Chapter 5

Data Collection for Fault Analysis of Drag System

5.1 Introduction

The drag system is identified as the most critical component of the dragline from the FMECA study. This chapter contains detailed information about the drag system of dragline. The cause of possible failure of the drag system, its symptoms and faults are also described. The data collection and the classification of various states of cause, symptom and fault of the drag system are also described along with their threshold values.

5.2 Drag System: A Subsystem of Dragline

The drag system is mounted on the rotating frame inside the house of the dragline. The drag drum closest to the front of the machine house is used to hold the drag ropes when reeling in and paying out when the bucket moves toward the machine. The outer look structure of the drag system is shown in Figure 5.1. The schematic diagram of outer look structure of the drag system is depicted in Figure 5.2.

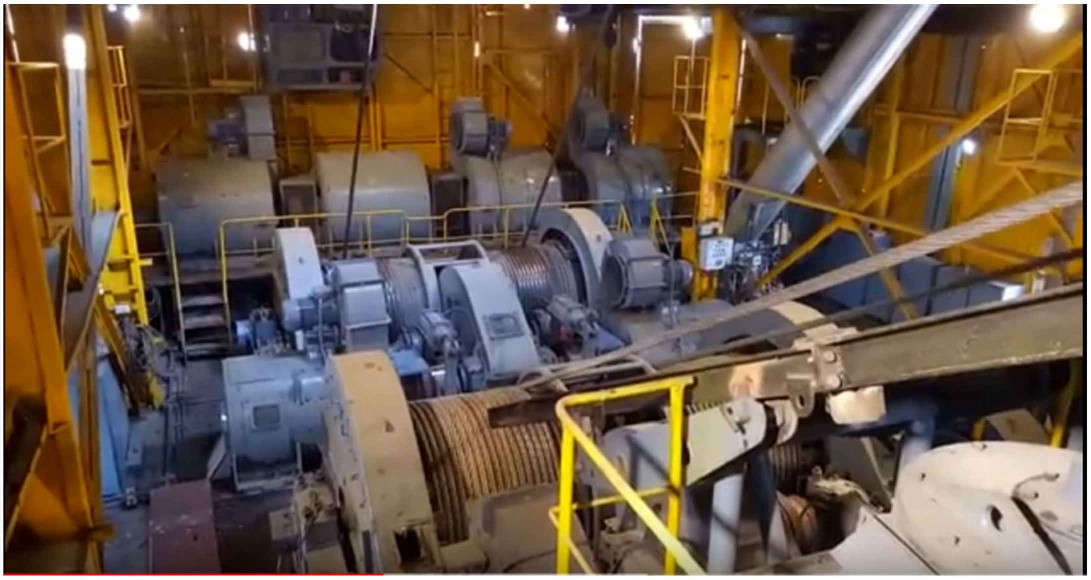

Figure 5.1. Outer look structure of the drag system

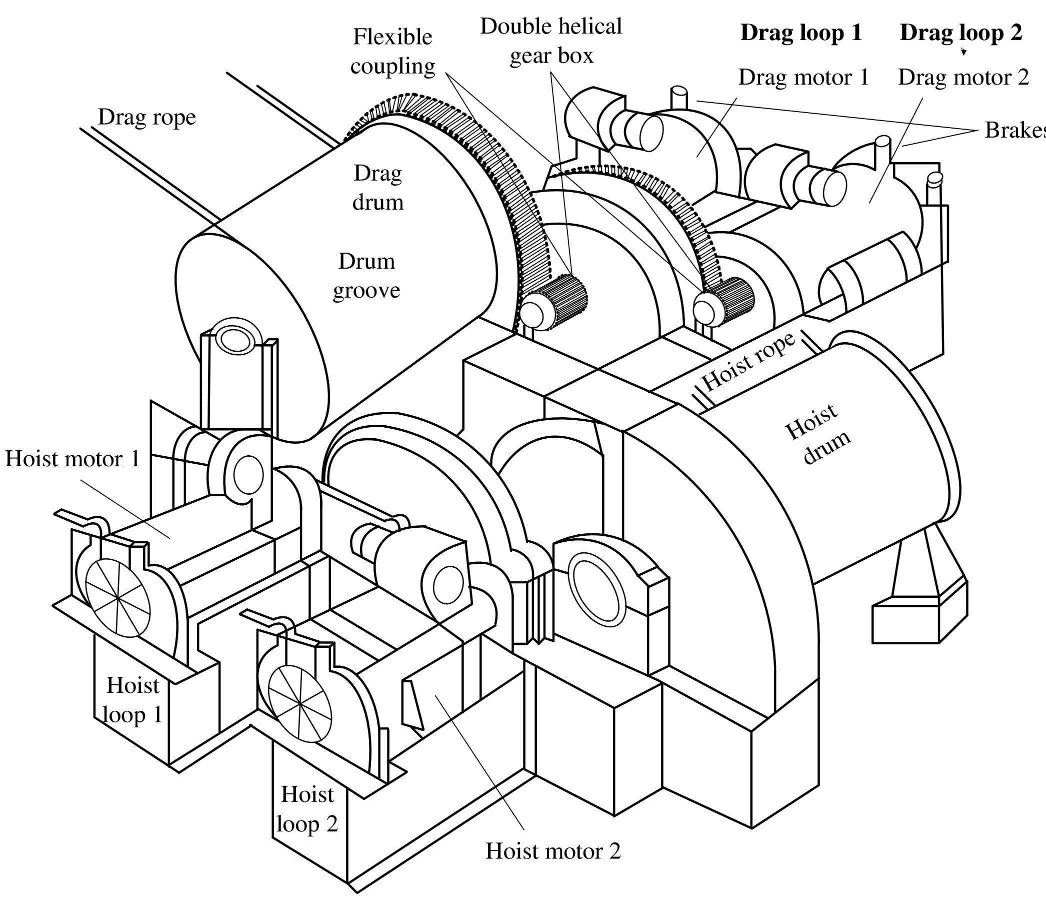

Figure 5.2. Schematic diagram of outer look structure of the drag system (Redrafted: HEC dragline manual [64])

The variation of field current of the generator is controlled by the generator voltage, which in turn controls the speed of drag motor and can be rotated both in clockwise and counter-clockwise directions. Each motor is mounted on the rotary frame inside the house, which drives a balance double-helical gearbox through the flexible coupling to a grooved drum and parking brake control by the operator [260]. A coupling is an internally flexible device that joins the drive motors to the relevant gearboxes. Drag system consists of two loops: drag loop 1 and drag loop 2. Each loop consists of four temperature sensors, a voltmeter, and an ampere meter, as shown in Figure 5.3. The temperature feedback of each loop of the drag system is recorded from the four different places such as drive end, shunt field, common pole and common end, which is displayed on the screen.

