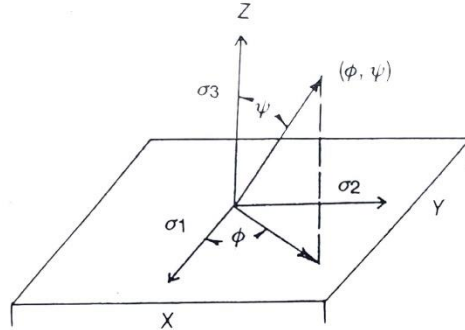


# 殘留應力分析

1. **先找到合適的繞射角**:選高角度，無干擾的繞射峰較好。
2. **測量多組不同  $\varphi$  角時之繞射峰並對  $\sin^2\varphi$  作圖利用其斜率及應力常數求取應力**:



主應力之座標系統圖，主應力為  $\sigma_1$ 、 $\sigma_2$  及  $\sigma_3$

在固定  $\phi$  下，測量多組不同  $\varphi$  角時的繞射峰  $2\theta\varphi$  會與  $\sin^2\varphi$  呈線性關係(斜率 =  $\frac{\Delta 2\theta\varphi}{\Delta \sin^2\varphi}$ )。

$$\sigma_\phi = K * \frac{\Delta 2\theta\varphi}{\Delta \sin^2\varphi} \dots\dots\dots(1)$$

$$K = -\frac{E}{2(1+\nu)} * \cot\theta_0 * \frac{\pi}{180} \quad K:\text{stress constant}$$

$\theta_0$ :Undistorted diffraction angle.

作圖求得斜率後乘以應力常數(K)可得試片表面沿著  $\phi$  角方向之應力。

3. **量取  $\phi$  角=0、45、90 之應力以求得主應力**:以上求得之應力不一定是主應力，以上述之正弦平方法求得  $\phi$  角=0、45、90 之應力  $\sigma_0$ 、 $\sigma_{45}$  及  $\sigma_{90}$ 。

假設主應力軸方向與實驗時( $\phi$  角=0)之方向夾角為  $\phi'$ ，主應力軸之應力為  $\sigma_1$ 、 $\sigma_2$  及  $\sigma_3$ (一般  $\sigma_3 = 0$ )

$$\tan 2\phi' = -\left[\frac{2\sigma_{45} - (\sigma_0 + \sigma_{90})}{\sigma_0 - \sigma_{90}}\right] \dots\dots\dots(2), \text{可求得}\phi' \text{帶入公式(3)、(4)}$$

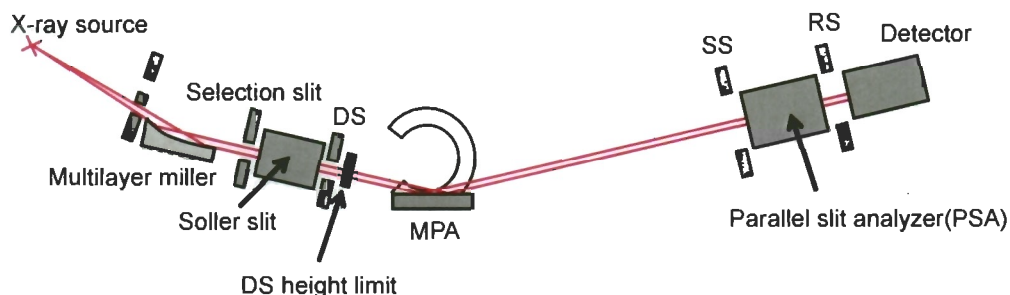
$$\sigma_0 + \sigma_{90} = \sigma_1 + \sigma_2 \dots\dots\dots(3)$$

$$\sigma_0 - \sigma_{90} = (\sigma_1 - \sigma_2)\cos 2\phi' \dots\dots\dots(4)$$

可求得  $\sigma_1$  及  $\sigma_2$

# Residual stress measurement

## 【Optics】



## 【Procedure】

### A. Test Scan

Phase identification is performed and measured plane is selected.

### B. Investigation of measure condition

Sampling step, scan speed and scan range etc are investigated.

### C. Selection of measurement method

Measurement method is selected and stress measurement is performed.

