Chapter III

Application

In order to determine the location of casing wear, results from each algorithm (vector sum or ellipse fit) must be processed further. To identify casing damage and scale precipitation, only a single set of measurements is required. In case of the vector sum, each corrected radius must be compared with the average of the corrected radii. In case of the ellipse fit, the raw measurement and the distance from the center of the ellipse to the fitted ellipse curve must be compared. By comparing the radii (the corrected radii in case of vector sum or the raw radii in case of ellipse fit) and the curve (average radius in case of vector sum or ellipse curve in case of ellipse fit), the location of casing damage or scale precipitation can be pinpointed.

In order to see if there is a change in casing condition, two sets of measurements are conducted at different times and used for comparison. In each run, the caliper tool is rotated during the logging in order to measure the radii of the casing. Since each measurement may start at different positions, a run made some time later may not take reading from the same positions as the first time. Thus, the measurements of the two runs must be synchronized.

3.1 Damage and Scale Identification

Damage identification between the vector sum and the ellipse fit algorithms is a little bit different and can be summarized as follows:

1. Vector sum.

To identify the location of the casing wear or scale precipitation, we subtract the corrected radii from the average radius at each depth as shown in Fig. 3.1.

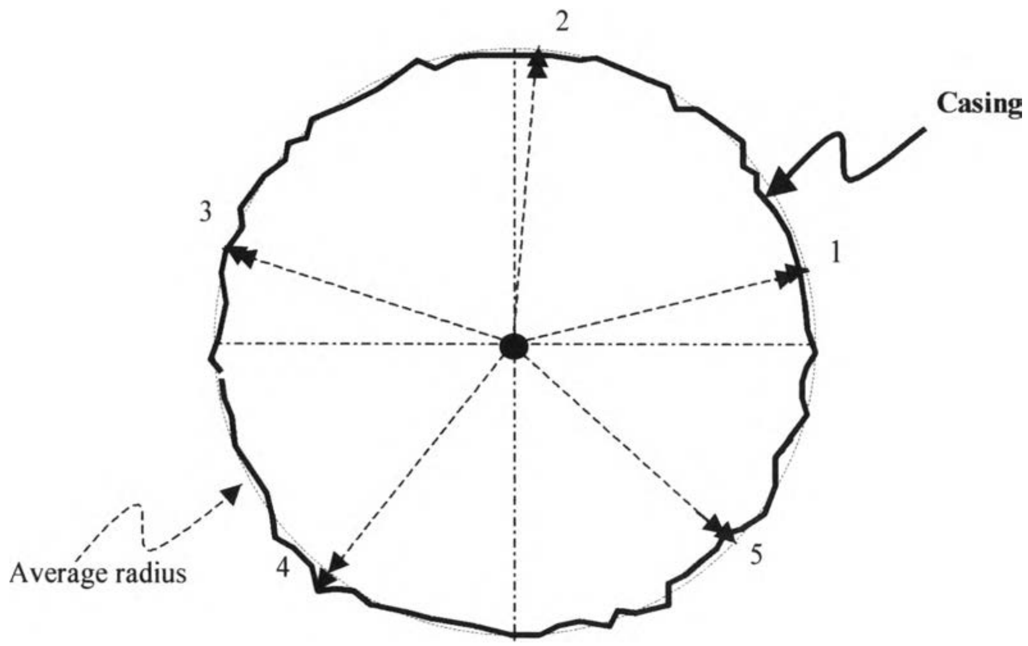

Figure 3.1: Damage identification by vector sum.

2. Ellipse fit.

To identify the location of the casing wear or scale precipitation, we subtract raw measurements from the center to the fitted ellipse curve for every position in each depth as shown in Fig. 3.2.

