TEC/11-21-01

5.3.4 How to Read the Residual Stress Report

Select **VIEW | REPORTS**, or click the **REPORTS** button on the toolbar, and select the **RESIDUAL STRESS REPORT** from the dialog box. **SARATEC** automatically calculates the results and displays the report on the monitor.

1. At the top of the report you will find the name of the file, its path, the sample description you entered on the **SETUP** tab, and the date and time of the acquisition.

2. The next several items describe the material, the stress constant, depth below the surface, and the Phi angle.

> ***NOTE:*** *The Material Stress constant is the value of* $(1 + \nu)/E$ psi^{-1} *for your material, where* ν *is Poisson's ratio and E is Young's modulus. You should determine this value experimentally using x-ray diffraction per ASTM Standards for the set of planes you are measuring. This is the conversion factor between strain and stress.*

The Residual Stress is the calculated residual stress in units ksi (1000 psi), MPa, and/or kg/mm^2.

Next in the report are the stress results, errors, d-spacing intercept, slope, and statistics.

The Peak Bounding Range is the percentage of the peak **SARATEC** used to fit a parabolic curve to the spectrum (**SARATEC** uses the parabola to find the peak of the spectrum).

3. The next items summarize the configuration of the system for this measurement, including the number of channels into which the detector was divided. The Detector Calibration Coefficients are the coefficients that the program used to correct the data in each channel of the detector.

4. At the bottom of the report, the D-Spacing Intercept is the intercept in Angstroms of the d-spacing versus $\sin^2\psi$ plot. This number is an approximation of the unstressed d-spacing.

5. The Slope of Fitted Line is the slope of the d-spacing versus $\sin^2\psi$ plot. **SARATEC** uses this number together with the d-spacing intercept and the x-ray elastic constant to calculate the residual stress value.

6. The Counting Statistics Stress Error (+/-) is the error in the residual stress value due to counting statistics. You can improve this value by using a larger collimator, counting for a longer period, increasing the x-ray tube power, or a combination of these factors.

7. The probable error is the error due to non-linearity of the d-spacing versus $\sin^2\psi$ data. This error is an indication of the degree of large grain size, preferred orientation, measurement setup errors, etc.

> ***WARNING!*** *The probable error is the linear least squares fit of the data. However, when counting statistics errors are substantial relative to the linear least squares error,* ***SARATEC*** *generates a warning notice here so you will look at the relationship of both error values.*

8. The table in the report gives the following information:

   - Psi — the angles of tilt used for the acquisition. You specify these values for the detector (for the primary detector in a two-detector system).
   - Sin^2(psi) — the corrected $\sin^2\Psi$ values used in the data analysis.
   - Pk Chnl — the channel number of the location of the diffraction peak. Shifts in this peak position are used to determine the stress.
   - Intensity — the integrated intensity of each diffraction peak. Uniform intensities imply fine grain size with random orientation; non-uniform intensities imply large grain sizes and/or preferred orientation.
   - FWHM — the diffraction peak width in degrees at half of its maximum intensity. It is used to qualitatively determine the relative amount of cold working in a sample. The greater this value, the more cold working at the surface. If you develop calibration samples, you can use the FWHM quantitatively to determine the amount of cold working and to non-destructively measure hardness in steels.
   - Ka Corr — the $K\alpha_2$ correction in degrees. Whenever you use $K\alpha$ radiation, both a $K\alpha_1$ and $K\alpha_2$ component are present. At some Psi angles, these components are completely separated, while at others they may merge. To accurately determine the peak position, you must remove the $K\alpha_2$ contribution.
   - Flag:
     - 1 = detector 1
     - 2 = detector 2
     - X = Excluded
     - D = Dropped (like Excluded, only done by analysis)
     - R = Restricted peak search
     - E = Edited spectrum (deleted wings)

- M = Modified

- 2-Theta — the peak position in degrees two theta. A shift in the peak position is used to calculate stress.
- D-Spacing — the calculated distance between atomic planes measured in Angstroms.
- St. Dev. — the standard deviation in the d-spacing due to counting statistics. This number indicates the smoothness of the diffraction peak If the standard deviation is less than 0.000100, the counting statistics are considered excellent.

