

Outline



- ➤ Types of Power Plants
- ➤ Important Equipment
- ➤ Common Types of Failures and some stats
- ➤ Examples of PP losses Pakistan
- ➤ Future Outlook
- Lessons and Conclusion

Power Plant Types



Power plants are classified on the basis of:

- Technology (Gas Turbines, DG sets, Steam Turbines, Combined Cycle/Simple Cycle etc.)
- Capacity
- ➤ Fuel Fossil (Oil, Coal), Nuclear, Renewable Energy (wind, solar, geo thermal, hydroelectric etc)
- Utility Base Load Power Plants vs. Peak load power plants

Prime Movers for Power Generation



- Steam Turbines
- > Gas Turbines
- > Hydro Turbines
- Wind Turbines

- Fuel powered internal combustion engines
- > Solar Photovoltaic cells
- Nuclear Reactors

Due to the nature of equipment involved, Failures and losses are inevitable!

Common Types of Failures-Critical Equip't



> Steam & Hydro Turbines

Rupture due to centrifugal forces, High Cycle Fatigue, Erosion, Pitting, Blade failures, Design failures

> Gas Turbines

Rupture due to centrifugal forces, High Temperature Creeping, HCF, Blade failures, Design failures

Generators

Rupture due to centrifugal short circuits, Explosion (H2-cooled generators), Fire

Diesel Engines

Lubrication failure, overheating, turbocharger failures, material fatigue, material failure, hi-cycle fatigue etc.

Common Types of Failures (cont'd)



> Transformers

Explosion, fire, due to insulation failures

Boilers

Flue gas explosion, fire

Wind turbines

Over speeding, Lightning, fire of electrical equipment, gearbox failures, remote locations

Solar Panels(PV modules)

Atmospheric disturbance, theft, electrical Fires, damage to invertors

Some Statistics – General Engg losses

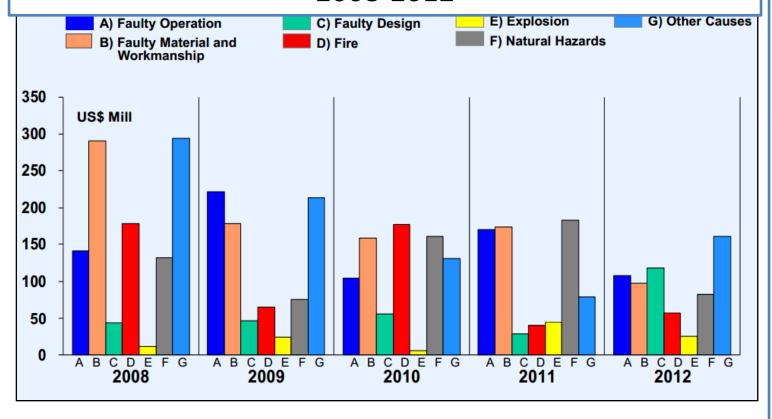


- Statistics for General Engineering Losses for contribution of the mentioned failures in claims
- ➤ Study carried out by IMIA in 2013 for 2008 -2012, Engg Insurance for all lines of business, Premiums, loss ratios, large losses, cause/nature of damages etc.
- ➤ Allianz published the report
- ➤ 23 member countries participated including most of Europe, North America, Australia, Turkey, Russia
- ➤ Large loss >= USD 1 million

