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TROUBLESHOOTING OF RAW MATERIAL HANDLING IN BAGASSE PULPING

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ABSTRACT

Due to foreign materials, the agitator bearing and shaft bending are reduced by using a stuffing box in the agitator between the bearing unit and impeller. The foreign materials in the bagasse wet washing are collected by using SS Pivot Needles/Bars in the wet washing system. The vibrations which cause damage (cracks) in the pump pipeline are reduced by using rubber bellow between the pump and delivery pipeline. The rubber bellow absorbs the vibration and deflections, which protects the pump and pipeline from damage. Earlier, the foreign materials were stuck up in the pump impeller. These foreign materials were removed by dismantling the entire pump set-up. In the current work, the design of suction line has been altered by introducing an inspection dummy. At the end of the suction line, through a new design, the foreign materials were moved off from the pump impeller easily by removing the inspection dummy instead of dismantling the entire pump set-up. Through the new design, the efficiency of the wet washing plant has been increased up to 55%. Further, the downtime of the wet washing plant is also reduced, and equipment availability has been increased.

Keywords: *Bagasse, Vibration, Impeller, Rubber bellow and Foreign materials*

1. Introduction

Generally, Bagasse is the dry pulpy fibrous residue that remains after sugarcane or sorghum stalks are crushed to extract their juice. It is used as a biofuel to produce heat, energy, electricity and in the manufacture of pulp and building materials [1]. Bagasse is shown in Fig.1. Agave bagasse is a similar material that consists of the tissue of the blue agave after extraction of the sap.

Fig. 1 Bagasse

For every 10 tons of sugarcane crushed, a sugar factory produces nearly three tons of wet bagasse. Since bagasse is a by-product of the cane sugar industry, the quantity of production in each country is in line with the amount of sugarcane produced. The high moisture content of bagasse, typically 40–50 %, is detrimental to its use as a fuel. In general, bagasse is stored before further processing [2, 13, and 14]. For electricity production, it is kept under moist conditions, and the mild exothermic process that results from the degradation of residual sugars dries the bagasse pile slightly. For paper and pulp production, it is usually stored wet to assist in removing the short pith fibres, which impede the paper making process and remove any remaining sugar. Bagasse is a heterogeneous material containing around 30-40 percent of "pith" fibre, which is derived from the core of the plant and is mainly parenchyma material, and "bast", "rind", or "stem" fibre, which makes up the balance and is primarily derived from sclerenchyma material. These properties make bagasse particularly problematic for paper manufacture and have been the subject of a large body of literature.

2. Literature Review

Packed stuffing boxes are mechanical sealing systems that are extensively used in pressurised valves and pumps. Yet, there is no standard design procedure that could be used to verify their mechanical integrity and leak tightness. It is only recently that standard test procedures to qualify the packing material have been

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suggested for adoption in North America and Europe [3]. While the packing contact stress with the side walls is predictable using existing models, there is no analytical methodology to verify the stresses and strains in the stuffing box housing. This paper presents an analytical model that analyses the stresses and strains of all the stuffing box components, including the packing rings. The developed model will be validated numerically using FEM and experimentally on an instrumented packed stuffing box rig specially designed to test the mechanical and leakage performance of different packing materials [4].

Objectives: A bellows expansion joint is an assembly of two or more bellows that help to tackle expansion or contraction in the system designed to fit in. Various independent researchers did a lot of research in the design and geometry of bellows expansion joint, but a review of all is scarce. The different possible features of bellows design have been presented in this paper. Methods/Analysis: The bellows, consisting of one or more convolutions, are designed to offer further agility in the configuration of piping structures and pressure vessel applications involving thermal expansion and relative movement in the system. Numerous researchers have conducted studies on bellows expansion joints with the help of standards such as ASME and EJMA [5, 6]. They have wide applications and are understood as significant. Thus various parameters of the design of bellows expansion joints, which affect the system's characteristics, have been reviewed. Findings: From this review, it can be said that for all the design conditions, there was no bellow geometry or design parameters are superior. Under such designs based on the standards, it is expected to perform exhaustive analysis involving sound engineering judgment. Meanwhile, the choice of bellows expansion joint is sufficiently broad depending upon the applications [7, 8].

The opportunity to increase the fuel value of bagasse by drying during storage is worth pursuing. Judging from the Bagatex-20 process, this could be achieved by simultaneously building multiple piles of bagasse ‘chunks’ (produced by a continuous baler) such that each layer dries for 7-10 days before being covered by another layer. The space between chunks would assist with initial ventilation, but most of the bagasse would be sufficiently compacted to restrict access to oxygen [9, 10]. The electrically driven stationary baler would reduce costs of pile compaction and stacking and would minimize dust. Significant environmental challenges exist and require early recognition and planning. The likely difference in behaviour of diffuser bagasse (compared to mill-run bagasse) needs to be recognised – the possible benefit of adding sugar and bacteria to this bagasse before storage requires investigation [11, 12].

3. Problem Identification

3.1 Chemical Bagasse Plant

Bagasse from the storage bins is fed into a digester to which chemicals have been added. The bagasse is then ‘cooked’ to remove lignin. Lignin is the binding material that holds the cellulose fibres together. The chemical process is energy self-sufficient as nearly all by-products can be used to fire the pulp mill power plant.

3.2 Major Problems in Chemical Bagasse

The following problems were identified in the wet washing area of the chemical bagasse plant due to foreign materials,

1. Frequent Agitators bearings failure
2. Frequent Agitators drive belts failure
3. Frequent agitators are changing (Every month, we are changing two agitators). If it fails more than two agitators, then no spare
4. Frequent bigger pump opening. While pump opening, heavy vibration from the nearby pumps and leakages creates an unsafe condition
5. Sometimes foreign materials inside the pump are not able to remove (Being removed by using chain block)
6. Frequent bigger pump delivery lines cracking
7. Valve - stub end failures
8. Instrument ON-OFF valve failures
9. On the 16th night, all the reclaim cheat agitators tripped.
10. If it is stuck up in the drain line, then draining is not possible to take up the work
11. Agitator wall nozzle damages
12. While opening the pump, if jam is released suddenly, then unsafe
13. Frequent pump opening leads to ETP overload.
14. Pump bed and foundation getting weak
15. Chest wall damages.

