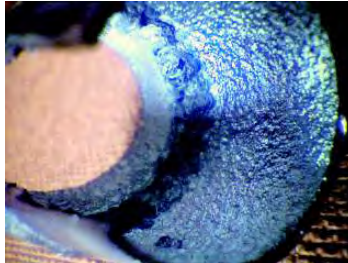
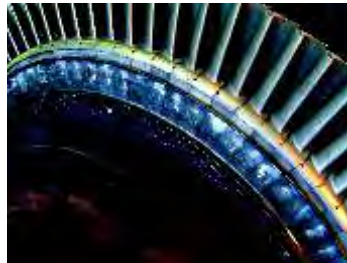




**TCR** Engineering  
Services



**FAILURE INVESTIGATION, METALLURGICAL & CORROSION  
CONSULTANCY SERVICES**



**Failure Investigation,  
Metallurgical & Corrosion  
Consultancy Services**

## We Cater to

Refinery & Petrochemical  
Engineering & Fabrication  
Chemical  
Pharmaceutical  
Food Industry  
Power & Energy  
Fertilizers  
Automobiles  
Foundry & Forging

With in-depth knowledge and experience in the field of Metallurgy and Corrosion, TCR undertakes Root Cause failure investigation for variety of industries like Petrochemicals, Refinery, Oil exploration, Chemical, Fertilizers, Power and Energy, Pharmaceuticals, Transport and Automobile, Fabrication and Engineering Industries.

Approach to failure analysis at TCR is unique and unequivocal. We are meticulous in carrying out first hand examination and gathering background information with regard to the problem. We at TCR are fully aware about the complexity of the analysis and pit falls of taking short cuts. The team of experts from different discipline synergize scenario of failure analysis and assist in arriving at correct solution to the problem. Professional approach adopted at TCR is unique and has evolved over the years of hard work. Experience gained by our immaculate approach to the failure analysis has brought accolades not only within the country but also from the overseas customers.

# Why one needs failure investigation service?

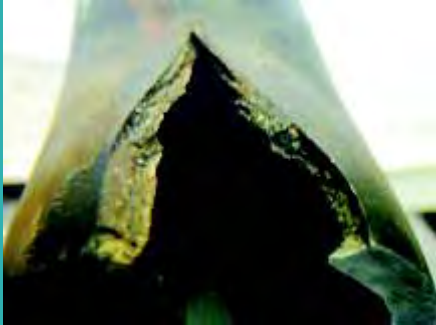
Often a component or equipment does not perform to its intended use and its recurrence requires to be prevented. A robust common sense based on pragmatic considerations can solve many of the problems. However, when it becomes repetitive, critical and when the consequences of failure result into formidable economical losses, violation of safety and environmental considerations, it requires to be attended with more scientific approach. Once the root cause of the problem is ascertained, solution is always around the corner. Nevertheless, approach requires to be systematic to trace the root cause, which is more often influenced by parameters like process inputs, raw material, fabrication, heat treatment and several other aspects.

The laws of forensic science equally apply to the metal when they fail. They record evidences of failure at subject location. The language of failure can only be deciphered by an experienced metallurgist after close observation of the failed part on fracture surface under optical and electron microscope.



# Whom do you trust for investigation needs?

TCR has repertoire of customers, over 2000 in number, to meet their day to day testing and quality control needs. We work in close liaison with professional team of experts having specialised knowledge in variety of disciplines. TCR has solved more than 1000 critical problems related to many industries on different components having services like high temperature, high pressure rotating, corrosive environment etc. The set up is fully equipped with in house material testing facility for advanced mechanical, corrosion and metallography, providing a leading edge.



Reactor failure



Boiler tube failure



# Metallography

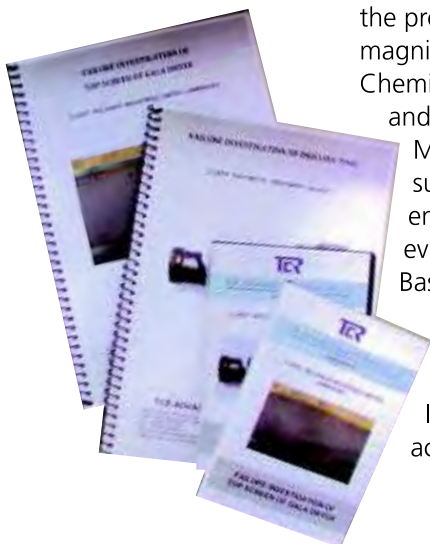
– stronghold of TCR.

