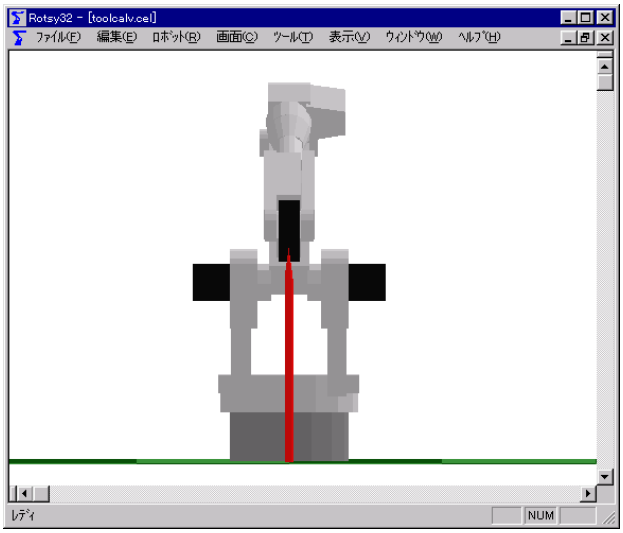


《Second Posture》

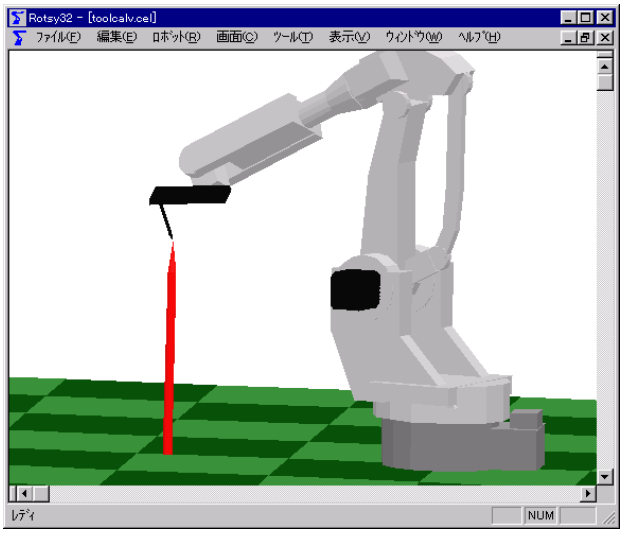


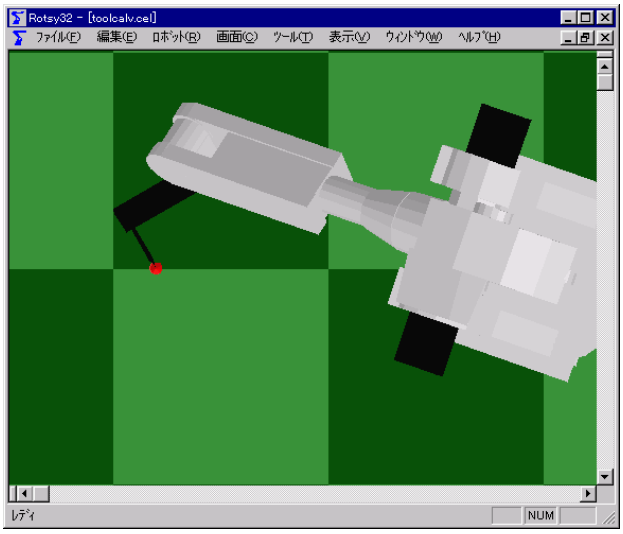
《Third Posture》



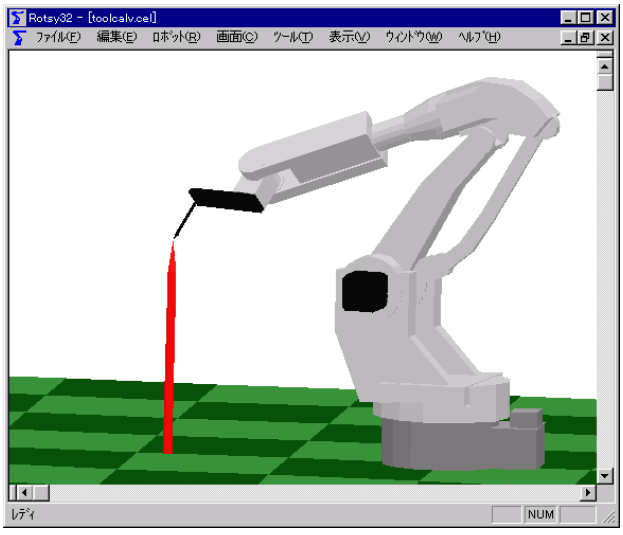