Sample

SaraTEC 2.00 (OCT222001A)
Residual Stress 2.00
File: D:\sa1\data\1182.mmt
Date: 02/12/2001 09:40:51

RESIDUAL STRESS REPORT

Sample Description: sf - dsk

Material:	Carbon Steel	Depth:	0.0000
Material Stress Constant:	3.714e-08	Phi Angle:	0.00

COMBINED STRESS RESULTS

Residual Stress:	-1.9 KSI	-13.2 MPa
Counting Statistics Error(+/-):	1.2 KSI	7.9 MPa
Probable Error (+/-):	1.8 KSI	12.4 MPa

(Warning: Counting statistics may be the controlling error)

Fitted Delta D vs Sin^2(psi) Data:

d-Spacing Intercept:	1.168698
Slope of fitted line:	-0.000083
d-Spacing 2-Sigma:	0.000104
Intensity 2-Sigma:	29.43

MEASUREMENT PARAMETERS

Collimator:	Round 4.0 mm
Orientation:	Psi
Count Time:	45.0 sec
Psi Osc Range:	2.00
X-Ray Tube:	Chromium / Vanadium
X-Ray Wavelength:	2.289700
Tube Voltage:	25.0 kV
Beam Current:	0.40 mA
Data Mode:	Combine
Compression Ratio:	1
Peak Bounds:	20.0
Z Height:	0.737
Z Cal Date:	02/08/2001 17:29:04
Z Cal Orientation:	Psi

DETECTOR INFORMATION

Det	S/N	Bracket	Chans	K Factor	K Factor2	Bias	Cal Date
1	TEC004	156	325	-0.145	0.000	0.000	02/07/2001 09:42:45
2	TEC005	156	326	-0.115	0.000	0.019	02/07/2001 09:42:45

Detector Calibration Coefficients

Det	A	B	C	D
1	-1.98877e-07	9.69818e-05	0.0414722	147.528
2	-1.54156e-07	7.31679e-05	0.0432806	147.907

COMBINED DATA

Psi	Sin^2	Pk Chnl	Intensity	FWHM	Ka Corr	2-Theta	D Spacing	SDev	Flag
-45.0	0.50741	179.23	629.8	1.93	0.15462	156.849	1.168618	3.65e-05	1
-45.0	0.50711	174.93	616.3	1.88	0.15402	156.814	1.168691	3.93e-05	2
-30.0	0.25602	178.86	618.7	1.85	0.15365	156.793	1.168735	3.62e-05	1
-30.0	0.25645	176.11	618.0	1.80	0.15353	156.850	1.168615	3.45e-05	2
-15.0	0.07045	179.16	614.2	1.86	0.15369	156.783	1.168755	3.36e-05	1
-15.0	0.07059	175.84	589.5	1.78	0.15312	156.815	1.168689	3.17e-05	2
0.0	0.00005	179.96	608.6	1.82	0.15357	156.819	1.168680	3.57e-05	1
0.0	0.00006	176.74	584.9	1.74	0.15301	156.857	1.168602	3.01e-05	2
15.0	0.06364	179.37	631.9	1.80	0.15316	156.777	1.168770	3.97e-05	1
15.0	0.06347	176.13	592.4	1.76	0.15297	156.816	1.168687	3.60e-05	2
30.0	0.24402	180.16	637.3	1.82	0.15340	156.795	1.168731	3.50e-05	1
30.0	0.24365	177.03	613.4	1.81	0.15361	156.843	1.168630	3.68e-05	2
45.0	0.49286	181.23	652.4	1.89	0.15415	156.819	1.168682	3.37e-05	1
45.0	0.49259	177.66	621.0	1.81	0.15371	156.849	1.168618	3.58e-05	2

SaraTEC 2.00 (OCT222001A)
Residual Stress 2.00
File: D:\sa1\data\1182.mmt
Date: 02/12/2001 09:40:51