## 【Exchange of geometry】

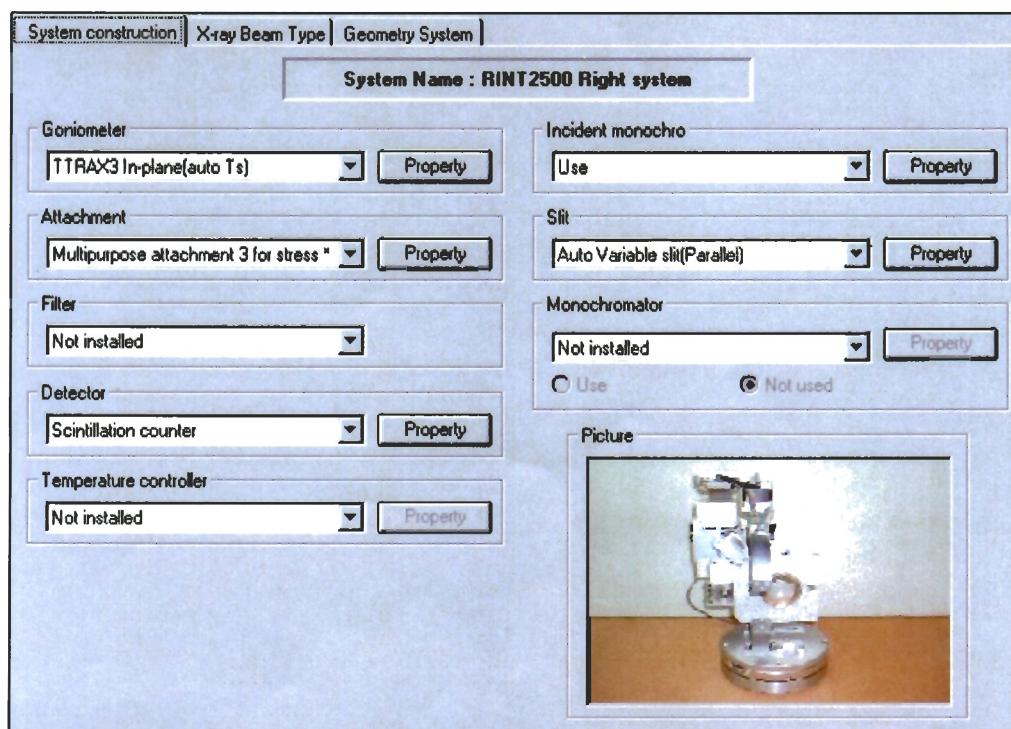
1. It is required to finish auto alignment of parallel beam with "Standard sample holder". In most cases, stress measurement is performed with PSA0.5deg not 0.114deg because the peak width in high angle area is wide and the intensity is small.

2. Multipurpose attachment is mounted. The power of RCD is turned off. (There is the switch on back side).

3. After connecting attachment cable, the power of RCD is turned on.

4. The sample is mounted on MPA.

5. Click "RINT2500 Right system" in [Rigaku]-[Control]-[Rigaku Control Panel]. Select items as follows.

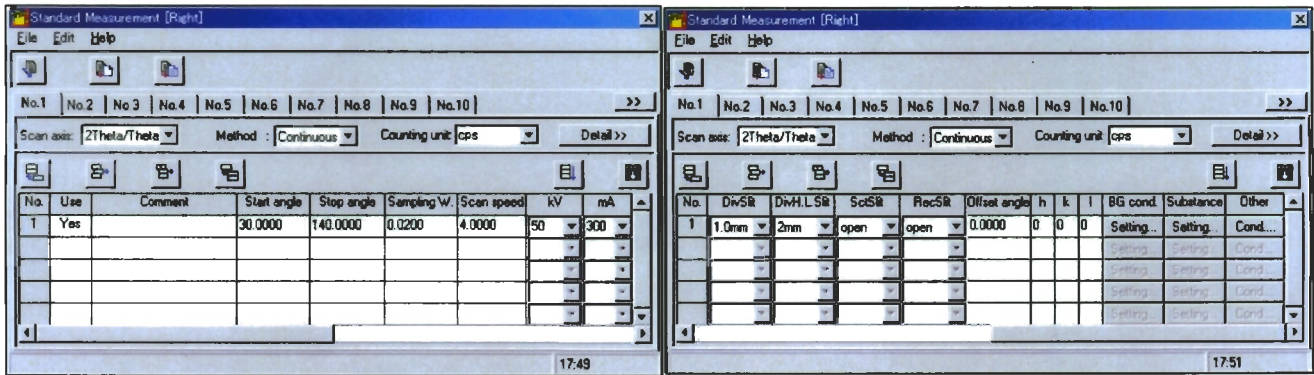


6. Click "Auto alignment" in [Rigaku]-[Control]. The optimization of theta axis and sample height is performed.

\*After finishing auto alignment, irradiated area is restricted to get stress value correctly with vinyl tape etc in case measured surface is round shape.

