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System Failure Analysis in Hydro Power Plant

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ABSTRACT: The main objective of this work is to develop applicable quantitative method for identifying critical components of system in power generating plant. This paper describes the analysis of major failure of hydro turbine, generator and transmission system which is unable to deliver the power. So, the use of fault tree analysis as one method of analyzing the reliability of these complex systems.

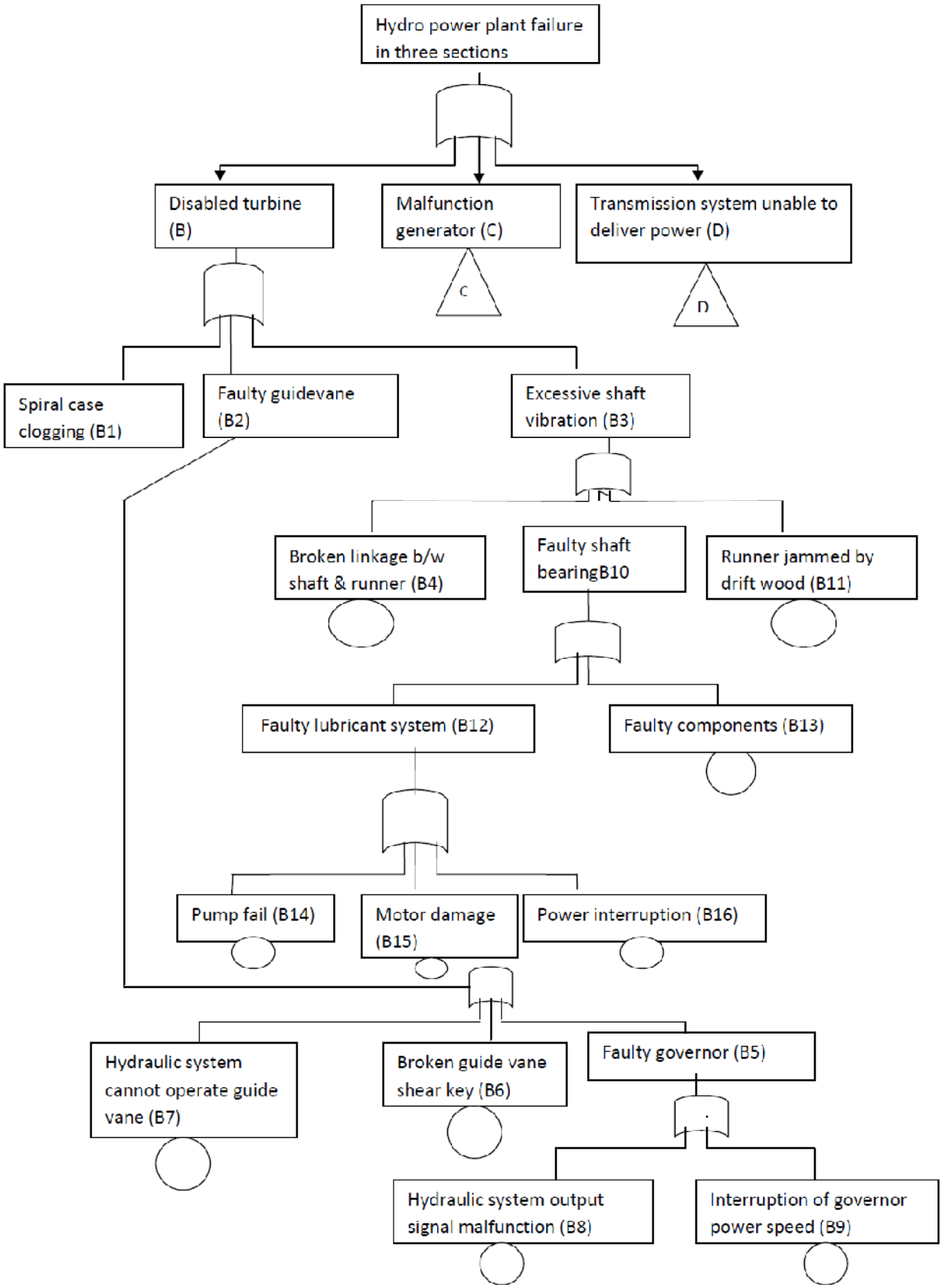
Keywords: Fault tree analysis, Hydro Power Plant, Transmission system