4. Experimental Procedure

4.1 Reducing shaft bending and bearing failure in agitator using stuffing box

A stuffing box is an assembly that is used to house a gland seal. It is used to prevent fluid leakage, such as water or steam, between sliding and turning parts of machine elements. The stuffing box is shown in Fig.2. A stuffing box of a sailboat will have a stern tube that's slightly bigger than the prop shaft. It will also have packing nut threads or a gland nut. The packing is inside the gland nut and creates the seal. The shaft is wrapped by the packing and put in the gland nut. Through tightening it onto the stern tube, the packing is compressed, creating a seal against the shaft. Creating a proper plunger alignment is critical for correct flow and long wear life. Stuffing box components are of stainless steel, brass or other application-specific materials.

Fig. 2 Agitator and stuffing box

A gland is a general stuffing box used to seal a rotating or reciprocating shaft against a fluid. The most common example is in the head of a tap (faucet), where the gland is usually packed with a string that has been soaked in tallow or similar grease. The gland nut allows the packing material to be compressed to form a watertight seal and prevent water from leaking up the shaft when the tap is turned on. The gland at the rotating shaft of a centrifugal pump may be packed in a similar way, and graphite grease is used to accommodate continuous operation. The linear seal around the piston rod of a double-acting steam piston is also known as a gland, particularly in marine applications. Likewise, the shaft of a hand pump or wind pump is sealed with a gland where the shaft exits the borehole. Other types of sealed connections without moving parts are also called glands; for example, a cable gland or fitting that connects a flexible electrical conduit to an enclosure, machine or bulkhead facilitates assembly and prevents liquid or gas ingress. The stuffing box will be placed between the gear box and the agitator blade. Using a stuffing box, the damage should be avoided, and the lifetime of the agitator and bearing will increase. The efficiency also increases.

4.2 Removing of foreign materials in pump through inspection dummy

The pump continuously pumps the wed bagasse from the reclaim chest to the destoner. During that process, bagasse along with foreign material may jam the pump impeller. To remove the foreign materials in the impeller, the whole pump set-up needs to be dismantled. It takes more time. To reduce work time in the pump inspection dummy is used. If any foreign materials jam in the pump impeller, there is no need to disassemble the whole pump; stop the pump-open the inspection dummy and remove the foreign materials in the pump impeller. It is shown in Fig.3

Fig. 3 Centrifugal pump and Inspection Dummy set-up

4.3 Reduction of vibration using rubber bellow in pump

Rubber Expansion joints or rubber bellows are primarily used to absorb noise and thermal movements and remove vibration between equipment such as cooling water pumps, condensers, chillers, and their mating pipework. Their high flexibility also makes them suitable for compensating small installation misalignments. Rubber bellows can be used just like a metal expansion joint to compensate for axial, lateral or angular movement.

As with any other unrestrained expansion joint, rubber bellows will extend under pressure. Their pressure thrust varies with length as the shape of the bellows changes. However, the forces involved are just as large, and the pressure thrust should be calculated by multiplying the cross-sectional area by the maximum pressure. Tie rods should be fitted to prevent the bellows from extending, or the pipework should be anchored well. It is shown in Fig.3.

5. Result & Discussion

5.1 Root Cause Analysis

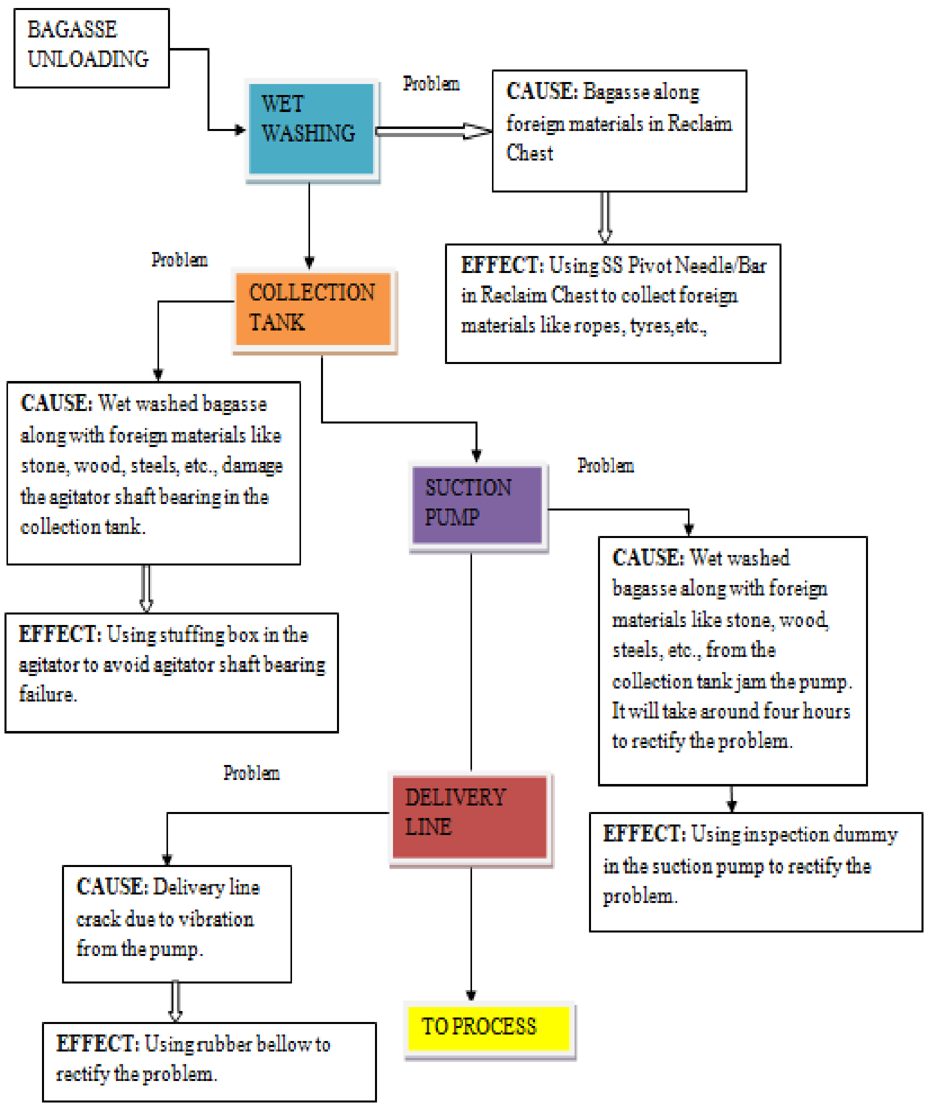


Fig. 4 Root Cause Analysis

The root cause analysis of the system is shown in Fig. 4.