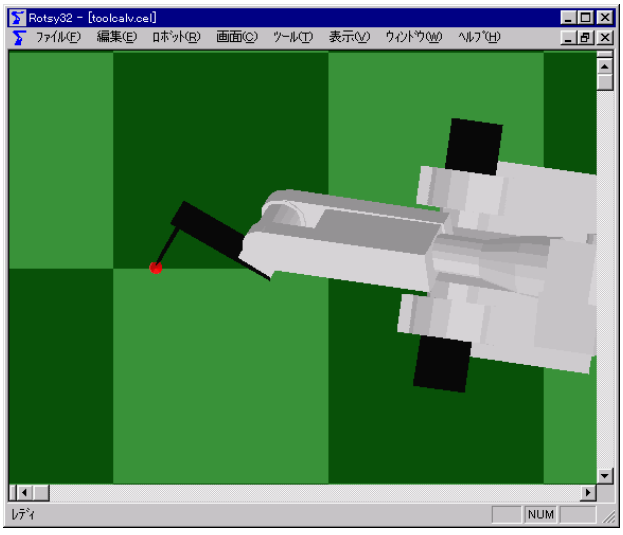
《Fourth Posture》



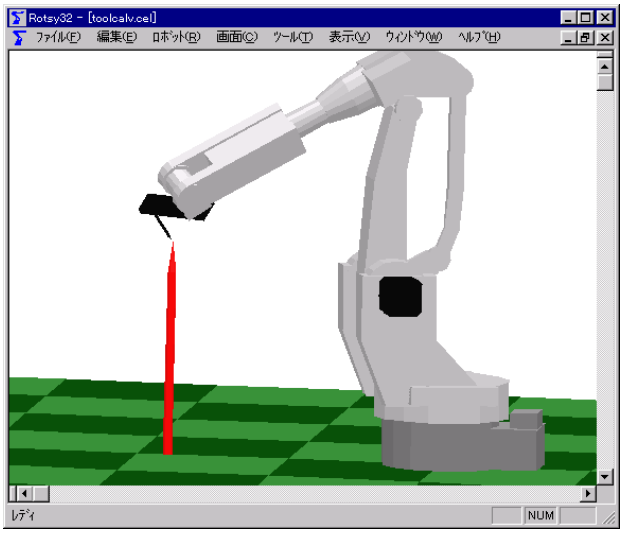


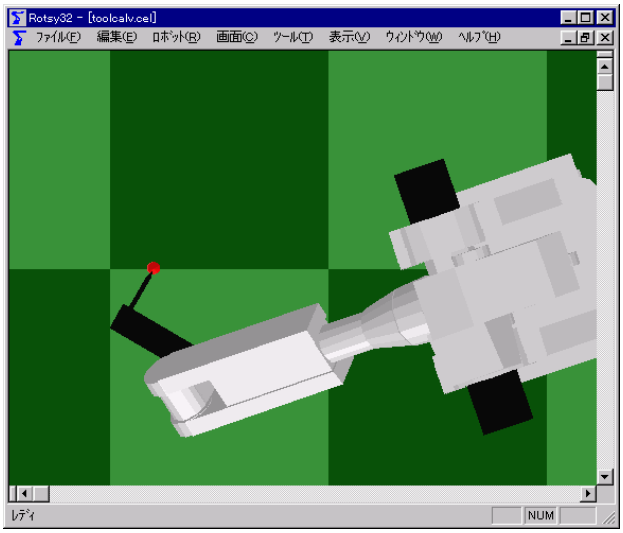
《Fifth Posture》



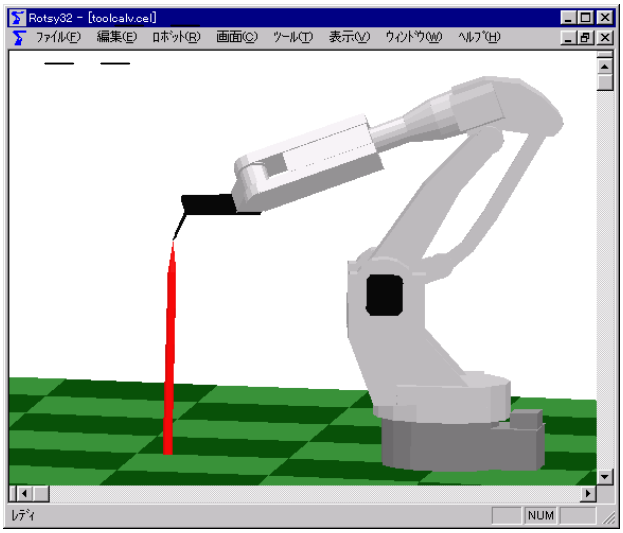