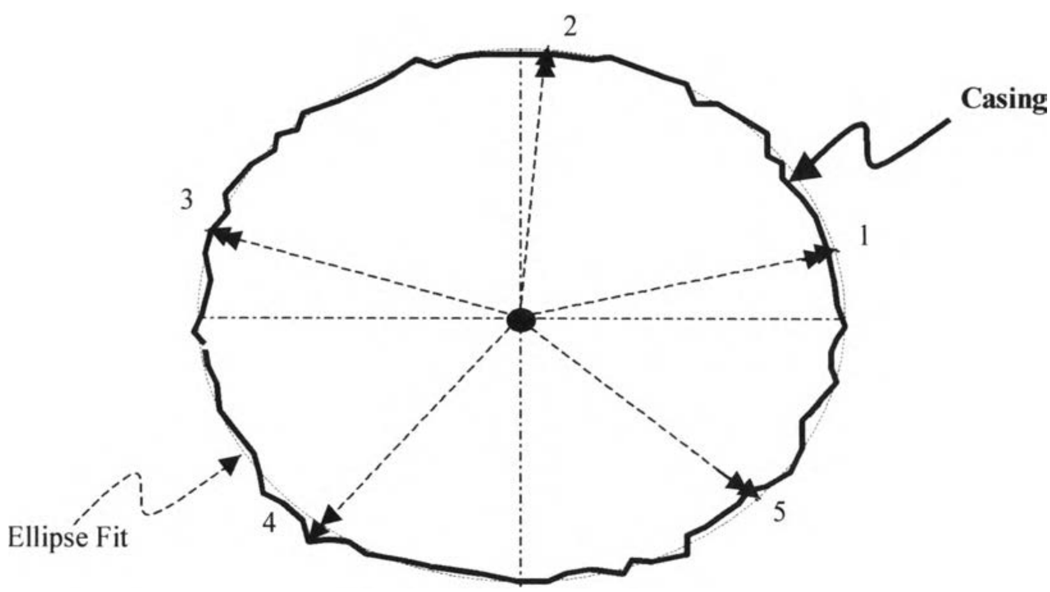

Figure 3.2: Damage identification by ellipse fit.

Then, an image is plotted to show the differences between the corrected radii and the average radius in case of the vector sum or the differences between the raw radii and ellipse curve in case of the ellipse fit at all depths. The location of damage can be determined by these differences.

3.2 Synchronization of measurements obtained in two runs

As mentioned before, the caliper measurements at different times show information whether the casing condition has changed. For instance, there might be more damage or scale on casing as the well has been on production for a long time. Synchronization between different runs must be performed since each run may start at a different position.

If the deviation sensor is used in both runs, we can easily synchronize the measurements between the two runs (since we know the tool orientation). In this case both the vector sum algorithm and ellipse fit algorithm can be used to process the data. If the deviation sensor is not sent down along with the caliper tool in the second measurement, we need to synchronize the new measurement with the previous one. And only the ellipse fit algorithm can be used to process the data. For example, in the first run the caliper tool is used to measure 5 radii (actually 72 radii) at the depth of 1140 feet. These groups of data called “Run 1” are plotted as shown in Fig. 3.3.

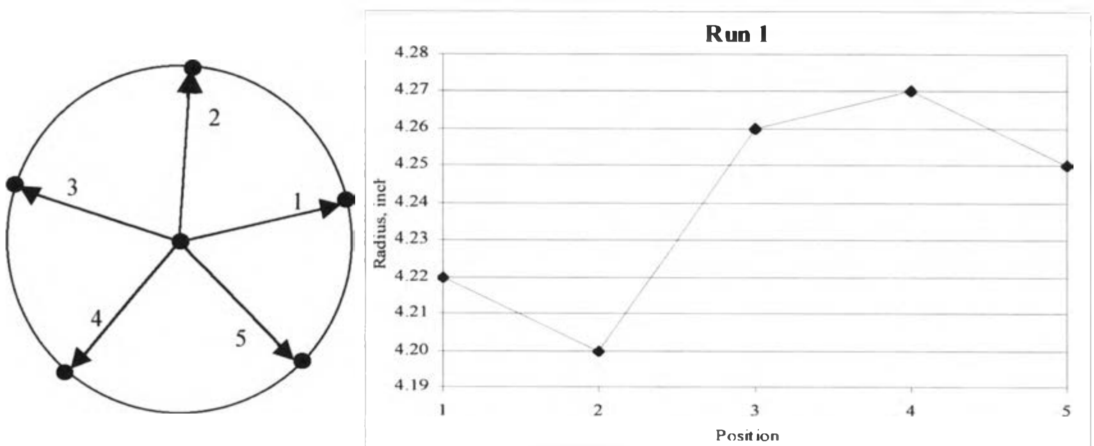

Figure 3.3: The data measured in the first run.