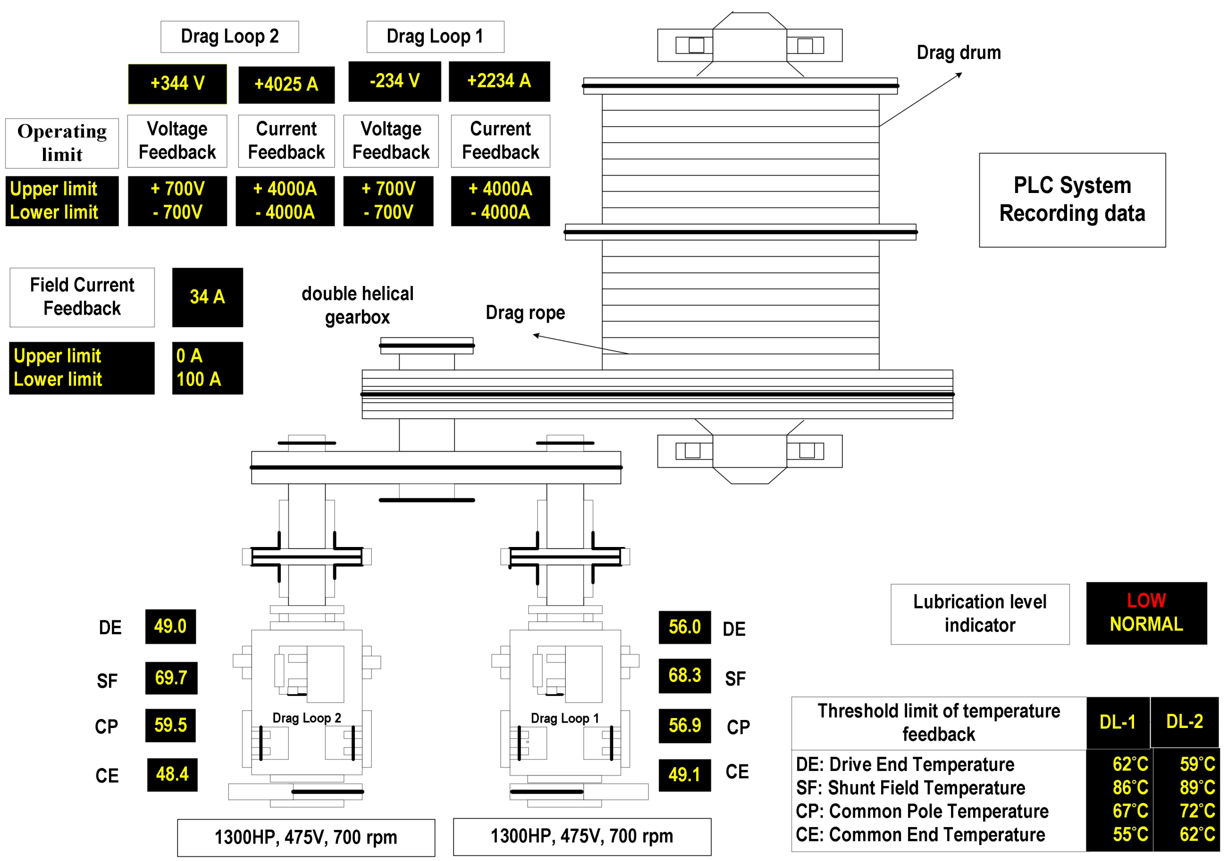

Figure 5.3 Schematic diagram of the drag system of dragline

5.3 Cause, Symptom and Fault of Drag System

The sequence of occurrence of the failure in the drag system is interlinked to its cause, symptom, and fault. The cause is the source of a symptom. There are six cause nodes considered in the drag system such as bearing and loose bolt (BLB), improper control (IC), loose connection (LC), overheating (OH), overloading (OL) and drum and coupling (DC). However, six symptom nodes are considered such as current feedback (CF), voltage feedback (VF), vibration and unwanted sound (VUS), lubrication level (LL), temperature feedback (TF), sparking (Sp) and they can be detected by the visual inspection or suitable sensors. For symptoms CF, VF, TF, LL, the threshold limit values are already defined and inbuilt in the sensor based on material, insulation type, safety parameters used during the manufacturing of machine and their threshold limit values are shown in Figure 5.3. The threshold values of vibration amplitudes of the drag system should be 0.076 mm horizontally or vertically (maximum possible vibration amplitude during normal operation) defined by the manufacturer, and it is continuously recorded in the inbuilt sensor in the drag system [11]. On the other hand, the symptom sparking is a condition monitoring based parameter identified by visual inspection or by the smell due to burning of insulation of wire that occurs due to loose connection, overloading or fluctuation of electric supply.

The presence of symptom in a system increases the likelihood of occurrence of a fault. When at least one characteristic property or parameter of the system is unacceptable, it is referred to as a fault, and after removing the fault, the system continues to work [11], [13]. There are four fault nodes considered, such as bearing and bolt failure (BBF), drive control problem (DCP), starting and braking problem (SBP), insulation damage (ID). If the occurrence of these faults is not repaired within the prescribed time, it may lead to failure.

5.4 Data Collection of Drag System

The cause, symptom, and fault data of the drag system of dragline were collected from the opencast coal mine located in northern India. Sensor data have been collected at every 15 min during 9th May 2014 to 22nd September 2016 for a dragline starting from its commissioning till 7267:30 EHMR (Engine Hourly Machine Rate). A total of 29070 data were recorded. The collected data from sensors, logbooks, and visual inspection have been transformed into categorical data based on their threshold limit. The collected data for causes, symptoms and faults were converted into two categories (1 and 0): '1' refers to the value that exceeds the threshold limit, and '0' signifies that the sensor data lies within the threshold limit. The dataset was divided into two groups: Testing dataset that refers to the machine HMR 00:00 to 5590:30 during 9th May 2014 to 25th September 2015 as presented in Table 5.1(a), and validation dataset that belongs to the machine HMR 5590:45 to 7267:30 and the time frame was between 26th September 2015 to 22nd September 2016, as presented in Table 5.1(b).