Some Statistics - IMIA research



Cause of Large Losses - All Lines of Engg Business 2008-2012

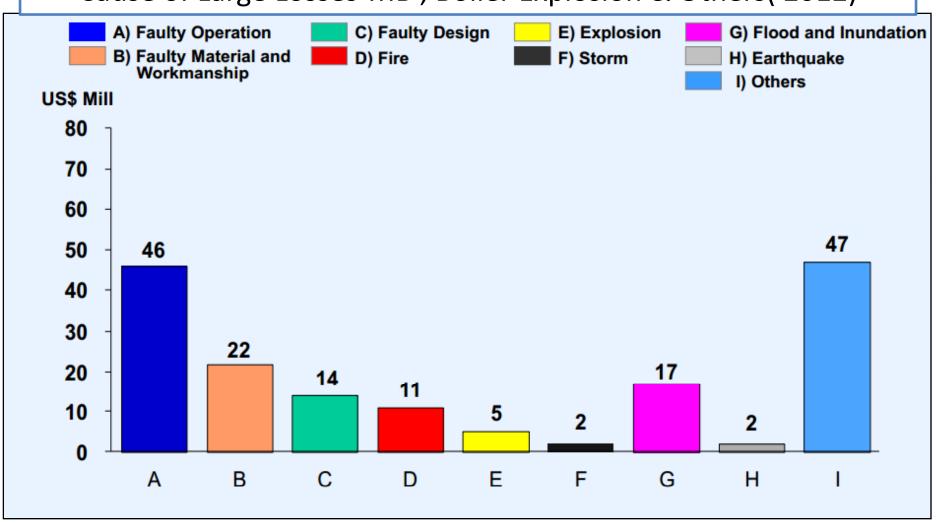


- •A + B + C (Breakdown)= 67%, Fire 12%, Explosion Very Low
- •Faulty Material & Workmanship almost a third of 2008 Levels
- •Nat Cat Mainly unpredictable
- •Faulty Design somewhat consistent from 2008 to 2011 but doubled in 2012

Some Statistics - IMIA research



Cause of Large Losses-MB, Boiler Explosion & Others (2012)



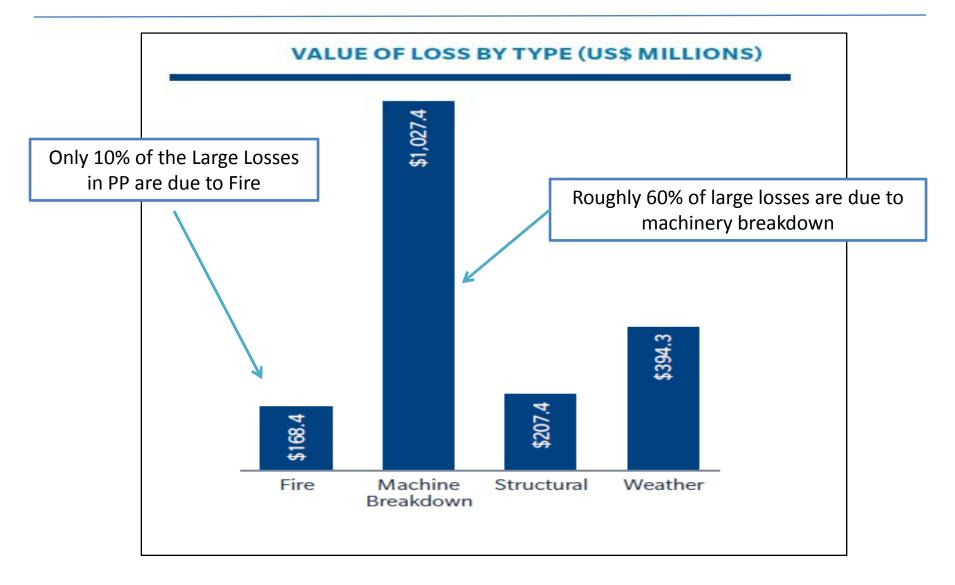
Loss Types in PP – study by Marsh



- ➤ Information specifically for power plants from a different angle
- Since 2005, based on a sample of 150 major losses totaling US\$1.8 billion, a study of a range of different causes show some clear patterns emerging.
- In total, losses attributed to weather events, fire, or machinery breakdown account for more than 95% of the 150 losses used in this analysis.