**[A. Test scan]**

A-1. Click "Standard measurement" in [Rigaku]-[Right measurement]. Enter parameters as follow.



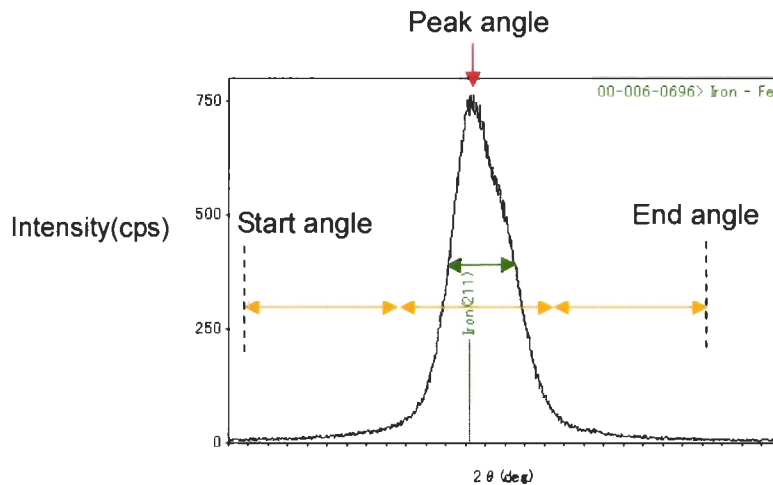
A-2. Press "Start measurement". Normally, receiving soller slit is not used and 2mm divergence height limit slit is used. In case of using monochromator, crystal is faced to "Flat" and receiving slit for monochromator is removed.

A-3.

Phase identification is performed and the measured plane is decided. It is better to select a peak in higher angle than the one in lower angle in terms of Psi range and the error in conversion from angle to d value.

**[B. Investigation of measure condition]**

Check FWHM and peak intensity. Sampling step depends on FWHM and measurement time depends on peak intensity in residual stress measurement.



--way to decide sampling step--

Set 1/7 to 1/10 of FWHM. If this is the above case, sampling step is set to 0.1deg because FWHM is 0.97deg.