5.2 FEA analysis of stuffing box using ANSYS

Design details:

Material used	: SS316
Young's modulus	: 2E5 N/mm^2
Poisson's ratio	: 0.3
Load applied	: 10 N/m^2

Stress analysis of stuffing box:

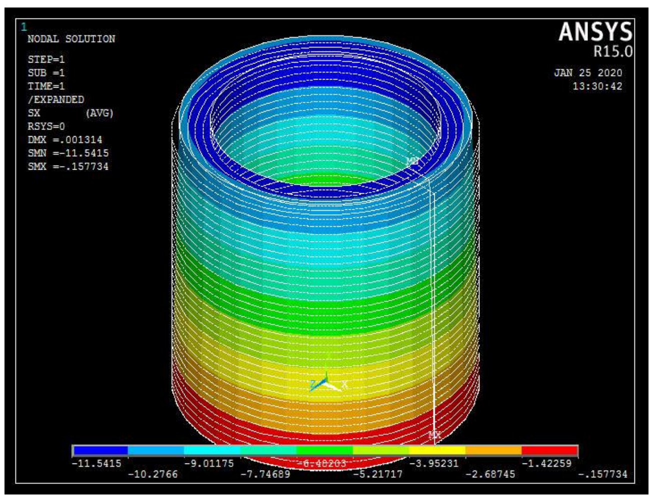


Fig. 5 Stress Analysis of Stuffing Box

Fig. 5 shows the stress concentration on the stuffing box. It is observed that the maximum stress is -0.157734 N/mm^2 and the minimum stress is -11.5415 N/mm^2.

Von-misses stress analysis of stuffing box:

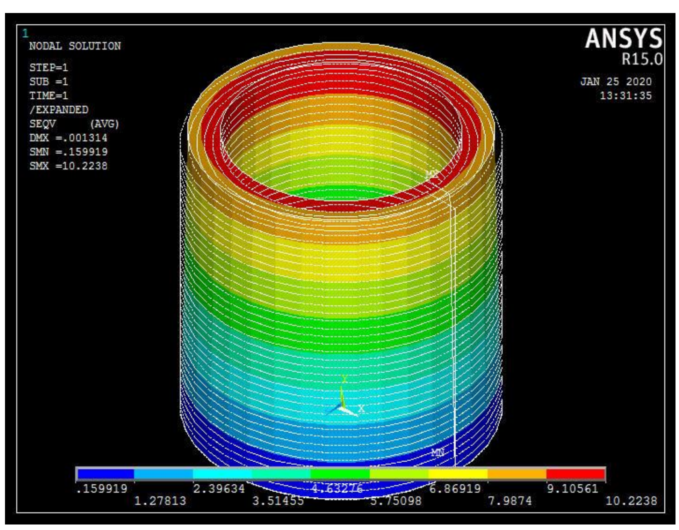


Fig. 6 Von-misses Stress Analysis of Stuffing Box

Fig.6 shows the concentration of Von-misses stress on the stuffing box. It is observed that the maximum stress is 0.159919 N/mm^2 and the minimum stress is 10.2238 N/mm^2. The maximum allowable stress for SS316 material is 137.9 N/mm^{2,} and the result values obtained are 0.157734 N/mm^2 and 0.159919 N/mm^2. Hence, the design is safe.

5.3 Overall Equipment Efficiency (OEE) Analysis

The overall equipment efficiency of the plant is calculated before and after the OEE analysis and illustrated in the following flowcharts.