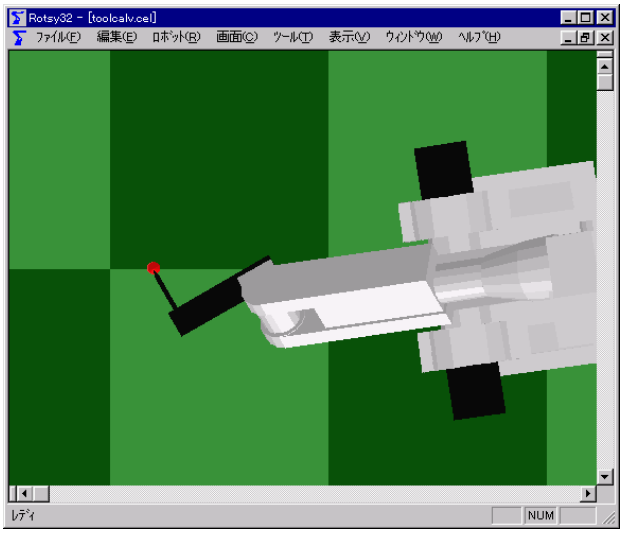
《Sixth Posture》





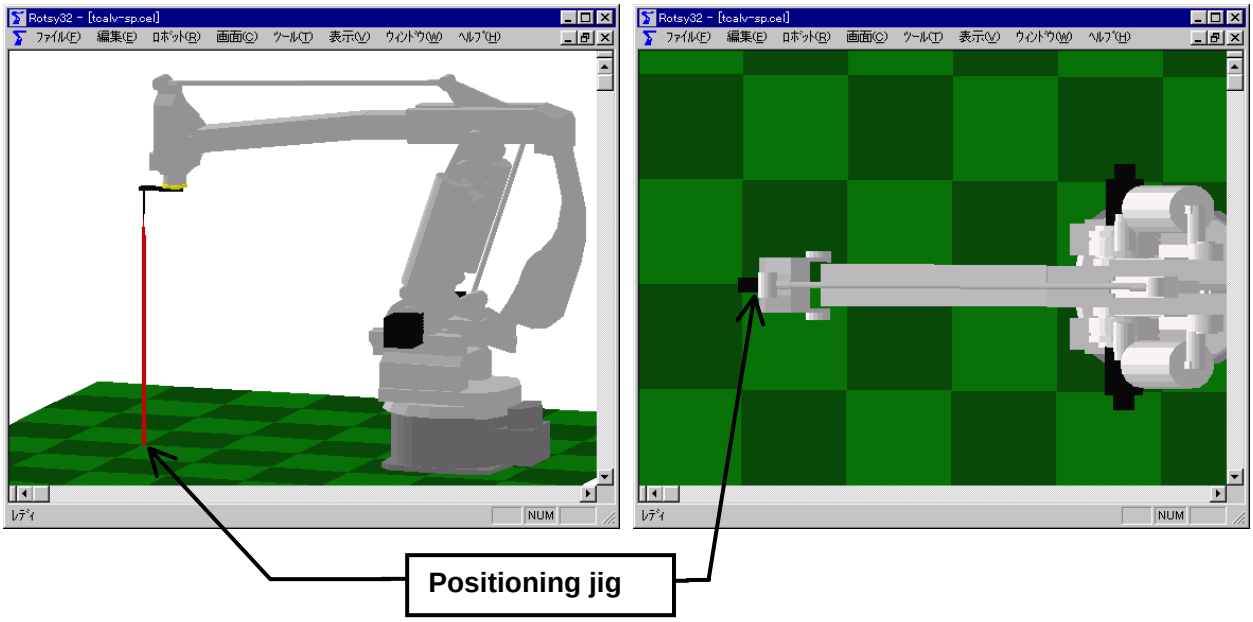
《Seventh Posture》



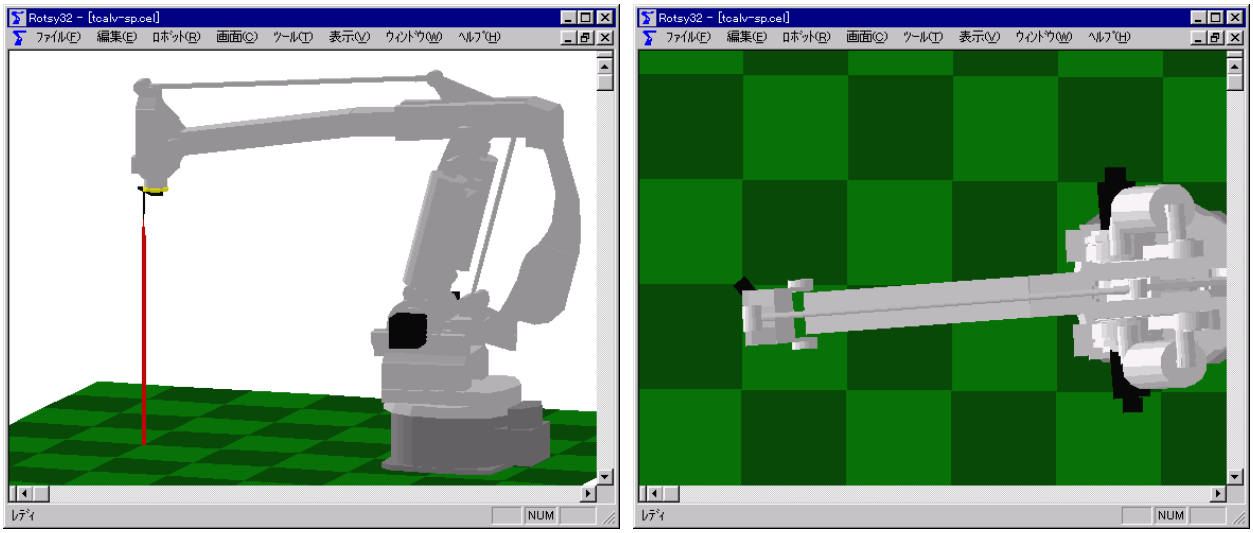


- **For SP100**

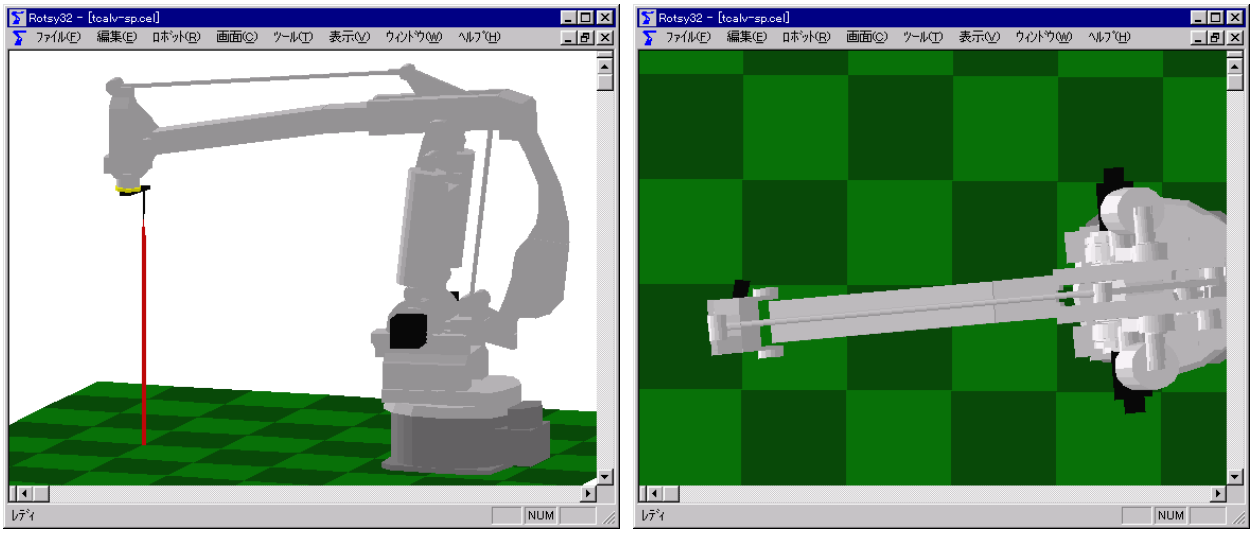
