Successful Failure Analysis Strategies

Heinz Bloch, P.E.
Reliability / Rotating Equipment Consultant

There was a time when people did failure analysis by guessing at the cause and trying something different. The result: repeat failures; the same machine ending up in the shop time after time. Today, we can no longer afford to guess. A structured, repeatable approach is needed.

A comprehensive approach to failure analysis starts out by defining the deviation, or stating the problem. Next, such an approach encourages, or even mandates, careful observation and definition of failure modes. It employs pre-existing or developed-as-you-go checklists and troubleshooting tables. From here, an integrated approach leads to the identification of failure agent(s), realizing that there are only four possibilities:

- Force
- Reactive Environment
- Time
- Temperature

This means that components will only fail due to one, or perhaps a combination of several, of these four failure agents. Moreover, all machinery failures, without exception, can be put into one or more of these seven cause categories:

1. Faulty Design
2. Material Defects
3. Fabrication and/or Processing Errors
4. Assembly or Installation Defects
5. Off-Design or Unintended Service Conditions
6. Maintenance Deficiencies, including Neglect and Procedures
7. Improper Operation

Each failure, and indeed each problem incident is the effect of a causal event. In other words, for every effect there is a cause, just as our graphics show!

(Continued on back)
It’s the same with machinery, our next example. Again, we note that for every effect there is a cause; there is a reason for every failure. First, we observe and define:

• Machine is Down – because shaft broke
• Shaft Broke – failure mode inventory consulted; found surface fretted
• Surface Fretted – because coupling hub was loose
• Hub Loose – It’s a hub that was to be interference-fitted to the shaft

Second, we test the seven possible cause categories:

1. Design Error? Unlikely, since other couplings are designed the same way and are holding quite well
2. Material Defects? No, since metallurgical exam checks okay
3. Fabrication Error? Hardness okay; dimensional correctness verified and recorded upon installation three years ago
4. Assembly/Installation Defect? No data, defer for later
5. Off-Design or Unintended Service Conditions? No
6. Maintenance Deficiencies (Neglect/Procedures)? No, since no maintenance (PM) is required on coupling hub.
7. Improper Operation? No, operator activities were per standard

Our next step is to get back to what needs to be investigated further, or where we had no data. That’s where we need to examine or compile:

(a) checklist of possible assembly errors: None apply here
(b) checklist of possible installation errors:

• Force: Could have overstretched hub
• Could have had insufficient axial advance on taper (insufficient interference fit)
• Reactive Environment: None found
• Time: Run length not excessive
• Temperature: Could have been too high (causing over-stretch) or too low (not allowing dilation to result in sufficient axial advance)

In both of these examples, the analyst will now determine in which cause category there is a deviation from the norm, which item needs to be modified, and how this modification is to be implemented so as to prevent a repeat failure.

Change analysis completes the structured, comprehensive approach. This failure analysis method seeks to identify what is different in the defective item as compared to the unaffected item. The analyst probes into when, where and why the change occurred. He or she can outline a number of remedial action steps, and will ultimately choose to implement the steps that best meet defined objectives. These objectives might include lowest life-cycle-cost, highest safety, highest initial quality, meeting a certain industry standard, a deadline, etc.