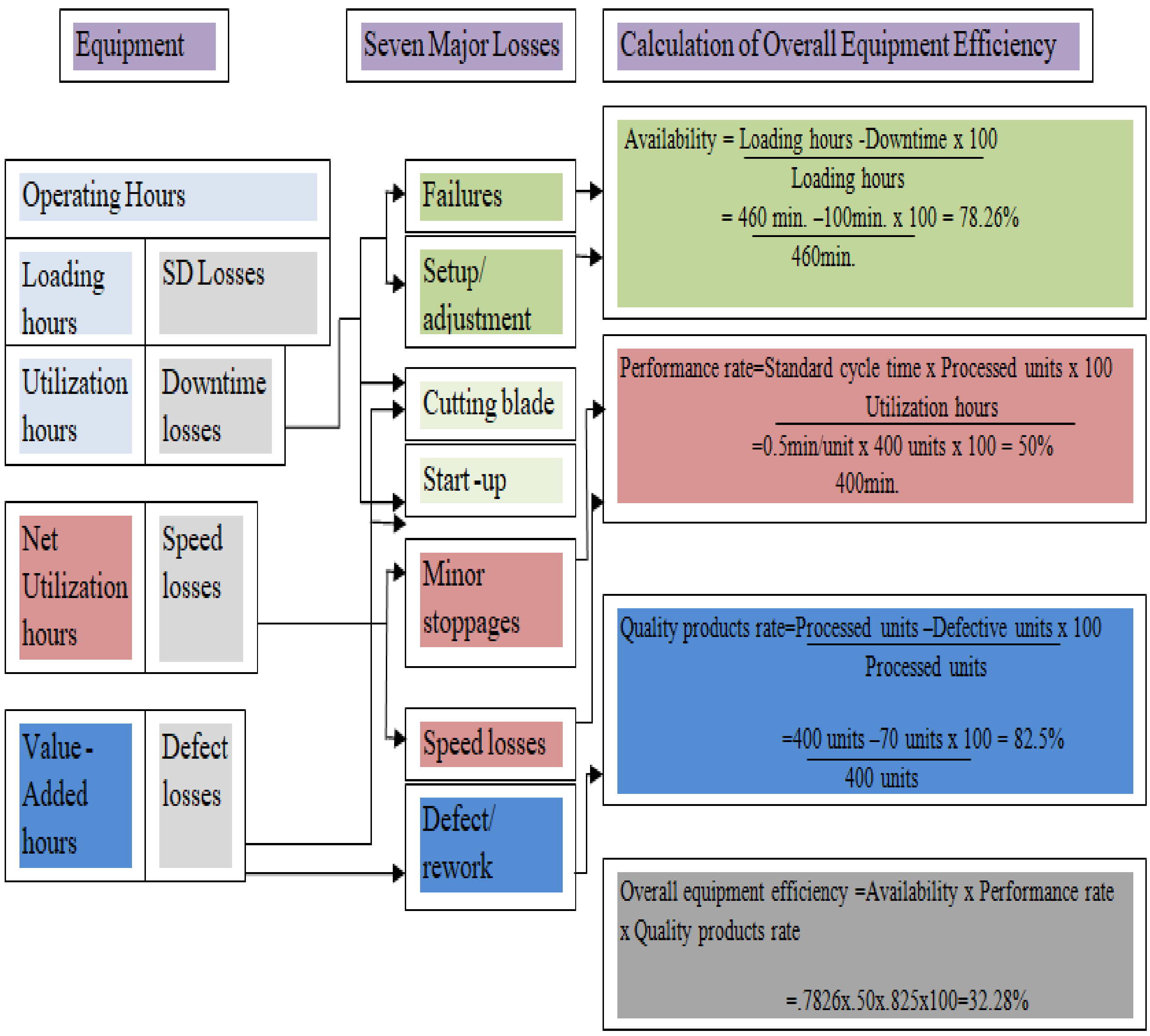


Fig. 7 Equipment efficiency before OEE

The above flow chart (Fig. 7) shows the overall equipment efficiency before implementing the project.

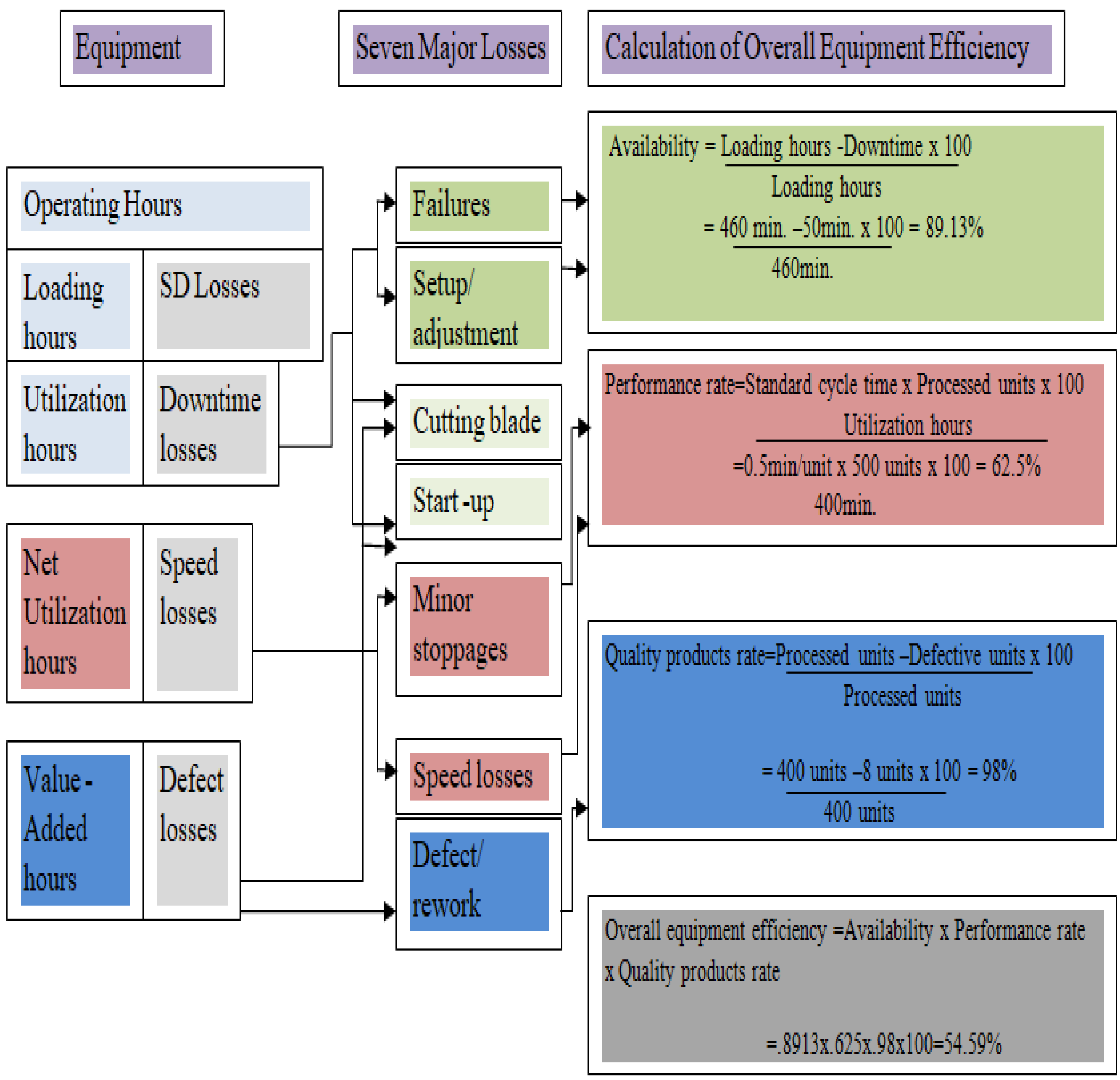


Fig. 8 Equipment efficiency after OEE

The above flow chart (Fig. 8) shows the overall equipment efficiency after implementing the project.

6. Condition Monitoring

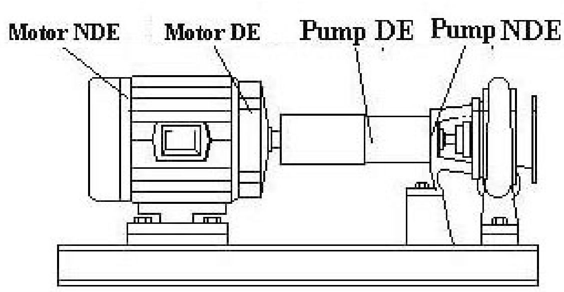
Condition monitoring of the agitator, stuffing box and collection tank pump is explained in the following contents. The results are tabulated, and the spectrum is presented in graphical form.

6.1 Condition monitoring of agitator before fixing the stuffing box

Table 1 provides the details about the significant peaks notable in the unit bearing frequency area and the relevant data before fixing the stuffing box.