Then, in the following year, the same tool is used to measure another 5 radii at the same depth in order to evaluate the change in casing conditions. The new measurements may not be at the same positions as those obtained in the first year. The new data are shown in Fig. 3.4.

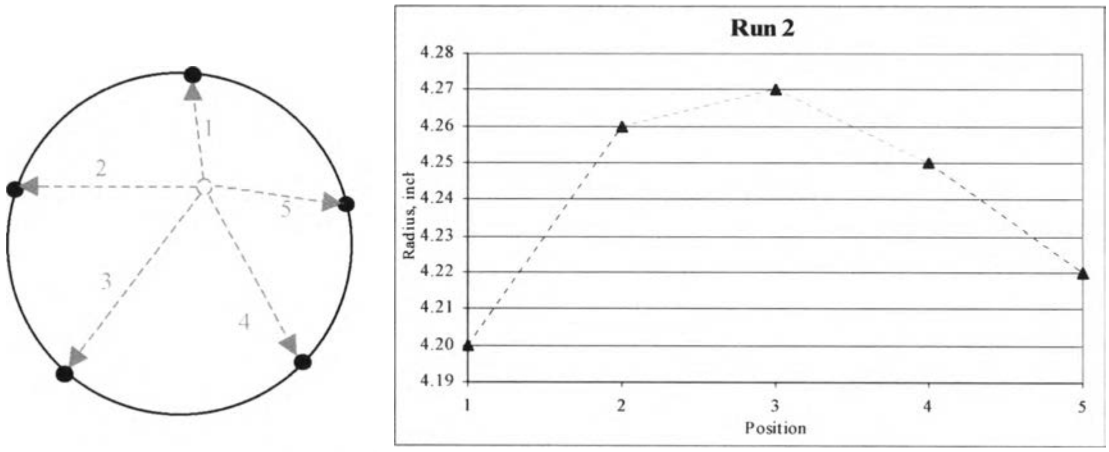

Figure 3.4: The data measured in the second year.

The two sets of data are compared in Fig.3.5. It can be seen that the measurements from the two runs are totally different. Data synchronization can be done by rotating the data in Run 2 until they match with the measurements in Run 1. The result is shown in Fig. 3.6.

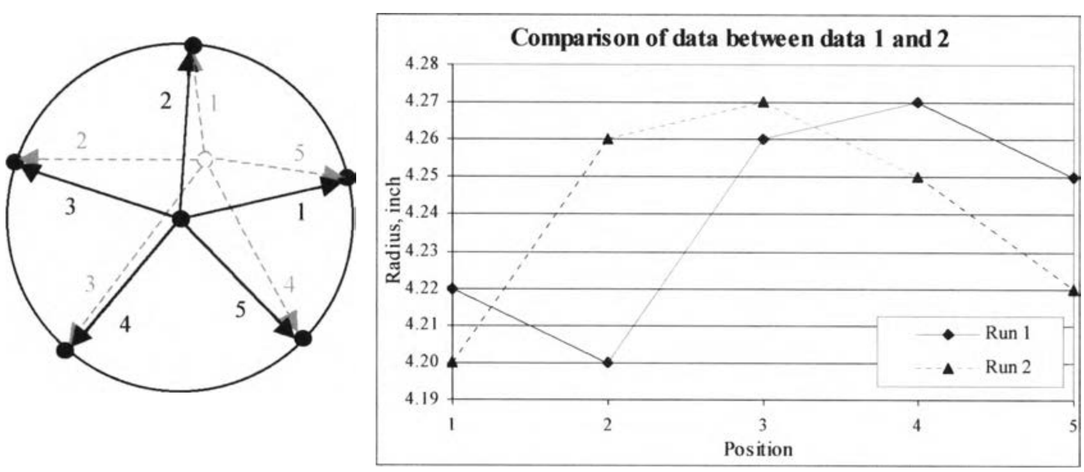

Figure 3.5: Comparison of data obtained from the first and second year.