Table 5.1. Fault analysis data of the drag system of dragline

(a)Testing dataset (Machine EHMR 00:00 to 5590:30) 9 May 2014 to 25 September 2015

Sl. No.	EHMR	Cause						Symptom																Fault			
		BLB	IC	OL	LC	OH	DC	Current feedback (CF)			Voltage feedback (VF)		VUS	LL	Drag Loop 1 Temperature within limit or not				Drag Loop 2 Temperature within limit or not				Sp	BBF	DCP	SBP	ID
								DMC_1	DMC_2	FCF	DMV_1	DMV_2			CF_1	CP_1	DE_1	CE_1	CF_2	CP_2	DE_2	CE_2					
1.	00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.	00:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.	00:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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184	46:00	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22362	5590:30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(b) Validation dataset (Machine HMR 5590:45 to 7267:30) 26 September 2015 to 22 September 2016

Sl. No.	EHMR	Cause						Symptom																Fault			
		BLB	IC	OL	LC	OH	DC	Current feedback (CF)			Voltage feedback (VF)		VUS	LL	Drag Loop 1 Temperature within limit or not				Drag Loop 2 Temperature within limit or not				Sp	BBF	DCP	SBP	ID
								DMC_1	DMC_2	FCF	DMV_1	DMV_2			CF_1	CP_1	DE_1	CE_1	CF_2	CP_2	DE_2	CE_2					
22363	5590:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22364	5591:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22365	5591:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
23383	5845:45	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29070	7267:30	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0

5.5 Summary

The drag system is the most critical component of the dragline that contributes 50% downtime of the considered dragline. The drag system is used to hold the drag ropes when rope is reeling in and paying out when the bucket moves toward the machine. The occurrence of failure in the drag system is interlinked to its cause, symptom, and fault. There were six cause, six symptom, and four fault nodes of the drag system for fault analysis. The cause, symptom, and fault data of the drag system were collected from the sensor, logbook, and visual inspection, and it is generated at every 15 min. A total of 29070 data was recorded. The variables of the data were classified as ‘0’ or ‘1’ based on their threshold limit values. These data are used for fault analysis using BN model as described in Chapter 6 for fault inference, and using ANN model as described in Chapter 7 for classification based fault analysis.