Maintenance Improvements in Continuous Digester for Bagasse Pulping

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ABSTRACT

This paper deals with some of the substantive modifications carried out in the Pandia Digester, which helped to improve the performance of Pandia digester significantly and today Pandia digester runs for even 24 hours/day.

INTRODUCTION

Seshasayee Paper and Boards Ltd. commenced operations in the year 1962 with a Continuous Digester (Pandia Digester) capable of pulping both bamboo and bagasse. In the initial few years of operation, the Digester had many maintenance and operation related problems and the mill could hardly operate the digester for about 10 hrs a day. The mill subsequently added Stationary Digesters in phases to increase wood pulping and started using the Pandia Digester only for Bagasse Pulping. The running hours of Pandia digester could be improved to about 17 hrs a day. However this was not adequate to meet the pulp requirement and it called for sustained efforts to overcome many operation and maintenance problems.

As a part of a phased Mill Development Plan, the bagasse preparation and handling system was completely revamped by installation of Stone Catch Tank, Sand Rifflers, Slush Tank and a Dewatering screw with a variable speed pin feeder arrangement. The above enabled the mill to improve the Pandia running hours to 22 hours a day. Though the running hours improved, there were still many operation and maintenance problems that needed attention.

General system description

A general arrangement of the Pandia Digester operation is given in Fig. 1.

The basic elements of Pandia Digester System are :

- Screw feeder
- Inlet chamber

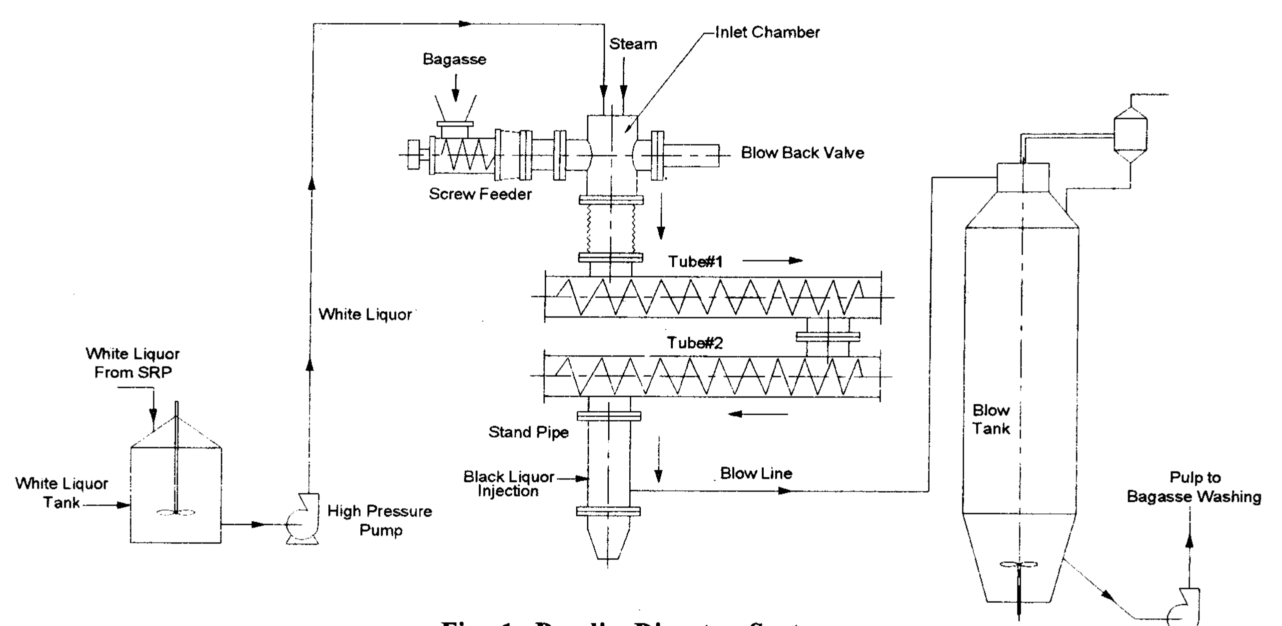

Fig. 1: Pandia Digester System

- Digester tube assembly
- Low consistency blow system

Screw feeder

Screw feeder is the initial element of the Pandia Digester. Its function is to feed raw materials from atmospheric conditions to the pressure zone maintained inside the Digester at a constant predetermined rate. The Screw feeder is coupled to the drive shaft and is housed in the inlet housing and throat of the digester.