Table 1 Significant Peaks Notable in the Unit Bearing Frequency Area and the Relevant Data Before fixing the Stuffing Box

Machine Name:	**RECLAIM AGITATOR**	Machine Condition	**MARGINAL**
Analysis: The spectrum indicates significant peaks in the Unit Bearing frequency area.			
Recommended Action Plan: 1. Check the Agitator NDE side bearing for any inaccuracies			



Machine Data

Machine KW	30
Machine RPM	990

As Per ISO 10816 Standard Class III

Vibration Limit	**Machine Condition**
Up to 2.8 mm/sec.	Normal
2.8 to 7.1 mm/sec.	Marginal
Above 7.1 mm/sec.	Critical

Location	*Measuring Point*	**Direction**	**SPM**		**Velocity MM/Sec(RMS)**
			Dbm	**Dbc**	
1	AGITATOR DE	Horizontal	47	37	**3.5**
		Vertical			**2.6**
		Axial			**3.5**
2	AGITATOR NDE	Horizontal	43	32	**4.0**
		Vertical			**3.6**
				Axial	**4.8**

The spectrum observed at the frequency area before fixing the stuffing box is as shown in Fig. 9.

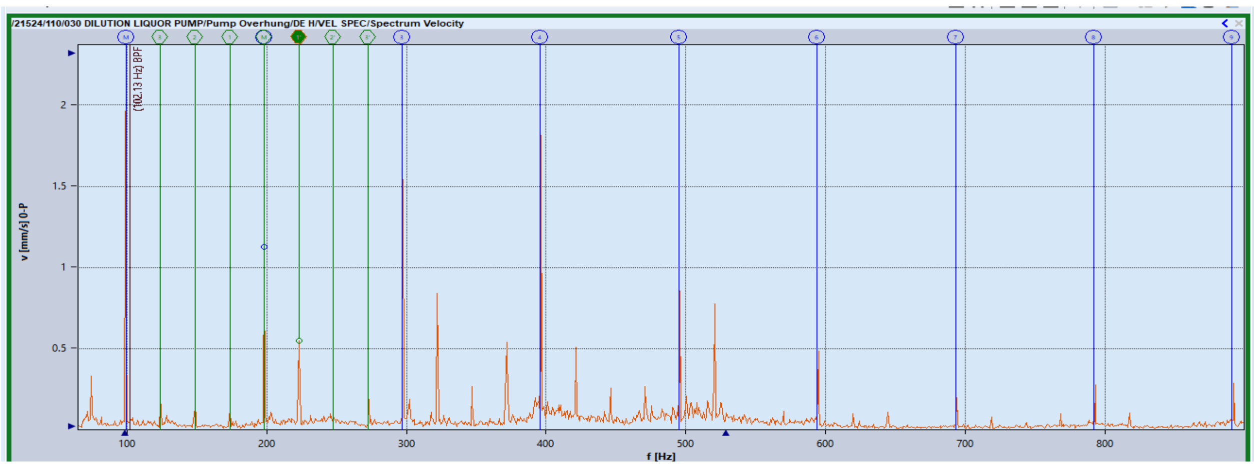


Fig. 9 Spectrum obtained before fixing the Stuffing Box

The SPM and velocity details of Agitator DE and Agitator NDE measuring points in various directions before fixing the stuffing box are presented in Table 2.

Table 2 SPM and velocity details of Agitator DE and Agitator NDE measuring points in various directions Before fixing the Stuffing Box

Location	**Measuring Point**	**Direction**	**SPM**		**Velocity MM/Sec(RMS)**
			Dbm	**Dbc**	
		Horizontal			1.7
1	AGITATOR DE	Vertical	46	34	1.0
		Axial			0.9
		Horizontal			1.9
2	AGITATOR NDE	Vertical	42	28	1.4
		Axial			1.9

The spectrum observed at the frequency area after fixing the stuffing box is as shown in Fig. 10.

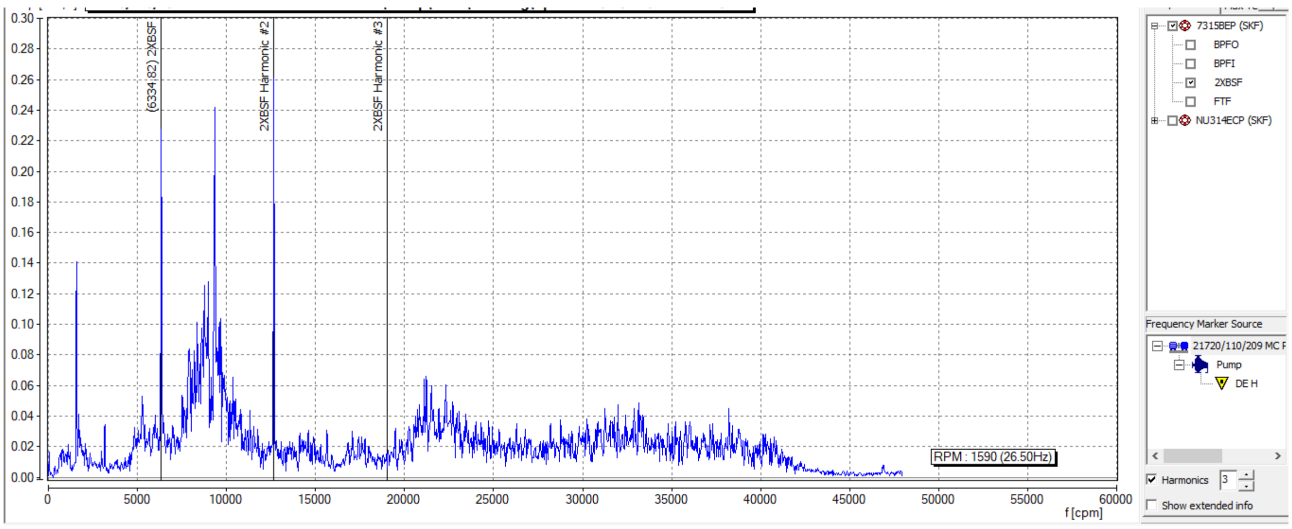


Fig. 10 Spectrum obtained after fixing the Stuffing Box

6.2 Condition monitoring of collection tank pump before fixing damper

The machine data, the SPM and velocity details of Agitator DE and Agitator NDE measuring points in various directions before fixing the damper are presented in Table 3.