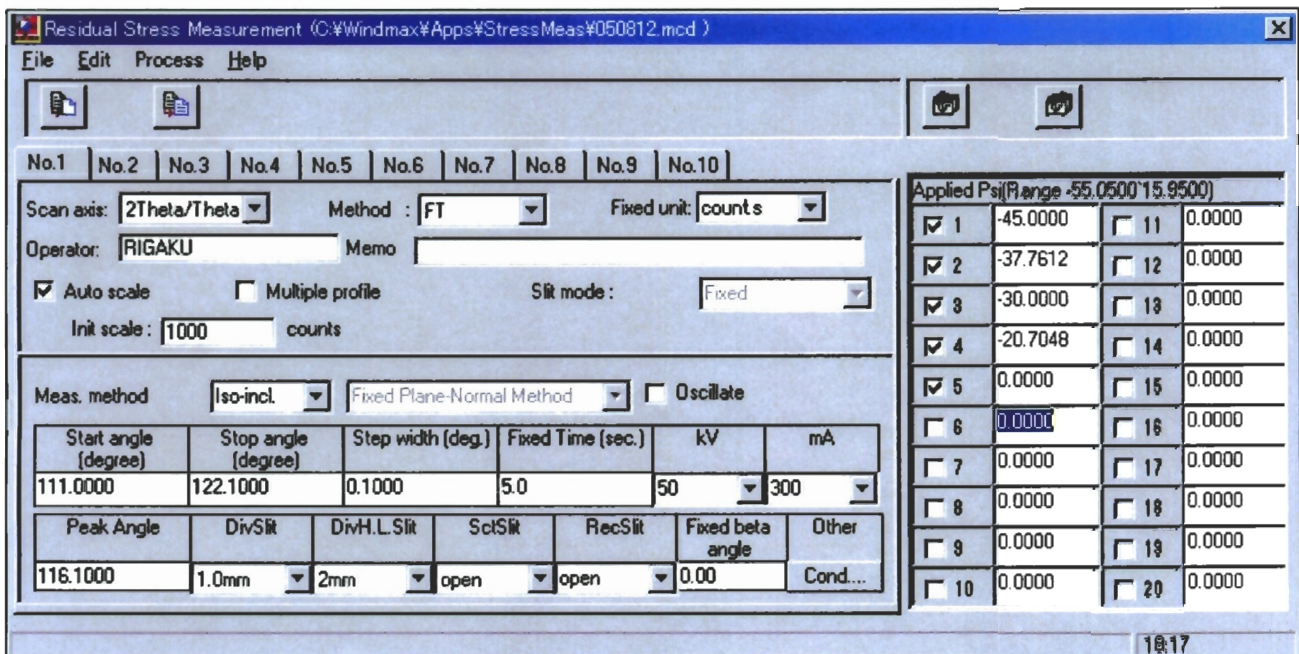
--way to decide FT time--

If possible, set measurement time per point is set so that peak intensity exceeds 3000counts. If this is the above case, FT measurement time is set to 4sec because peak intensity is 750 cps.

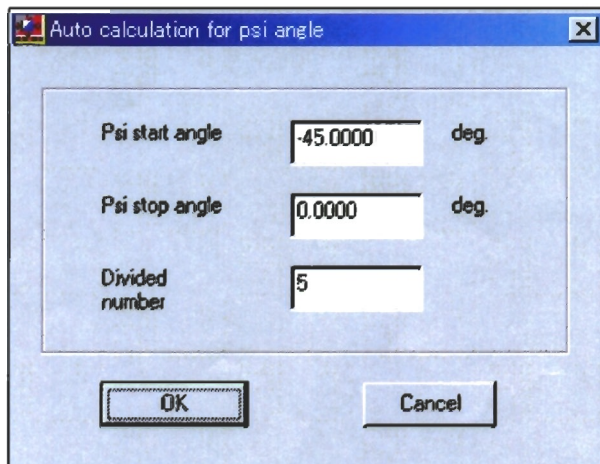
(reference) when measuring with continuous scan,,,,  
 If this is the above case, the intensity at 4deg/min is 750cps. Therefore, the intensity reaches to 3000counts when measuring at 1deg/min.

**[C. Selection of measurement method]**

- C-1. Click [Residual stress measurement] in [Rigaku]-[Right measurement].
- C-2. Select 2theta/theta in "Scan axis" , FT in "Method" and counts in "Fixed unit"
- C-3. Select "Iso-incl" or "Side-incl". See table below.
- C-4. Enter "start angle" , "stop angle" and "peak angle" in StepB
- C-5. Enter "Step width" and "Fixed Time" calculated in StepB
- C-6. Set "DivSlit":1mm, "DivH.L slit" 2mm, "SctSlit", "RecSlit" :open.
- C-7. Enter "Fixed beta angle" according to stress direction you'd like to measure.



C-8. Press "Applied Psi" button. Enter Psi start angle and stop angle. Psi range in Iso-inclination method depends on measured peak angle. "Divided number" means a number of Psi points measured.



| Method    | Axis         | Method type                | Psi range                | Comment               |
|-----------|--------------|----------------------------|--------------------------|-----------------------|
| Iso-incl  | 2theta/theta | Fixed plane-Normal method  | Depends on peak position | <b>Recommend</b>      |
|           | 2theta       | Fixed Incident angle(Psi)  |                          | -----                 |
|           |              | Fixed Incident angle(Psi0) |                          | Incident angle=90+Psi |
| Side-incl | 2theta/theta | Fixed plane-Normal method  | -75 to 30 deg            | <b>Recommend</b>      |
|           | 2theta       | Fixed Incident angle(Psi)  |                          | -----                 |

Iso-incl: It is possible to perform without MPA if oscillation is not used. Oscillation check box is active only when selecting FT measurement.

Side-incl: It is useful for complicated shape sample such as gear.

#### C-9. Start measurement.

There is possibility that diffracted intensity changes considerably according to incident angle because there is texture in many samples. Therefore, it is better to confirm the intensity in all Psi points at quick scan rate (FT 0.5sec or 1sec) before main measurement.