Loss Types in PP – study by Marsh

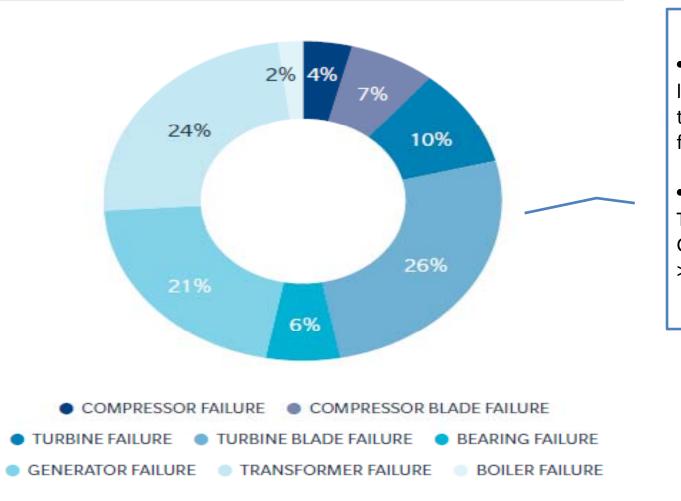




Loss Types in PP – study by Marsh



MACHINERY BREAKDOWN BY FAILURE



- •Highest % of losses due to turbine blade failure
- •Turbine Blade +
 Transformer +
 Generator Failure
 > 75%



EXAMPLES OF POWER PLANT LOSSES IN PAKISTAN

2007-2014



Flood Damage During Operation



- > 2010 Flood Damage (2 IPPs 350 Mw each at 1 Location)
 - ➤ Plant near Muzaffargarh flooded at a level of about 3 meters for 14 days.
 - ➤ One IPP out of service for 4 months and the second IPP out of service for 6 months
 - ➤ Property damage USD 30 million
 - ➤ Business Interruption USD 20 million

Flood Damage During Operation





First Site Visit – on a boat

Original Flood Level – Roughly 3m



Improper soot cleaning in HR system

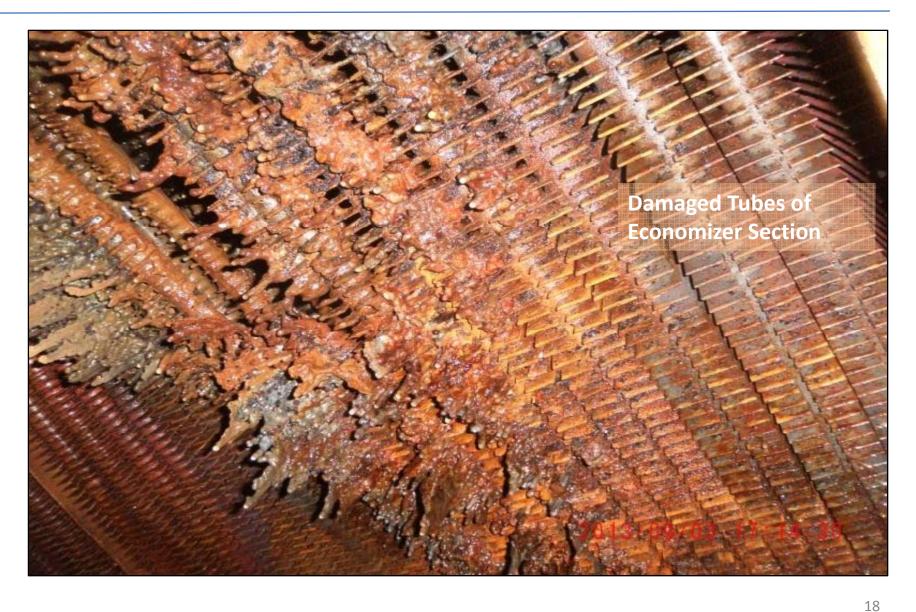


> 220 MW IPP HFO diesel generation plant HRSG Damage – MBD/BI

- > Improper soot cleaning resulted in fire in HRSG.
- > Tubes of LP section / Economizer damaged
- ➤ Property damage Rs 70 million
- Business Interruption Nominal
- > Out of service 15 days (temporary repair carried out)

Improper soot cleaning in HR system





Improper Water Treatment Regime



> 220 MW diesel generation IPP Steam turbine damage

- ➤ Improper water treatment regime despite world renowned O&M and water treatment specialists
- > caused corrosion deposits on nozzle ring and turbine blades and one stage completely eroded.
- ➤ Property Damage USD 2 million.
- ➤ Business Interruption USD 2 million
- ➤ Heat recovery steam turbine remained out of service for 7 months.