The screw feeder is basically a tapered screw. Due to this taper, the pocket area of the screw reduces resulting in compression of raw material as it passes to the inlet chamber. As the raw material is compressed, the excessive water is squeezed out of bagasse and is removed through holes provided in the throat. This compression also aids in the formation of the plug at the entrance of the pressurized zone to avoid steam leaking out of the Digester. This is also called "Blow Back". The bagasse is thus pushed into the inlet chamber of the Pandia digester in the form of a "Compact Plug".

Inlet chamber

The inlet chamber is connected with the screw feeder and is located at the entrance of the Pandia tube pressure zone. The inlet chamber is equipped with a blow back valve, which is used to 'shut' the inlet chamber whenever screw feeder fails to deliver adequate bagasse to the inlet chamber. The blow back valve is pneumatically actuated. Steam and chemicals are injected into the inlet chamber of the Pandia Digester.

Digester tube assembly

The bagasse and the chemicals added are mixed and moved through 2 Nos of horizontal tubes at a predetermined, uniform rate. At the end of the predetermined cooking time the bagasse pulp is discharged into the low consistency blow discharger.

Low consistency blow system

The function of the low consistency blow system is to discharge the pulp at a constant rate from the pressure zone in the digester tube to atmospheric condition at low consistency and low temperature. The weak black liquor is injected in the discharger to reduce the consistency of the cooked bagasse pulp. The combined action of liquor injection and the pressure release through the discharge valve shreds the fibre bundle to fibre. The pulp discharged from the blow system is taken to a blow tank from where further processing is done.

Improvements in Pandia Digester

Modifications in Screw, Throat and Plug pipe

The typical arrangement sketch of the screw feeder assembly is given in Fig. 2.

With the improved running hours of Pandia Digester we were beginning to face new set of operation and maintenance problems. The screw feeder was of 20" size. The size of the screw feeder is the major diameter of screw flight. The screw was connected to the drive shaft by a socket provision. Due to the limitations of the screw rpm, pulp production rate was only 3 tph. This arrangement had the following problems.

- With the socket driven arrangement, the weight of the screw rested on the wear bar necessitating the frequent renewal of wearing parts. Mean time between screw changes was less than 400 hours. Rebuilding cost was also very high.
- Pandia digester had to be stopped for changing the screw feeder and throat involving a down time of 12 hrs.
- Grease lubrication of the screw feeder bearing housing