《First Posture》



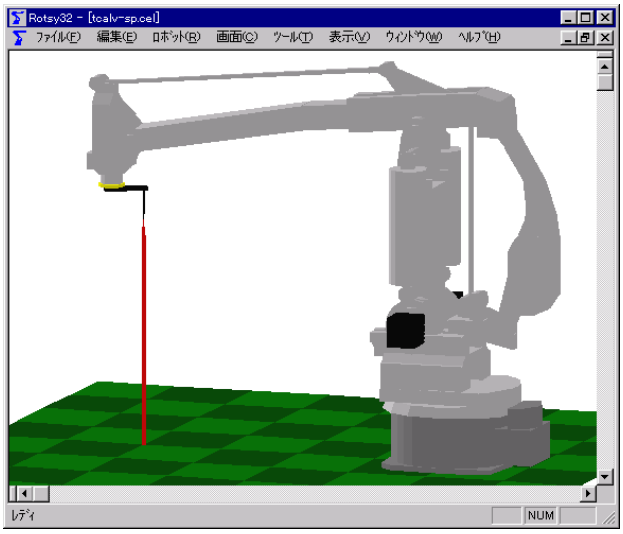
《Second Posture》

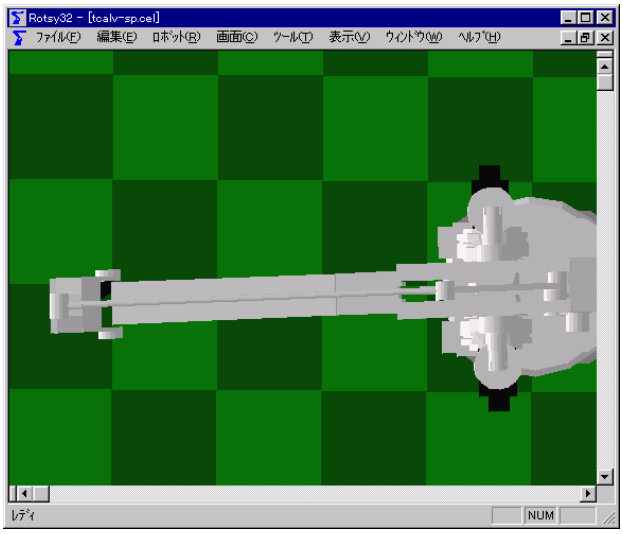


《Third Posture》

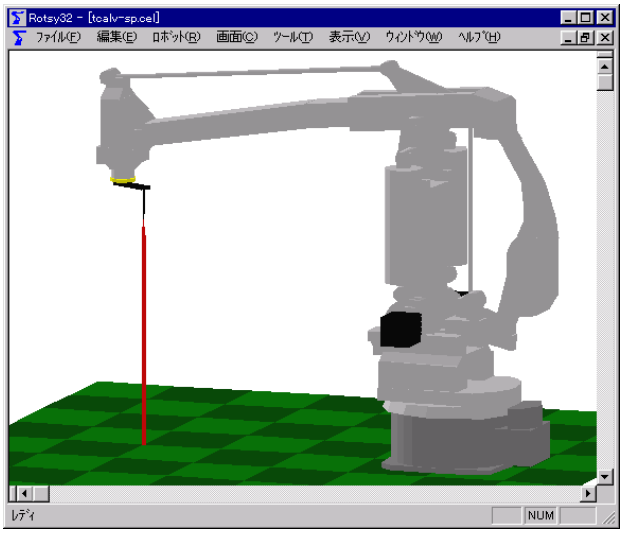


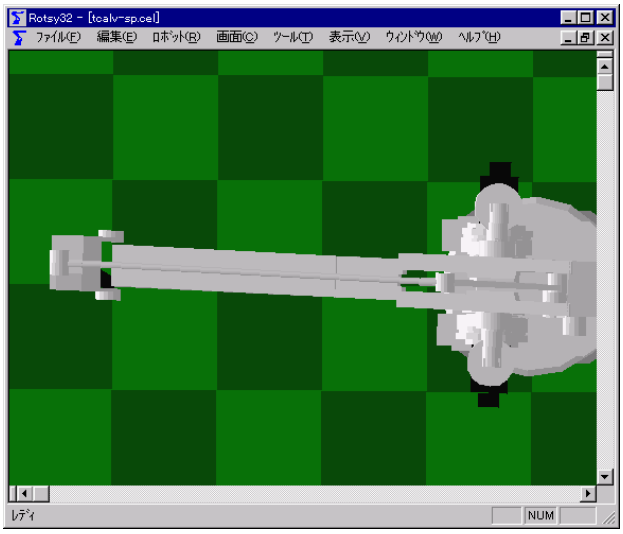