Improper Water Treatment Regime





Nozzle ring & turbine diffuser

Improper Water Treatment Regime







Corrosion deposits on steam turbine rotor

Broken stage 3 of steam turbine rotor

Improper Design Change

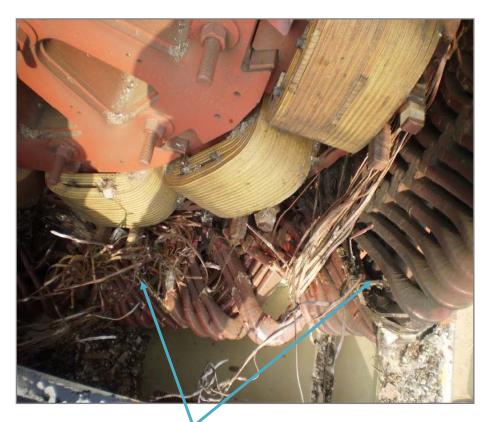


> 220 MW IPP HFO Diesel Generator PP-Alternator Damages - EAR/ DSU

- ➤ To save project completion time, it was decided to purchase Converteam alternators instead of original design with ABB alternators . Proper design calculations were not done .
- Resulted in cracks in base foot of alternators and alternator winding damage
- ➤ A very interesting Vibration analysis by an internationally renowned lab was carried out –Extra weights were installed to control vibration
- ➤ 3 similar projects having 33 DG sets under erection in Pakistan had to review contracts and redesign.
- ➤ Design fault was not covered in project insurance Supplier compensated

Improper Design Change





Short-circuiting marks and broken winding wires in Stator

Broken winding wires in Stator



Improper Design Change





Crack developed in welding of stator foot



> 130 MW HYDEL POWER PROJECT LOCATED IN NORTHERN PAKISTAN

- ➤ 2 Project sites Weir Site on Duber river and Power house on Indus river
- Connected by 9 tunnels
- Loss occurred due to unprecedented rainfall and flooding/land-sliding in July 2010
- Cofferdam overtopped
- Claimed loss Rs 2.3 billion (US\$ 28.75 m)
- ➤ Claim settled at Rs 750 million (US\$ 9.4 m)
- Approx 100 workers lie buried under debris, including 40 Chinese Engineers and workers.











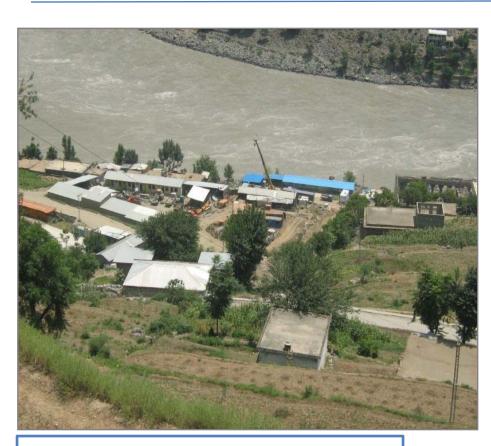


Stilling basin before landslide

Stilling basin after landslide







Campsite before landslide

Campsite after landslide



Since introduction of CCGT IPPs in Pakistan from 2007 onwards, a no of large losses in these plants have occurred which has created a requirement for new areas of expertise in Insurance and loss adjusting fraternity – it is now sufficiently available!