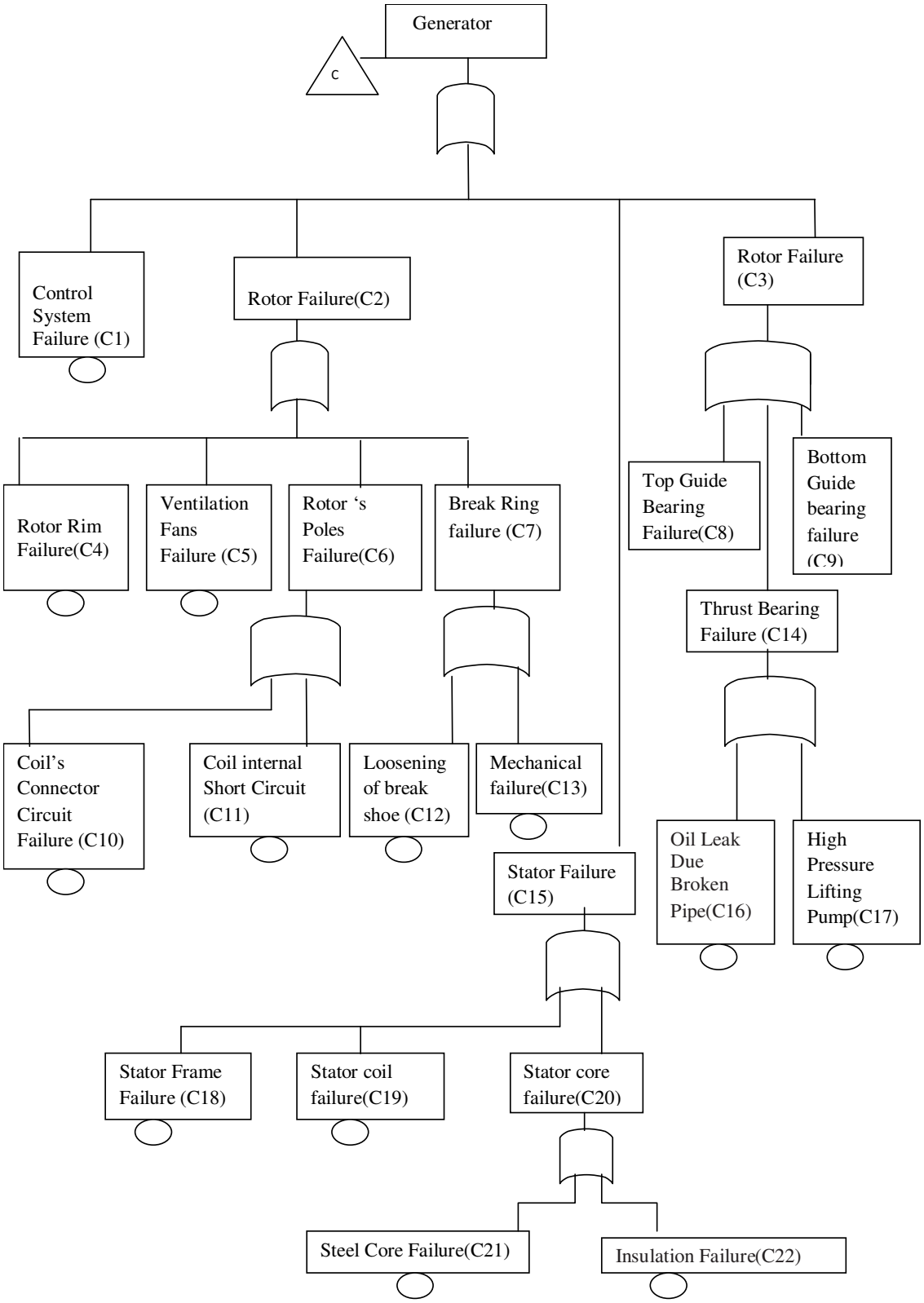
I. INTRODUCTION

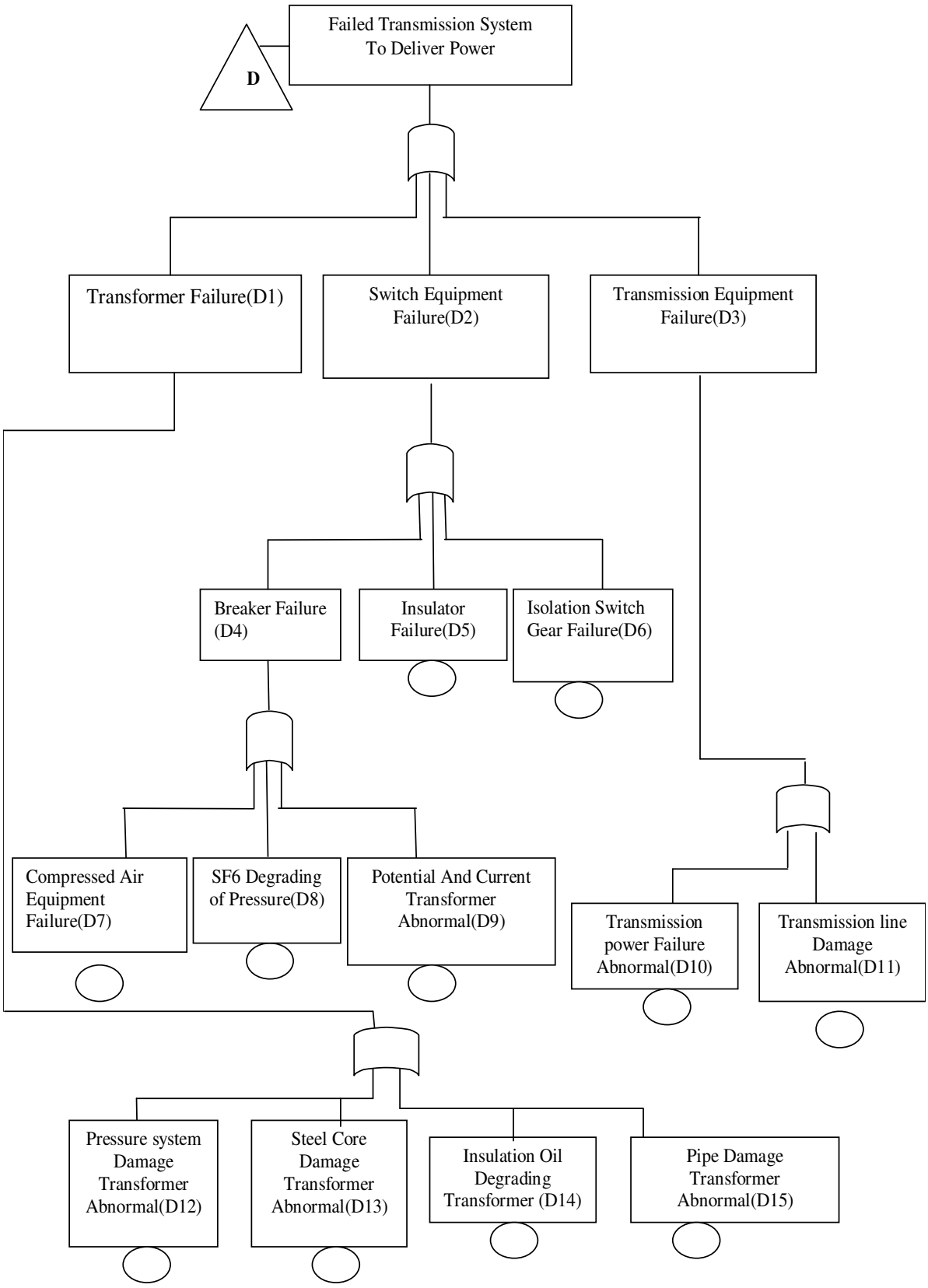
Hydro power plant has traditionally been considered to consist of three sections turbine, generator and transmission system. Information about cracks and failure of turbine, generator and transmission system is generally kept confidential by the plant management and by the machine manufacturer; therefore not all the cases have been reported and analyzed in literature, especially in the recent years. Catastrophic failure in hydro power plant are rare, mainly due to fact that main problem during operation are related to cavitations, erosion and material defect. The transmission system is constantly subjected to failure in its interconnected components, for example lighting, storms, human errors or aging equipments. Every failure has a major effect on economy due to loss of productive hours, man hour losses. Therefore for losses in production, corrective and preventive action should be taken. In order of this, hazard identification can play an important role. In order to reduce the probability, frequency and duration of failure events and reduce its effect, it is necessary to perform financial investments in direction to increase the system reliability. Fault tree analysis have been successfully applied in many kinds of technical processes to improve operation reliability and safety.

II. MATERIAL AND METHOD

Fault tree analysis is a systematic deductive procedure used to identify the basic causes of a fault event. The method is deductive because it starts from a single fault at the top of a flow chart and expands out and downward to identify the many contributing causes to that single top fault. Thus the method proceeds from one event to many events. Many fault conditions would be identified and then these conditions would be evaluated to find how they might connect to generate an undesired event. Fault trees are the model which is developed with the help of logic gates and the effect and cause relationship. Fault tree analysis have a cut sets which help to the actual cause of failure, we apply this technique on turbine and generator of power generating plant and hence find the probability of failure. Fta is often used to generate: 1) Qualitative description of potential problems. 2) Quantitative estimates of failure frequencies. 3) Suggested actions to reduce risk. 4) Quantitative evaluations of recommendation effectiveness.