《Fourth Posture》



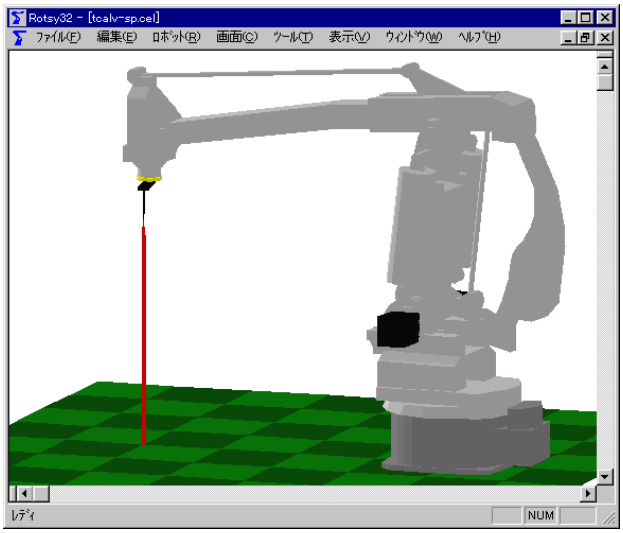


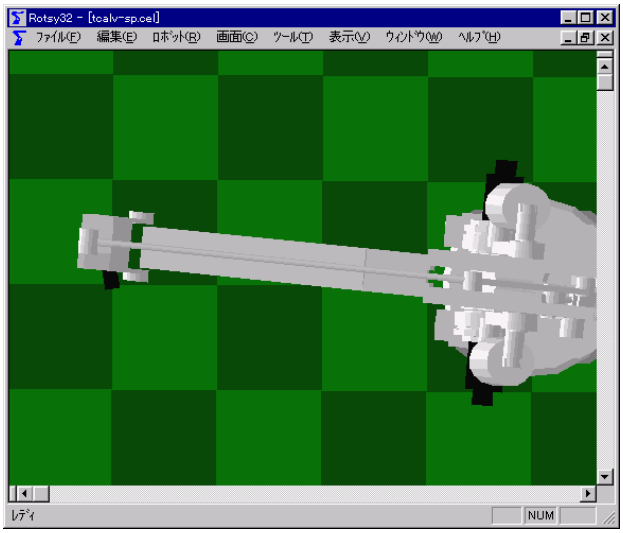
《Fifth Posture》



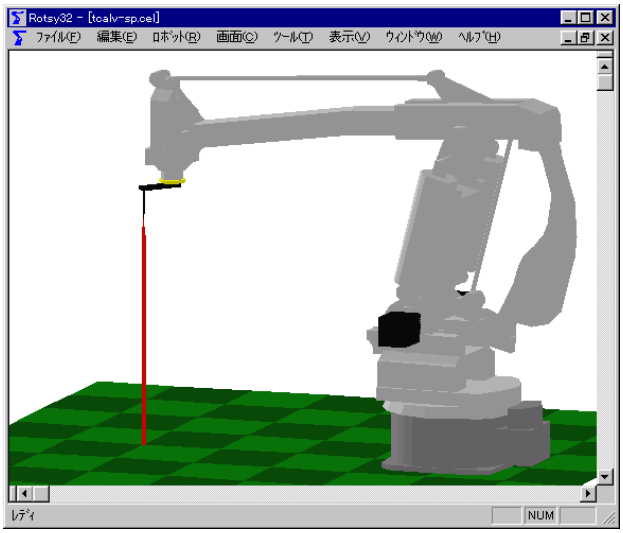


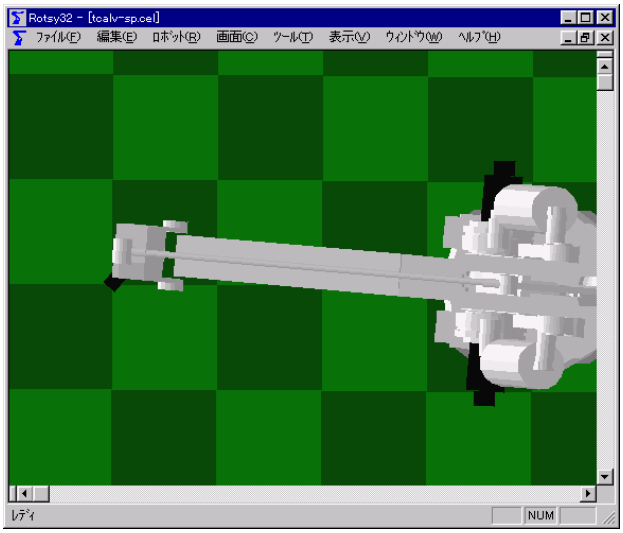