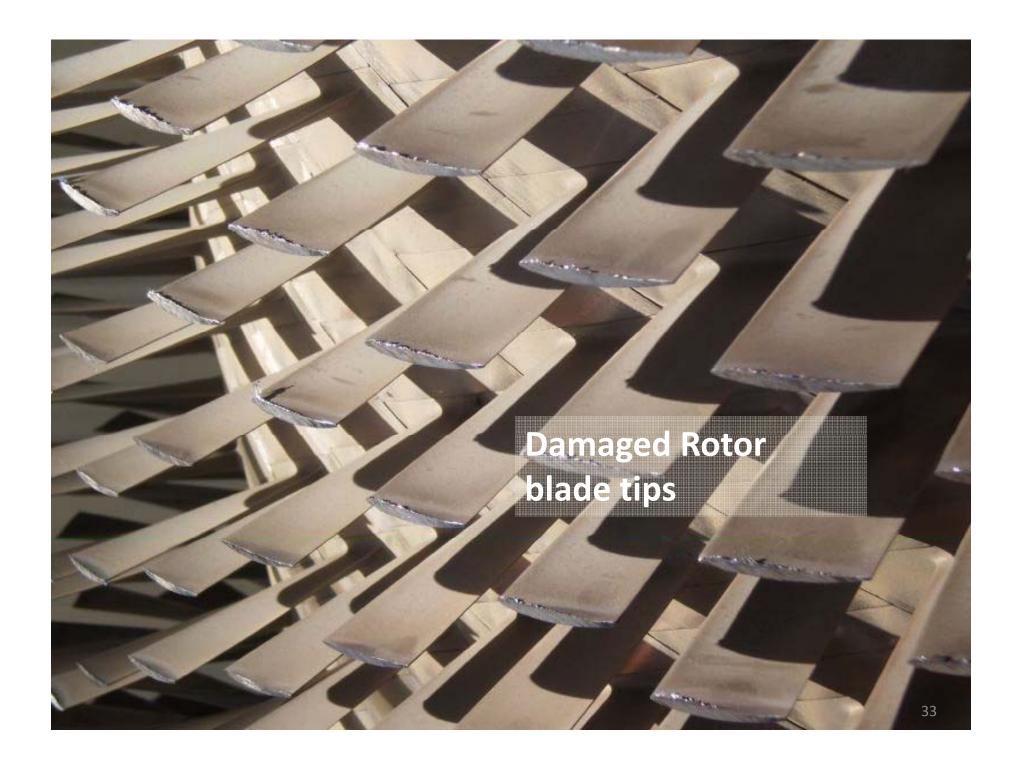
Human Error During Commissioning



> IPP Gas Turbine Rotor damage – EAR / DSU

- ➤ Human Error during commissioning. Operator closed the lubrication system by mistake during commissioning.
- ➤ Rotor blades, Stator Vanes, Rotor shaft damage
- ➤ Property damage US\$ 6.9 m
- ➤ DSU US\$ 3 million
- Turbine remained out of service for 4 months





Poor Intake Filtration System



> RPP Gas Turbine Compressor Blade & Shaft damage – MBD/ BI (ppr)

➤ Poorly designed air intake filter system. Blade fouling and damage to stages

> Property damage US\$ 2.1 m.