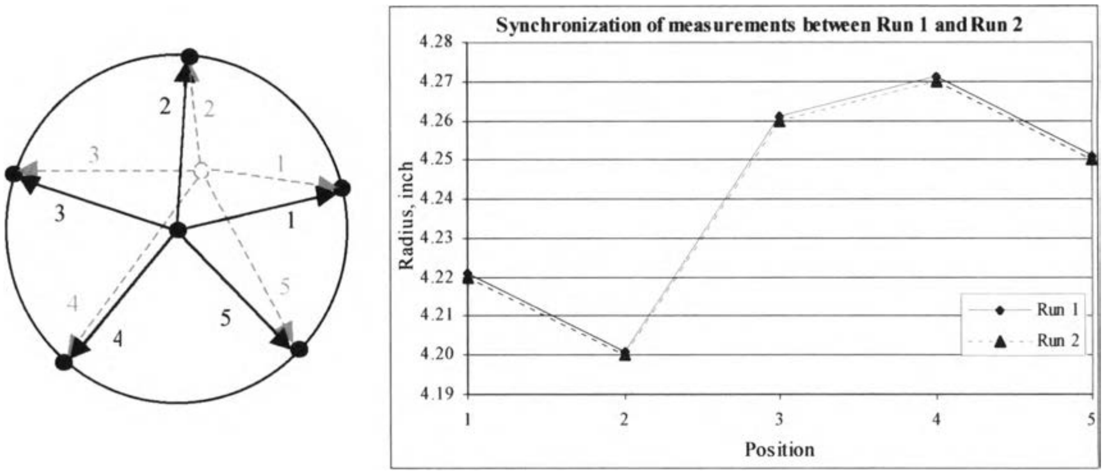

Figure 3.6: Synchronization of measurements between Run 1 and Run 2.

The 72 radii measured in Run 1 may not exactly be at the same positions as the 72 radii measured in Run 2 as illustrated in Fig. 3.7. Since there are only 72 measurements along a 360 angle of the casing, there is a maximum shift of 2.5 degree. As seen in the figure, position 4 in Run 2 is the same as position in Run 1 with a maximum error in the phase shift of 2.5 degree.

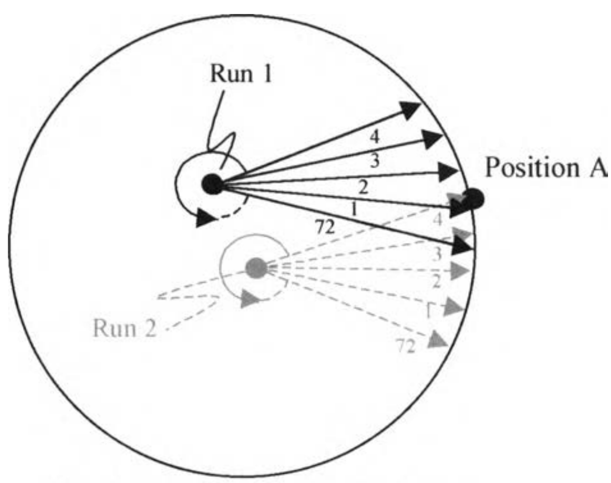

Figure 3.7: Error in phase shift.

As the tool center of two runs may not be at the same positions, the radii measured in two runs may not have the same values. Comparison between the radii of two runs cannot be done directly. Therefore, the coefficients *a*, *b*, *c*, *d*, *e*, and *f* of the two runs cannot be done directly. Therefore, the coefficients a, b, c, d, e, and f of the ellipses fitted to the data are compared instead. Since there is a shift in data measurements, there is a need to fit an ellipse to shifted data, i.e., the data in Run 2 must be shifted 72 times. In each shift, the sum of the absolute of the differences between the coefficients (error) can be calculated as shown bellow:

$$\text{Error} = |a_1 - a_2| + |b_1 - b_2| + |c_1 - c_2| + |d_1 - d_2| + |e_1 - e_2| + |f_1 - f_2| \quad (3.1)$$

where

a_1, b_1, c_1, d_1, e_1, and f_1 are the coefficients of ellipse fitted to data from Run 1.

a_2, b_2, c_2, d_1, e_2, and f_2 are the coefficients of ellipse fitted to data from Run 2.

This error calculated in Eq. 3.1 at one depth. In order to synchronize the two runs, we need to find the position of Run 2 at which the sum of errors at all depths is minimum. The method to find out the lowest sum of absolute is explained later in Section 4.2

In this study, we assume that the overall casing shape does not change between two runs. Therefore, we can synchronize between two runs to see the development of the damage and scale precipitation. If the overall casing shape changes, we cannot synchronize between two runs.