《Sixth Posture》





《Seventh Posture》





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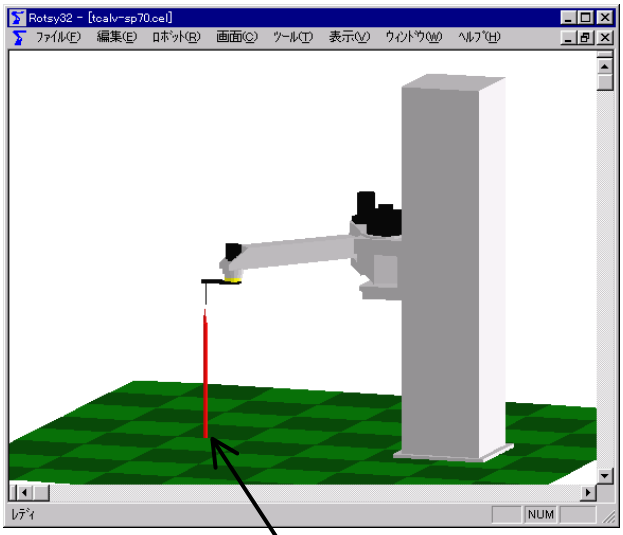
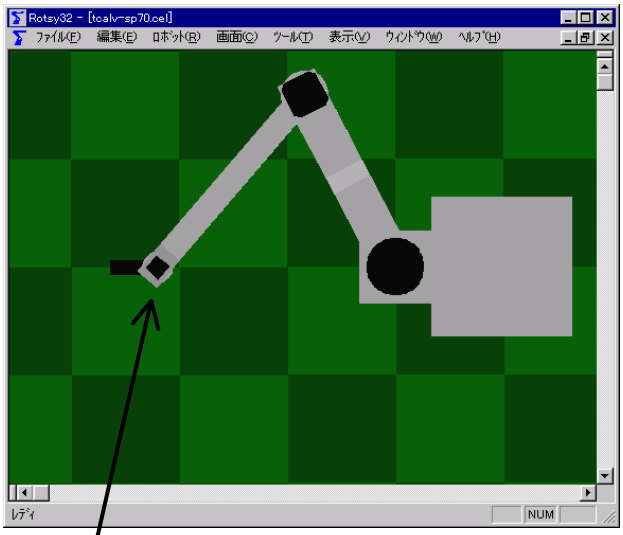
《First Posture》