Sample Description: sf - dsk

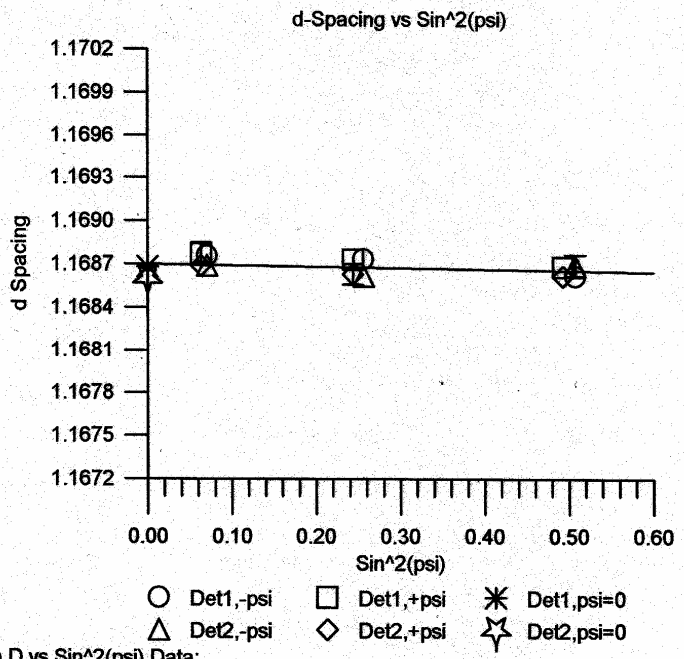
DETECTOR 1 DATA

Psi	Low	High	Gross	Peak Net	Peak Chnl	Avg	SNR
-45.0	166	194	29578	28342	179.23	570.53	24.97
-30.0	167	193	29557	27842	178.86	594.34	26.54
-15.0	167	193	28716	27638	179.16	569.95	26.77
0.0	167	195	28322	27386	179.96	567.71	26.28
15.0	168	194	29709	28437	179.37	598.09	28.37
30.0	168	194	30171	28679	180.16	606.44	27.71
45.0	168	196	30681	29357	181.23	593.24	25.55

DETECTOR 2 DATA

Psi	Low	High	Gross	Peak Net	Peak Chnl	Avg	SNR
-45.0	164	188	29476	27735	174.93	589.77	31.66
-30.0	164	188	29286	27809	176.11	596.52	32.94
-15.0	164	188	27720	26526	175.84	573.13	30.22
0.0	165	189	27757	26321	176.74	575.96	31.53
15.0	166	188	28378	26659	176.13	594.61	33.79
30.0	165	189	29175	27604	177.03	595.18	32.62
45.0	166	190	29131	27945	177.66	600.27	30.72

File: D:\sa1\data\1182.mmt
Comments: sf - dsk



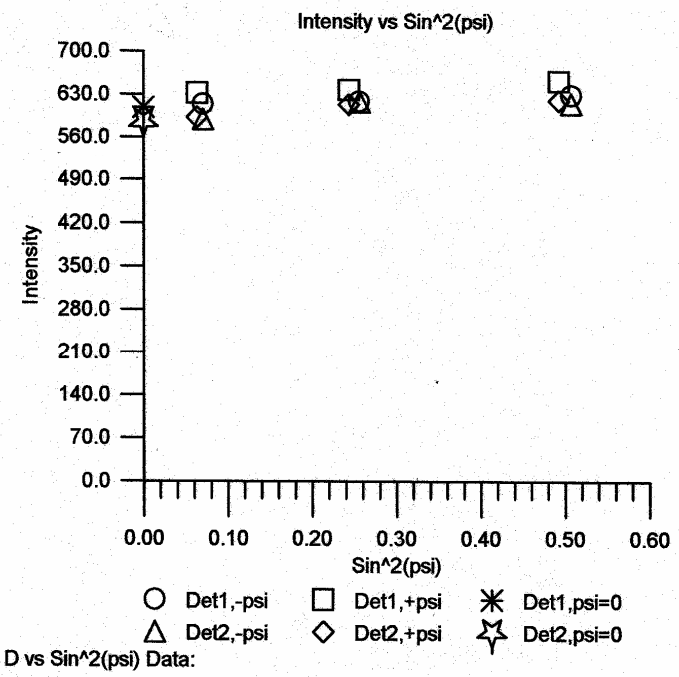
Fitted Delta D vs Sin^2(psi) Data:

d-Spacing 2-Sigma:	0.000109
Intensity 2-Sigma:	36.66

Residual Stress:	-1.9 KSI	-13.2 MPa
Counting Statistics Error(+/-):	1.2 KSI	7.9 MPa
Probable Error (+/-):	1.8 KSI	12.4 MPa

(Warning: Counting statistics may be the controlling error)

File: D:\sa1\data\1182.mmt
Comments: sf - dsk



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