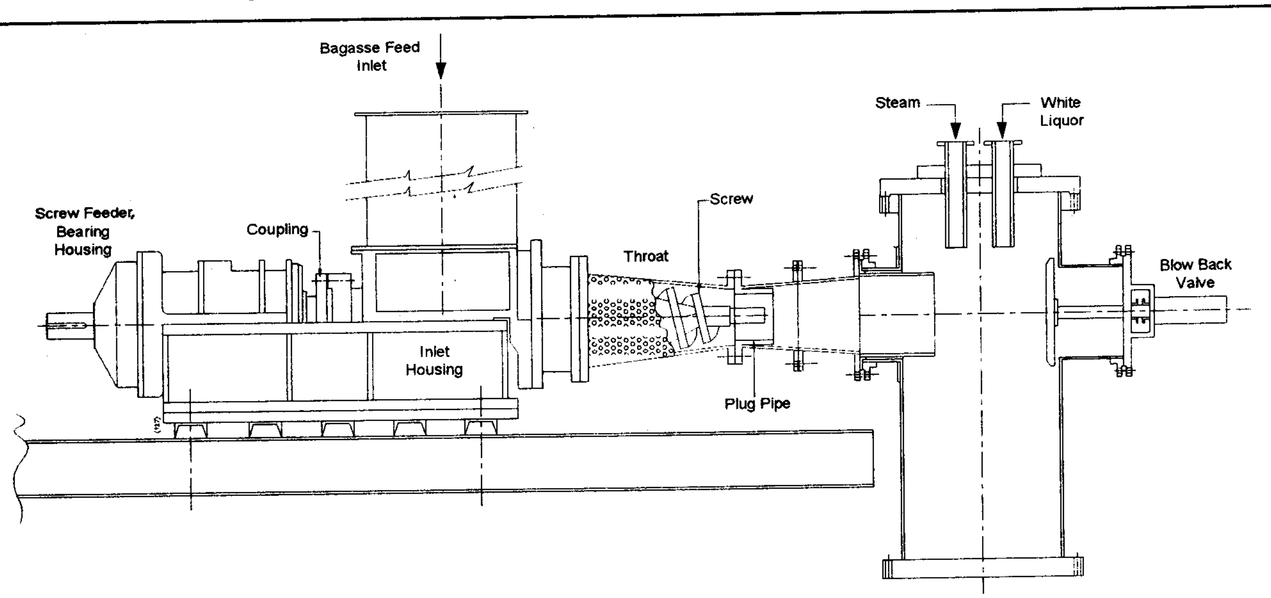

Fig. 2: General arrangement of screw feeder assembly

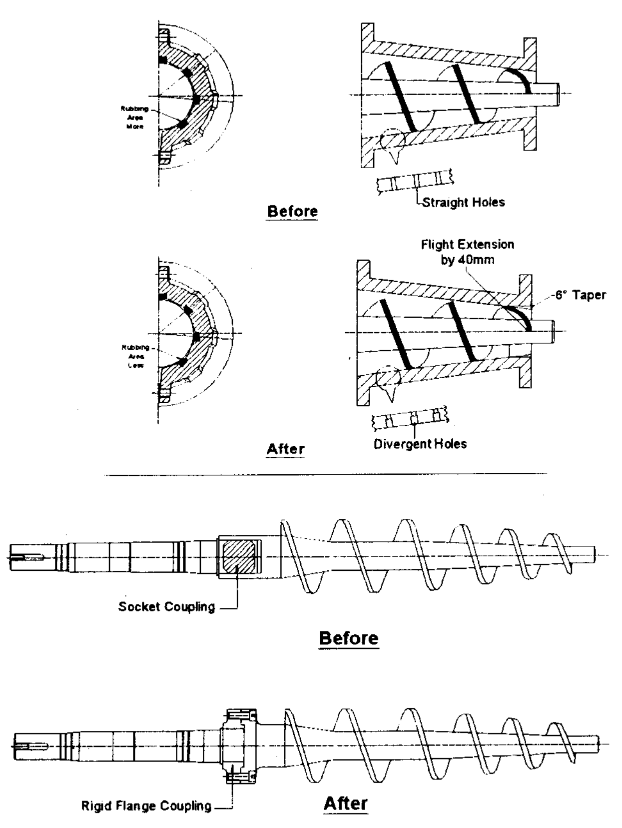

Fig. 3: Various modifications made in the screw feeder parts

was not effective and bearings were getting heated up very frequently.

- The screw could not be operated more than 55 rpm because of its weight and robust construction.

The modified arrangement of screw had the following features

- The screw was now coupled with main drive shaft by means of rigid flange type coupling which avoided the screw resting on the wear bar. The screw no longer rested on wear bars and hence reduced the need for frequent renewal of wear parts.
- The size of the screw feeder was changed to 17" screw feeder to reduce the weight.
- The screw flight length was increased by about 40 mm at the convergent end for free discharge of bagasse to the inlet chamber.
- For reconditioning of the screw, chromium carbide welding electrode was used.
- All the bearings were converted to oil lubrication bearings.
- The holes in the throat were modified to provide for divergent holes for better dewatering.
- The throat was converted from a purely convergent type to a convergent- divergent type by providing 6 deg enlarging provision at the end of the throat.
- The wear bars were located in such a manner so as to have a relief angle to ensure that the surface area of contact was reduced to a line contact on the traction side.
- The length of the plug pipe was reduced from 12" to 9".