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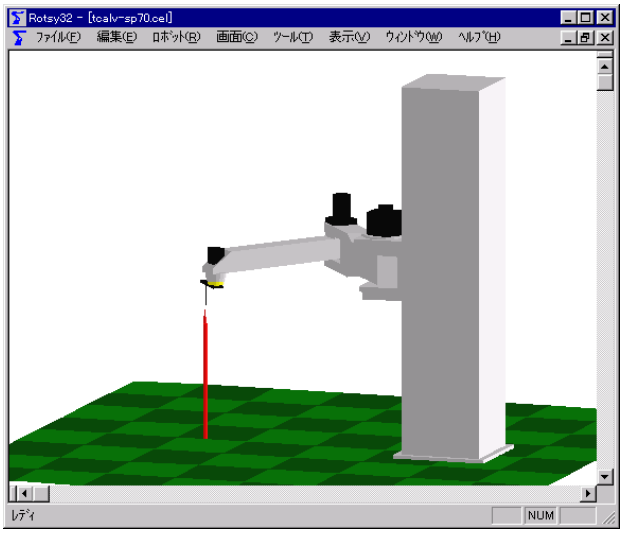
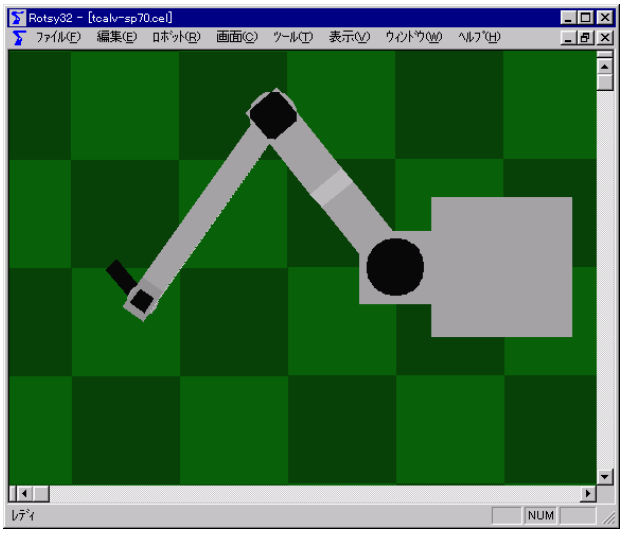
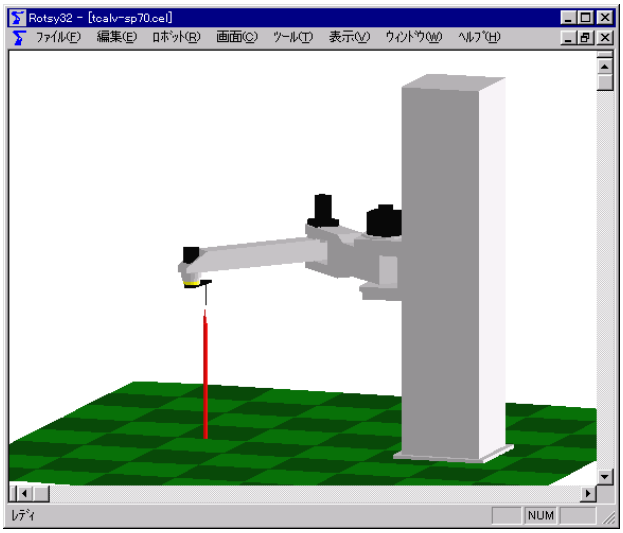
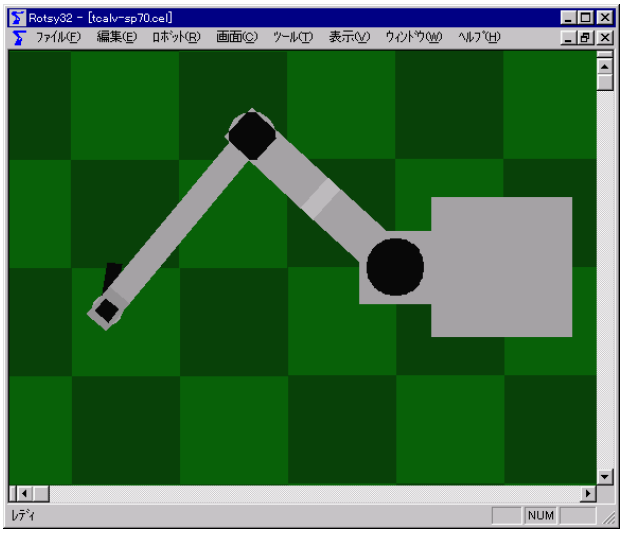
《Second Posture》