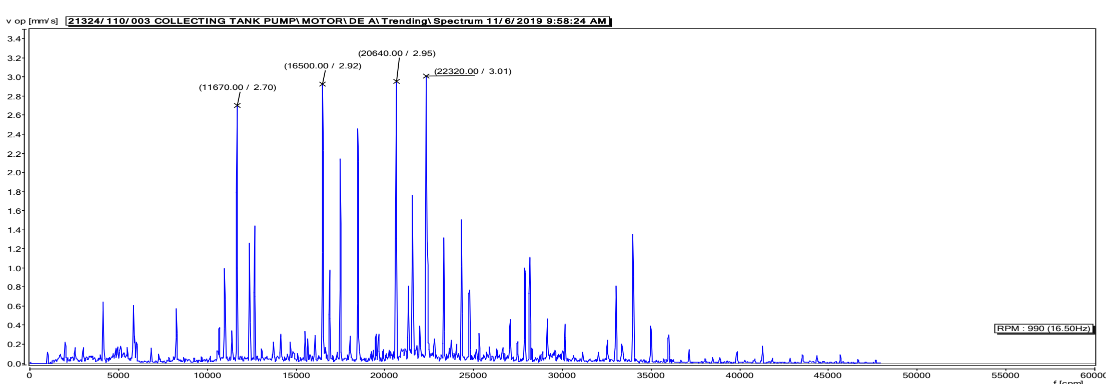


Fig. 11 Spectrum obtained before fixing the Damper

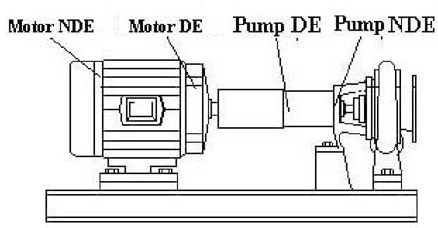
Table 3 SPM and velocity details of Agitator DE and Agitator NDE measuring points in various directions Before fixing the Stuffing Box

Machine Name:	**21324/110/003 COLLECTION TANK PUMP**	Machine Condition	**MARGINAL**

Analysis: The spectrum indicates significant peaks in the Unit Bearing frequency area.

Recommended Action Plan:

1. Check the Units for any inaccuracies and Pump Delivery line to be checked



Machine Data

Machine KW	30
Machine RPM	990

As Per ISO 10816 Standard Class III

Vibration Limit	**Machine Condition**
Up to 2.8 mm/sec.	Normal
2.8 to 7.1 mm/sec.	Marginal
Above 7.1 mm/sec.	Critical

Location	*Measuring Point*	**Direction**	**SPM**		**Velocity MM/Sec(RMS)**
			Dbm	**Dbc**	
1	MOTOR NDE	Horizontal	--	--	**2.5**
		Vertical			**2.6**
		Axial			**3.0**
2	MOTOR DE	Horizontal	--	--	**2.2**
		Vertical			**3.5**
		Axial			**6.0**
3	PUMP DE	Horizontal	42	38	**5.1**
		Vertical			**2.4**
		Axial			**3.2**
4	PUMP NDE	Horizontal	48	34	**2.0**
		Vertical			**2.4**
		Axial			**2.9**

The spectrum observed at the frequency area before fixing the damper is as shown in Fig. 11.

The machine data, the SPM and velocity details of Agitator DE and Agitator NDE measuring points in various directions after fixing the damper are presented in Table 4.

Table 4 SPM and velocity details of Agitator DE and Agitator NDE measuring points in various directions After fixing the Stuffing Box

Location	Measuring Point	**Direction**	**SPM**		**Velocity MM/Sec(RMS)**
			Dbm	**Dbc**	
		Horizontal			1.5
1	MOTOR NDE	Vertical	--	--	1.6
		Axial			1.0
		Horizontal			1.2
2	MOTOR DE	Vertical	--	--	2.0
		Axial			2.0
		Horizontal			1.1
3	PUMP DE	Vertical	44	38	1.4
		Axial			1.2
		Horizontal			1.0
4	PUMP NDE	Vertical	46	34	1.4
		Axial			0.9

The spectrum observed at the frequency area after fixing the damper is as shown in Fig. 12.

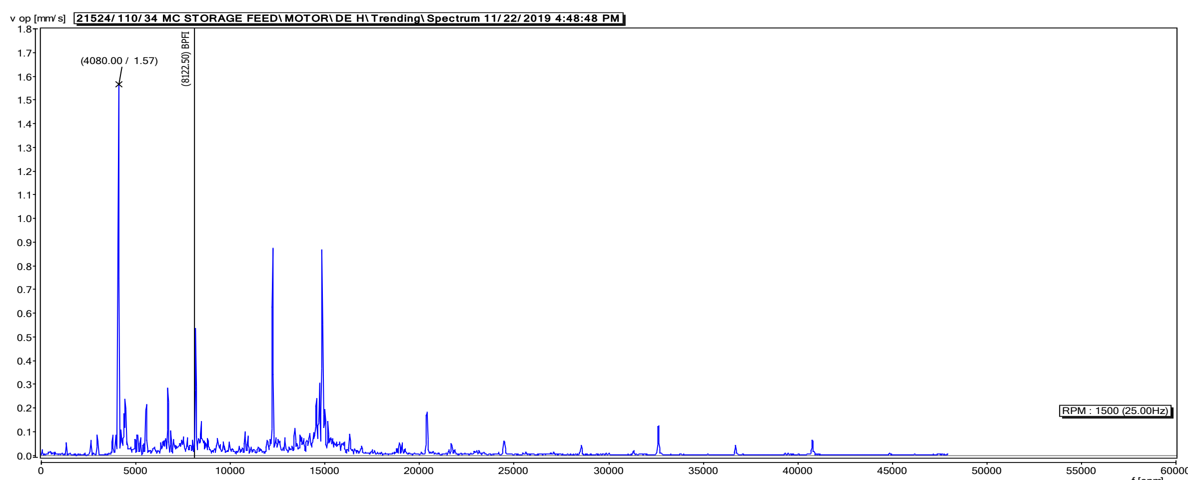


Fig. 12 Spectrum obtained after fixing the Damper

6.3 Trend before implementing project

The below table 5 shows the downtime of the plant before implementing our project.