> Business Interruption - Nil

Compressor Blade Failures – Gas Turbines

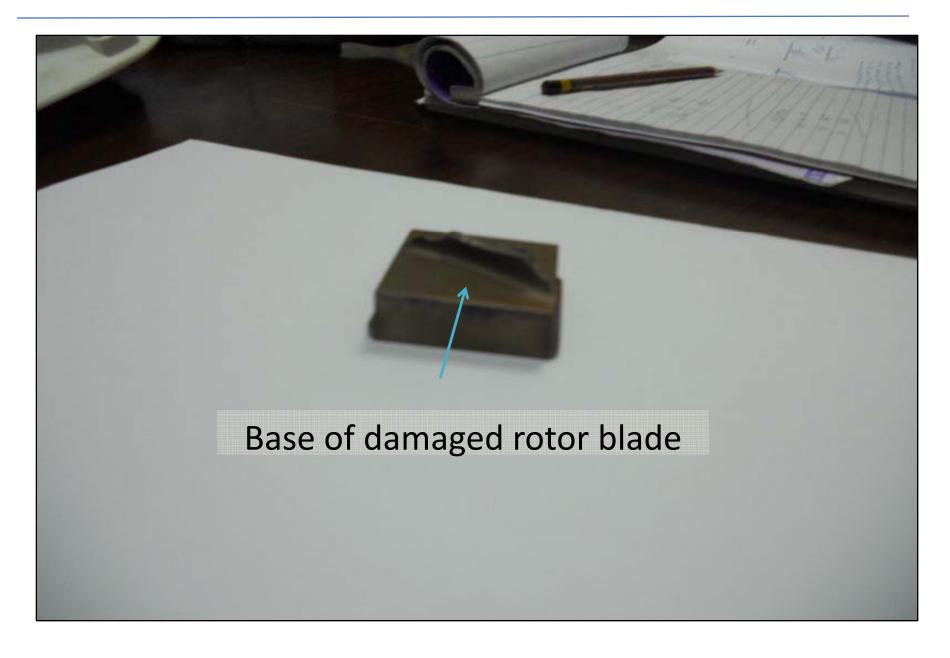


> 220 MW Combined Cycle Gas Turbine IPPs – Compressor Damage

- > 8 x 6FA GE Turbines are installed in 4 CCGT power plants in Pakistan
- ➤ 6 of these have suffered damages to their compressors since 2012 whilst in operational phase.
- ➤ Property Damage range USD 500,000 to USD 10 million.
- ➤ Business Interruption USD 700,000 to USD 2 million
- ➤ Interruption periods 1 to 4 months
- ➤ Root cause in some cases stress corrosion cracking of 1 blade leading to subsequent damagesFurther investigations in progress.

Typical Compressor Damage - 6FA Turbines





Damaged Stator Blades





Damaged Rotor Blades







What new can we expect in Pakistan due to new technologies emerging???



Wind Turbine Damage due to Windstorm

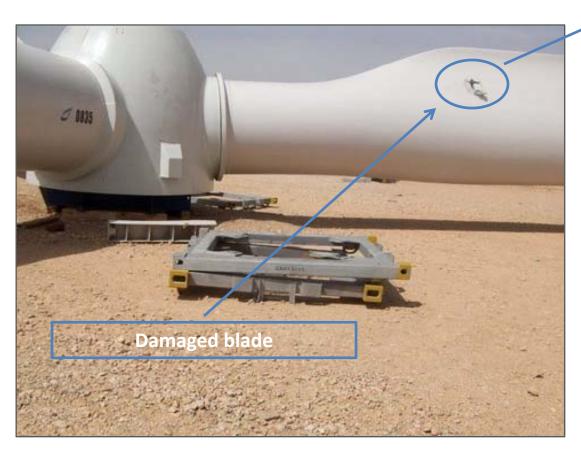


> IPP 50 Mw- Wind Turbine blade damage – EAR

- ➤ Blade damaged during erection
- ➤ Turbine was lying on the ground when sudden windstorm lifted it and resulted it in hitting against the crane.
- ➤ PD Rs 20 million
- ➤ BI Nil (spare blade was available)

Wind Turbine Damage due to Windstorm







adasffsaffaas

Wind Turbine Damage due to Over Speeding



- ➤ Wind Turbine Mechanical Damage during Operation- loss occurred in Europe but showing what we can expect in future in Pakistan
 - ➤ Due to problems with the control system of the pitch system the turbine went over speed.
 - ➤ Damaged parts. Nacelle (repairable), 3 blades, upper section of the tower, foundation
 - Estimated costs. 600.000 Euro. Plus business interruption.

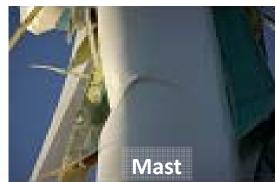
Wind Turbine Damage due to Over Speeding











Windstorm Damage to Solar Park



> Solar Park Typical Windstorm Damages (Europe)

- ➤ What happens when proper safety precautions are not taken with regard to maximum possible wind speeds.
- > Substantial damage to the photo voltaic cells and structure.
- > Claim figures not available.

Windstorm Damage to Solar Park





Damaged Solar Module & Structure Eg 1

Damaged Solar Module & Structure Eg 2



Lessons & Takeouts



- Continual professional development and training for Loss Adjusters required due to changing technologies and newer insurance products
- ➤ Use of experts tend to mitigate large losses
- Return period based design calculations need to be revisited for NAT CAT.
- Project delays always increase exposure for underwriters
- Regular follow up by Insurers and Risk surveys are always helpful