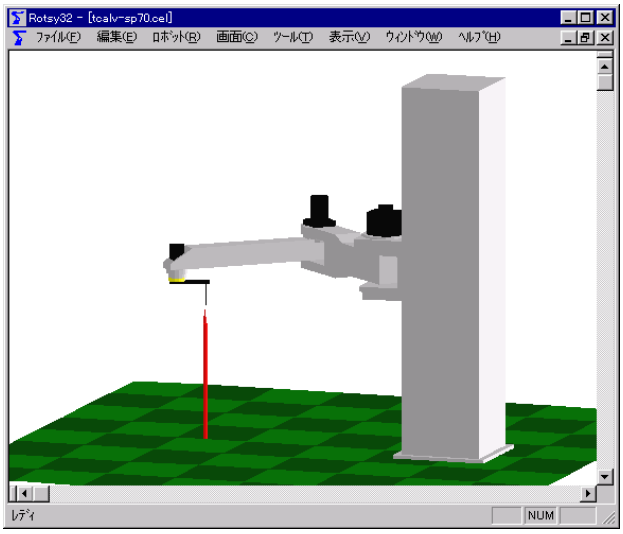


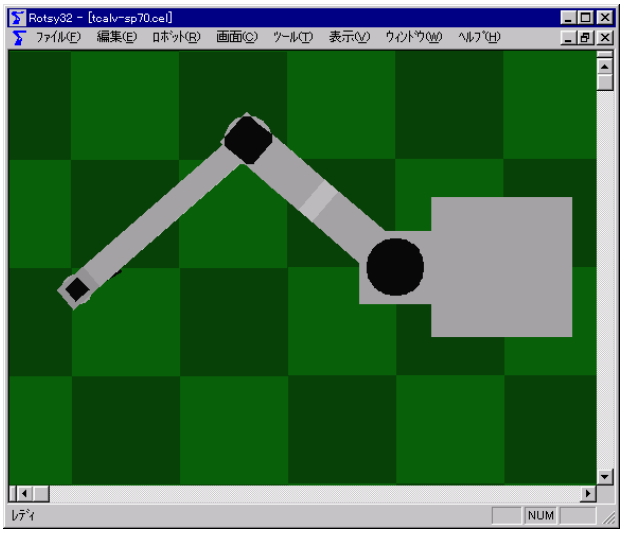
《Third Posture》



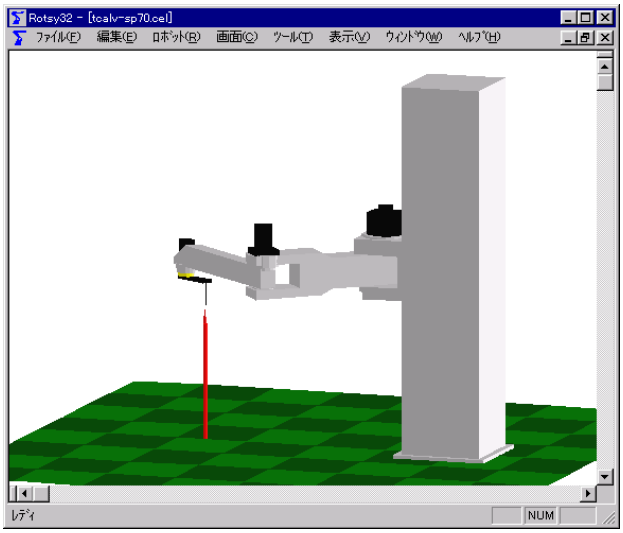


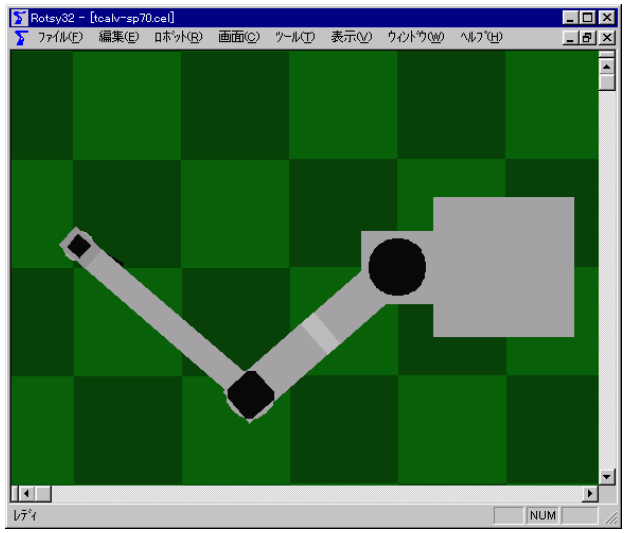
《Fourth Posture》



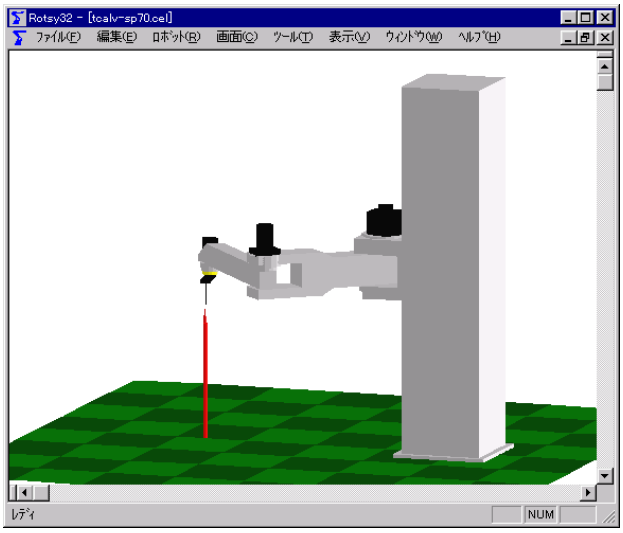


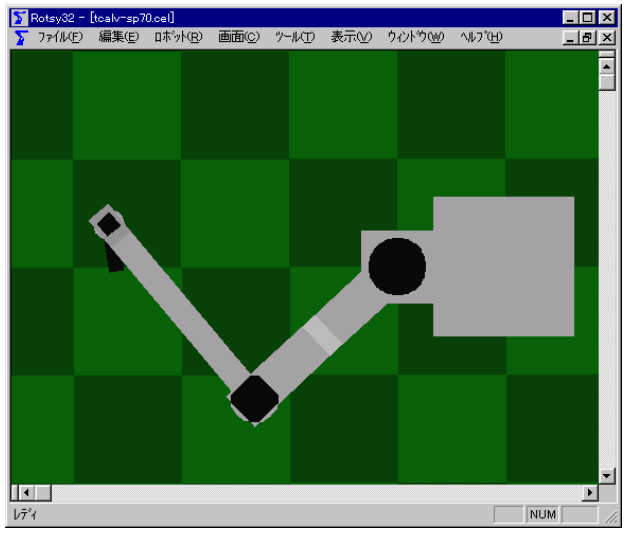
《Fifth Posture》





《Sixth Posture》





《Seventh Posture》