Table 5 Downtime of the plant Before Implementing the Project

Date	Down Time (hrs)	Equipment Type	Equipment No	Equipment detail	Work
2-Nov-19	3	Pump	003-BAGASSE COLLECTION TANK PUMP -1 (NORTH)	Bed	Welded
5-Nov-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
6-Nov-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
20-Nov-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
20-Nov-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
21-Nov-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
22-Nov-19	4	Pump	134 -COLLECTION TANK PP-1	Delivery Line	Welded
22-Nov-19	3.20	Pump	002-RECLAIM CHEST PUMP -2 (MIDDLE)	Delivery Line	Welded
25-Nov-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
28-Nov-19	4	Pump	134 -COLLECTION TANK PP-1	Delivery Line	Welded
28-Nov-19	3.20	Pump	002-RECLAIM CHEST PUMP -2 (MIDDLE)	Delivery Line	Welded
5-Dec-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Stubend Leak
7-Dec-19	3.20	Pump	002A-RECLAIM CHEST PUMP -3 (WEST)	Delivery Line	Welded
9-Dec-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
12-Dec-19	3.20	Pump	002A-RECLAIM CHEST PUMP -3 (WEST)	Delivery Line	Welded
16-Dec-19	3.20	Pump	002A-RECLAIM CHEST PUMP -3 (WEST)	Suction Line	Stubend Leak

The chart shows the downtime in X-axis and downtime hours in Y-axis before implementing the project. It is shown in Fig.13.

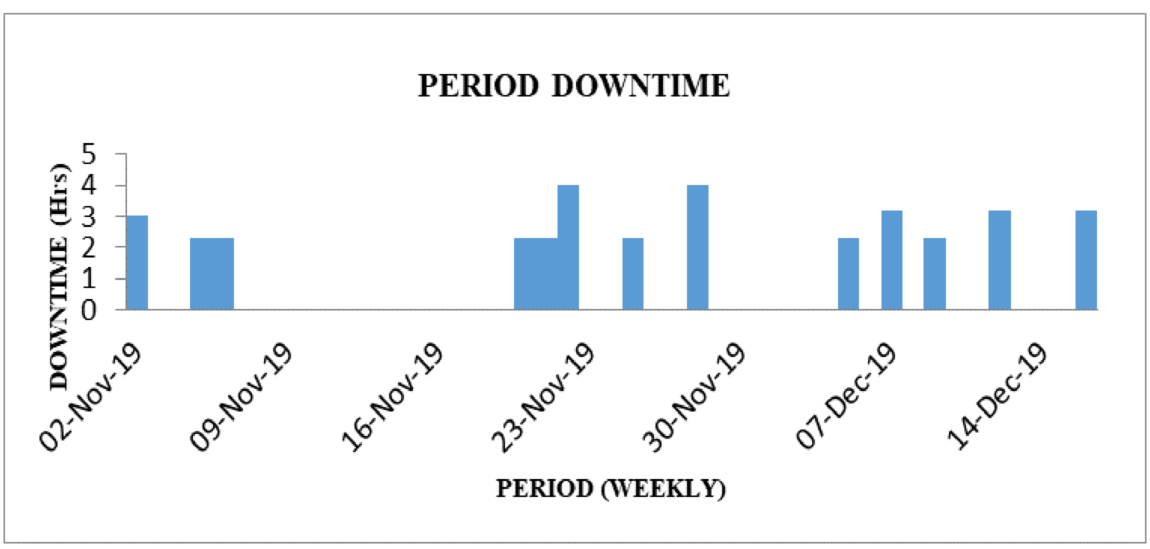


Fig.13 Downtime Chart before Implementing Project

The trend shows the downtime in the X-axis and downtime hours in the Y-axis before implementing the project. It is shown in Fig.14.

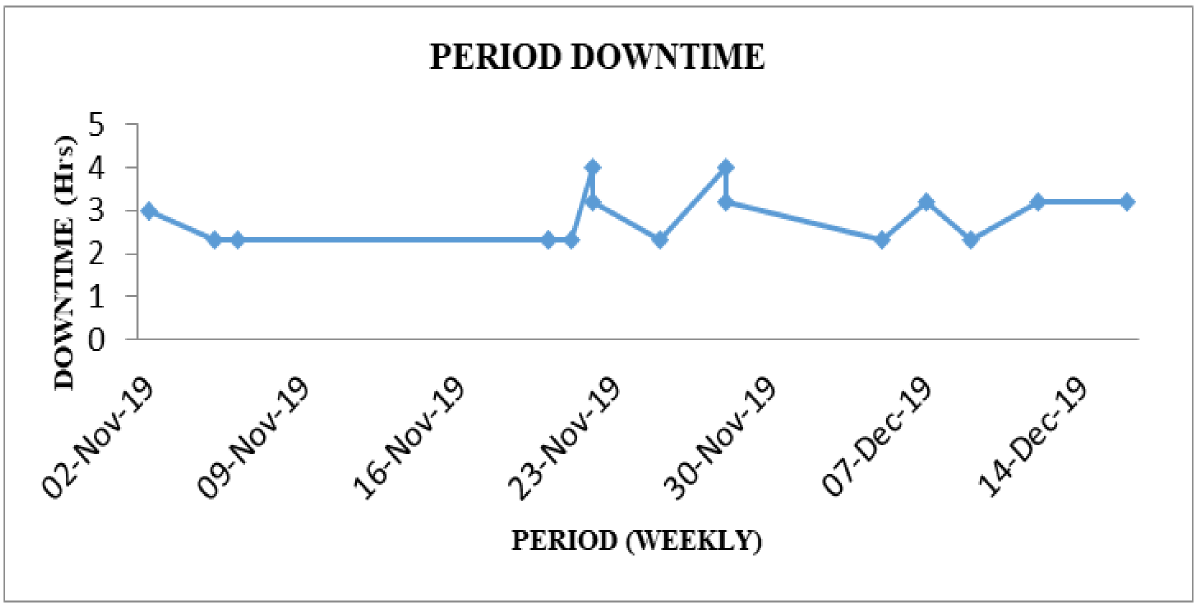


Fig.14 Downtime Trend before Implementing Project

6.4 Trend after implementing project

After implementing project, downtime of the plant is observed and presented in Table 6.

Table 6 Downtime of the plant after Implementing Project

Date	Down Time (hrs)	Equipment Type	Equipment N0	Equipment detail	Work
21-Dec-19	3.20	Pump	003-BAGASSE COLLECTION TANK PUMP -1 (NORTH)	Bed	Welded
26-Dec-19	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded
2-Jan-20	2.30	Pump	001-RECLAIM CHEST PUMP -1 (EAST)	Delivery Line	Welded

The chart shows the downtime in X-axis and downtime hours in Y-axis after implementing the project. It is shown in Fig.15.