Hydro power plant failure in three sections
Disabled turbine (B)
Malfunction generator (C)
Transmission system unable to deliver power (D)
C
D
Spiral case clogging (B1)
Faulty guidevane (B2)
Excessive shaft vibration (B3)
Broken linkage b/w shaft & runner (B4)
Faulty shaft bearingB10
Runner jammed by drift wood (B11)
Faulty lubricant system (B12)
Faulty components (B13)
Pump fail (B14)
Motor damage (B15)
Power interruption (B16)
Hydraulic system cannot operate guide vane (B7)
Broken guide vane shear key (B6)
Faulty governor (B5)
Hydraulic system output signal malfunction (B8)
Interruption of governor power speed (B9)


Generator
c
Control System Failure (C1)
Rotor Failure(C2)
Rotor Failure (C3)
Rotor Rim Failure(C4)
Ventilation Fans Failure (C5)
Rotor 's Poles Failure(C6)
Break Ring failure (C7)
Top Guide Bearing Failure(C8)
Bottom Guide bearing failure (C9)
Thrust Bearing Failure (C14)
Coil's Connector Circuit Failure (C10)
Coil internal Short Circuit (C11)
Loosening of break shoe (C12)
Mechanical failure(C13)
Oil Leak Due Broken Pipe(C16)
High Pressure Lifting Pump(C17)
Stator Failure (C15)
Stator Frame Failure (C18)
Stator coil failure(C19)
Stator core failure(C20)
Steel Core Failure(C21)
Insulation Failure(C22)


Failed Transmission System To Deliver Power
D
Transformer Failure(D1)
Switch Equipment Failure(D2)
Transmission Equipment Failure(D3)
Breaker Failure (D4)
Insulator Failure(D5)
Isolation Switch Gear Failure(D6)
Compressed Air Equipment Failure(D7)
SF6 Degrading of Pressure(D8)
Potential And Current Transformer Abnormal(D9)
Transmission power Failure Abnormal(D10)
Transmission line Damage Abnormal(D11)
Pressure system Damage Transformer Abnormal(D12)
Steel Core Damage Transformer Abnormal(D13)
Insulation Oil Degrading Transformer (D14)
Pipe Damage Transformer Abnormal(D15)

Cut sets are the key product, produced by FTA. Here we have taken, the cuts sets of faulty guidevane (B2). The cut sets of faulty guidevane are B6,B7,B8 and B9. Let, Failure Probability based on the failure time per (100) hrs.

Therefore, As per OR gate expansion formula

Cut Sets

B5 = B8 + B9

B2 = B5 + B6 + B7

= B8 + B9 + B6 + B7

Probability based on the failure time per (100) hrs....

As per OR gate expansion formula

$P(B5) = P(B8) + P(B9)-[P(B8,B9)]$

$= 3 \times 10^{-6} + 2 \times 10^{-6} - (3 \times 10^{-6} \times 2 \times 10^{-6})$

$= 4.99 \times 10^{-6}$

$P(B2) = P(B5) + P(B6) + P(B7)[P(B5,B6) + P(B6, B7) + P(B7, B5)] + P(B5,B6,B7)$

$= 4.99 \times 10^{-6} + 2 \times 10^{-7} + 2 \times 10^{-6}[4.99 \times 10^{-6} \times 2 \times 10^{-7} + 2 \times 10^{-7} \times 2 \times 10^{-6} + 2 \times 10^{-6} \times 4.99 \times 10^{-6}] + [4.99 \times 10^{-6} \times 2 \times 10^{-7} \times 2 \times 10^{-6}]$

$= 7.189 \times 10^{-6}$

Table showing the failure probability of various cuts sets during 100 hrs working

S.No	TEXT/NAME	FAILURE PROBABI-LITY	EXTE NSIN NAME
1.	Faulty guidevane	7.189×10^{-6}	B2
2.	Faulty governor Hydraulic system output signal	4.99×10^{-6}	B5
3.	malfunction	3×10^{-6}	B8
4.	Interruption of governor power speed	2×10^{-6}	B9
5.	Broken guide vane shear key	2×10^{-7}	B6
6.	Hydraulic system cannot operate guide vane	2×10^{-6}	B7

III. CONCLUSION

Fault tree analysis is a useful technique to define root causes of a fault event such as failure of critical components of the system i.e. turbine, generator and transmission system which is unable to deliver the power. The technique FTA has great importance for evaluation of potential failures in the system. They proportionate objective analysis to system project. The quantitative analysis made possible the determination of the most influential root causes of this event.

Methodology (FTA) concluded that the cut sets we have found along with their probabilities can plays a major part in the failure of the system i.e. turbine, generator and transmission system. The failure of any part of the system can cause due to the various reasons we have taken into account.

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