Certainly we are having a leading edge in preparing the metallography samples and their interpretation. Microstructure of metals and alloys is a resultant of many metallurgical processes right from melting to finish components. Also, it records misuse and the abuse of the component during either processing or service which is always in terms of some defects or degeneration of phases. We have a large data base of metallurgical structures which is quite useful for failure investigation. It has been developed after incessant hard work with commitment.



## Presentation of Investigation Report

TCR has developed its own way to report the details of investigations encompassing all the evidences recorded. It explains the background of the problem, visual examination, low magnification examination, NDT results, and Chemical Analysis, Scanning Electron Microscopy and EDS Analysis, Metallography, Corrosion and Mechanical Test results. All the test results are summarized in the discussion part and at the end the failure scenario is elucidated vis-à-vis evidences recorded, with the proper analysis. Based on the analysis done, the most probable cause of the problem is identified. Suitable recommendations are also made to prevent reoccurrence of the problem. Indeed it is a valuable document that can act as a reference guide for the future course.



# Why TCR is unique in approach to the investigation?

Prima facie, our approach is synergistic and creative based on proper team work between different specialists. We are down to earth practical in providing a pragmatic solution to the problem that provides complete satisfaction to our customers and we in turn gain their confidence. Thus, we build long term relations with them to meet their future demands of problem solving. It is not exaggerating to say that we provide the most indepth study of a failure investigation.





Stress Corrosion Cracking

Hydrogen Embrittlement

Erosion Corrosion

Galvanic Corrosion

Low Cycle Fatigue

High Cycle Fatigue

Thermal Fatigue

Selective Leaching

Graphitization

Ductile Failure

Brittle Failure

Corrosion

Fatigue

Pitting

Creep

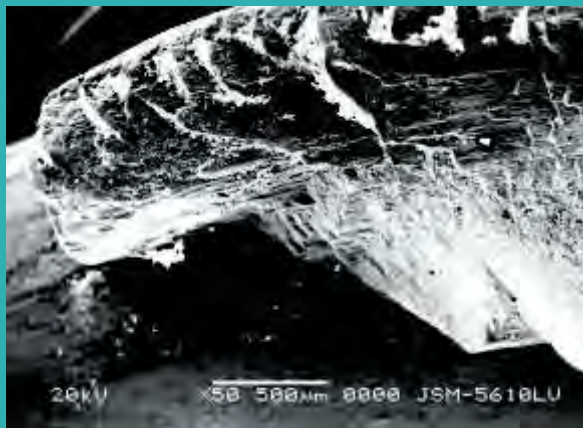
Wear

Solving a Variety of failure investigation cases:



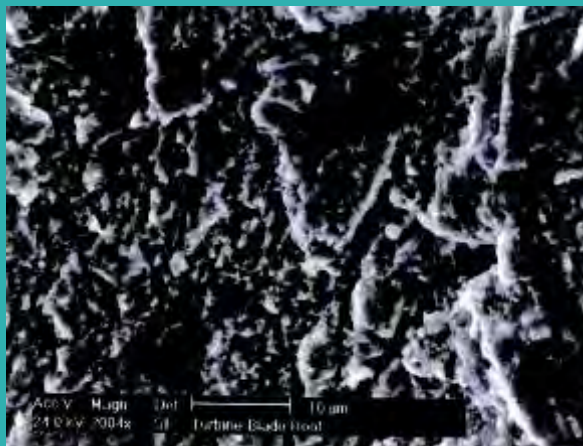
### Fatigue Failure

Ratchet marks are visible at the edge indicating multiple locations of fatigue crack initiations.



### Gear Failure

Gear Failure at teeth profile due to contact and bending fatigue.