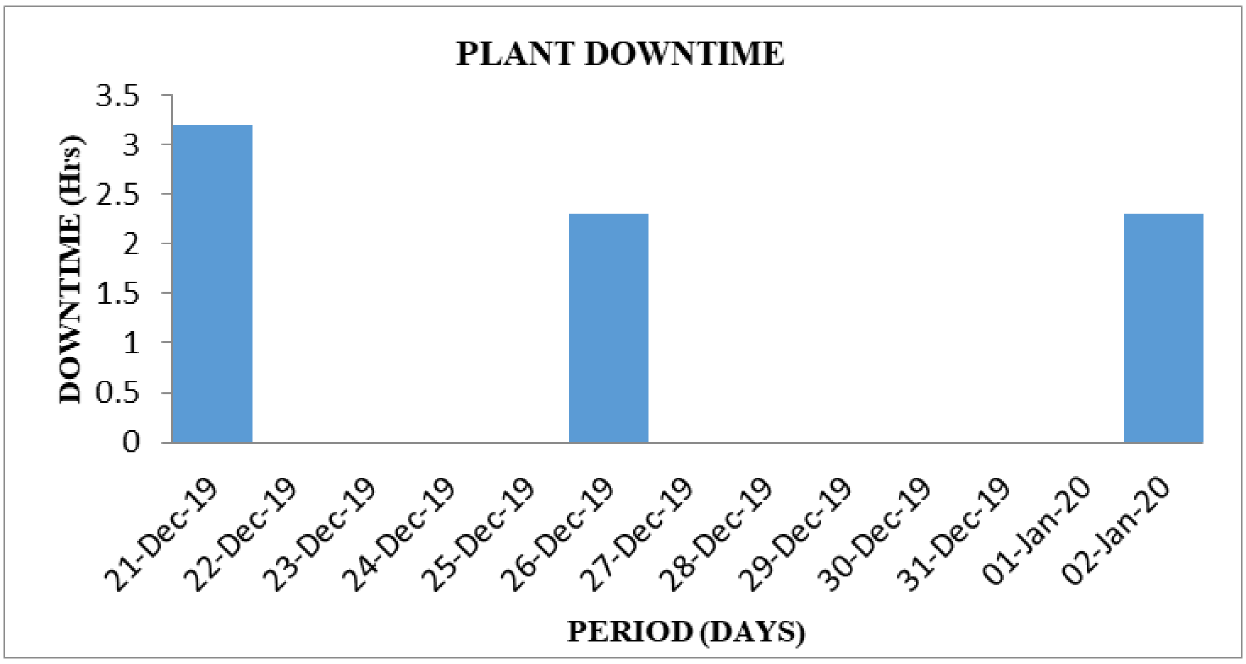


Fig. 15 Downtime Chart after Implementing Project

The below trend shows the downtime in the X-axis and downtime hours in the Y-axis after implementing the project. It is shown in Fig.16.

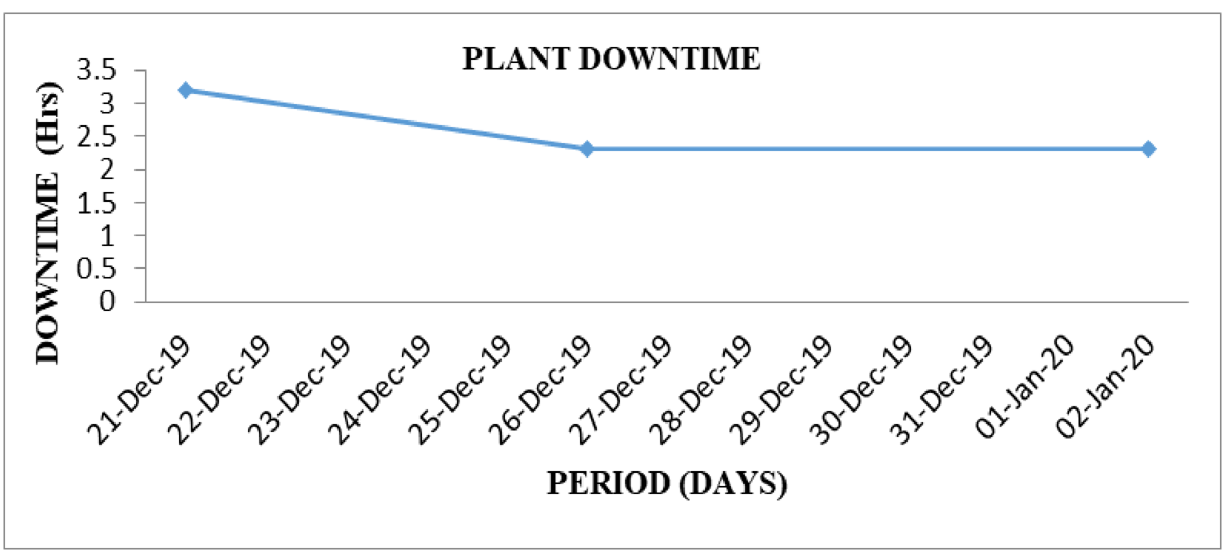


Fig. 16 Downtime Trend after Implementing Project

7. Cost Analysis

The observed parameters of the plant before the implementation of work is presented below.

i. Downtime per week = 2 times (4 hours/ time)
ii. Pulp loss per hour = 17 tons
iii. Pulp loss per week = 136 tons
iv. Pulp cost per ton = Rs.30000s
v. Downtime Pulp loss per year = 136x52 = 7072 tons
vi. Production loss per year = 7072x 30000 = Rs. 212160000

The observed parameters of the plant after the implementation of work is presented below.

i. Downtime per week = 1 time (4 hours/ time)
ii. Pulp loss per hour = 17 tons
iii. Pulp loss per week = 68 tons
iv. Pulp cost per ton = Rs.30000
v. Downtime Pulp loss per year = 68x52 = 3536 tons
vi. Production loss per year = 3536x 30000 = Rs. 106080000
vii. Net Saving = Production loss before implementation – Production loss after implementation
   a. = 212160000 – 106080000
viii. Net Saving per year = Rs.106080000.

8. Conclusion

This project was implemented due to practical difficulties in the chemical bagasse pulp mill. Due to foreign materials mixing with reclaim feed Bagasse and creating the problems than ever in CB wet washing area. The following significant observations were made after the implementation of the presented project work.

i. Down time reduced
ii. Equipment damages reduced
iii. Production increased
iv. Availability of equipment increased
v. Plant performance increased
vi. Specific consumption of chemicals reduced
vii. Profit increased

This project introduction of troubleshooting of raw material handling in bagasse pulping was designed to be beneficial to similar industrial fields.

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