### Corrosion Fatigue

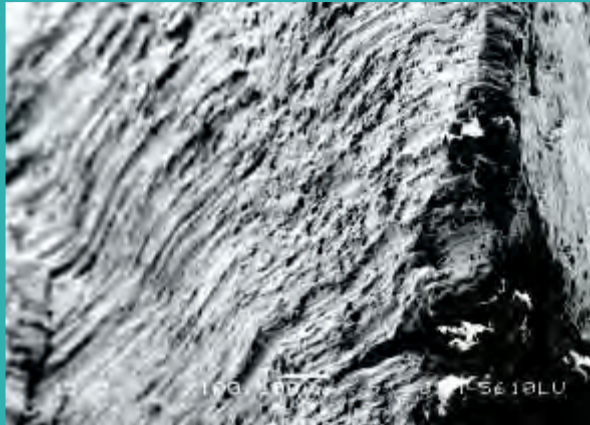
Fatigue Striations and scattered corrosion deposits are visible under scanning electron microscopy.

### Centrifuge

Pipe leakage at centrifuging machine due to pitting damage

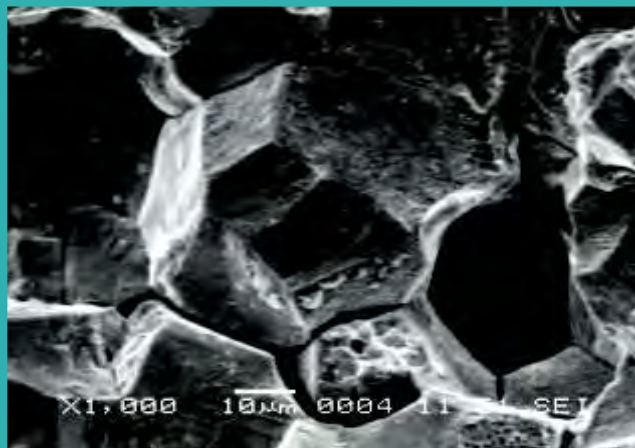
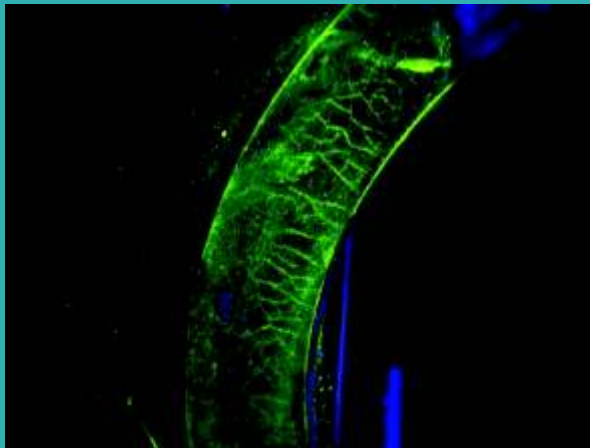
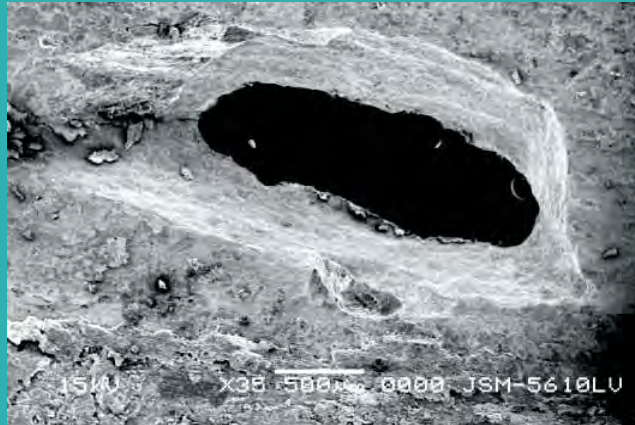
### **Fatigue Striations**

High cycle fatigue striations seen under scanning electron microscope.



### **Localized Corrosion**

Localized corrosion in form of pitting on stainless steel surface.



### **Grinding Crack**

Grinding cracks visible on case carburized heat treated forged gear component of helical gear box.

### **Inter-Granular Cracking**

Inter-granular cracking with grain dislodgement seen under scanning electron microscopy.

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