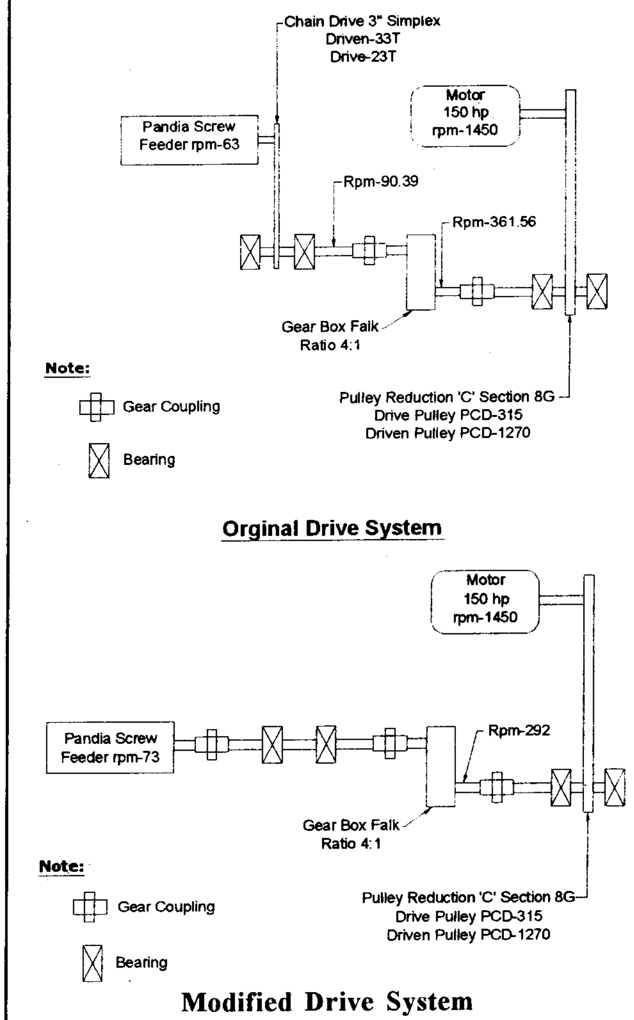

Fig. 4: Screw feeder drive arrangement

The above minor modifications ensured that the mean time between screw changes increased to 800 hours. Fig. 3 shows the salient modification made.

Modifications in drive arrangement of screw feeder

The screw is coupled with the drive shaft, which is assembled in a bearing housing, integral with mainframe. The radial and thrust bearings are mounted on the drive shaft. The drive arrangement of screw feeder consisted of the following components:

- First stage reduction by means of a pulley in the ratio of 4:1

- Second stage reduction by gearbox with a reduction of 4:1
- Third stage reduction with chain and sprocket with a reduction ratio of 1.4:1

With the above arrangement the motor RPM of 1450 was reduced to screw feeder RPM of 65. With the improved running hours and production with the Pandia Digester we were experiencing frequent failures of thrust bearing. The mean time between failures was about 3800 hours. The prime reason was traced on the location of the thrust bearing. The earlier design had the thrust bearing located between the two radial bearings. But in the 17" screw feeder bearing assembly, the thrust bearing is located at the drive end of the shaft. Hence with the pulling load of the chain drive system, the failure of the thrust bearing was frequent. To overcome the above problem the screw feeder shaft is directly coupled and chain drive was eliminated. The modified drive arrangement consisted of the only two stages of reduction and subsequently the screw feeder RPM is increased to 73.

- First stage reduction with pulley in the ratio of 5:1
- Second stage reduction by means of a gearbox in the ratio of 4:1

With the above

- The failure of the thrust bearing was eliminated
- There was an improvement in the production rate from 3.75 tph to 4.25 tph.
- The inventory on sprocket and chain is eliminated
- Maintenance down time of the digester system is reduced appreciably.

Modifications in screw feeder shaft assembly

While the bearing failure had been eliminated a new problem in the form of shaft breakage was experienced. Three screw feeder shafts got cut between the thrust bearing and the radial bearing. The mean time between failures was 3800 hours. Despite changing the material of the shaft from EN24 to EN19 and also the type of coupling there was no improvement. But a through review of the assembly revealed that the thrust bearing meant for absorbing the axial load was not actually loaded. Hence a 10-mm spacer was added to enable the thrust bearing to be loaded. Now thrust-bearing failures have been eliminated. The assembly of the screw feeder shaft after the modifications is given in Fig. 5.

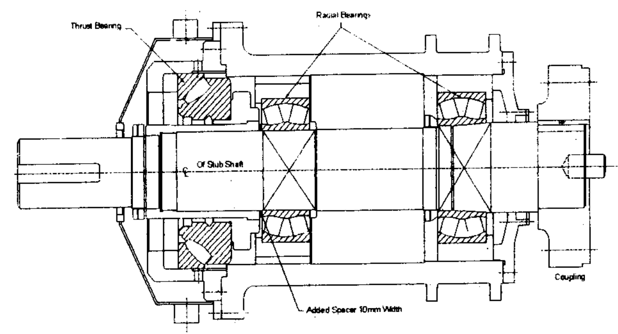

Fig. 5: Screw feeder shaft assembly.

Modifications in blow back valve

With the blow back valve we were frequently facing the following problems

- Shaft bending
- Frequent gland leakages at the steam end
- Air leakages at the piston

It was observed that

- Shaft was getting bent with continuous high temperature application.
- Due to shaft bending, the piston cup had an eccentric wear resulting in air leak inside the cylinder.

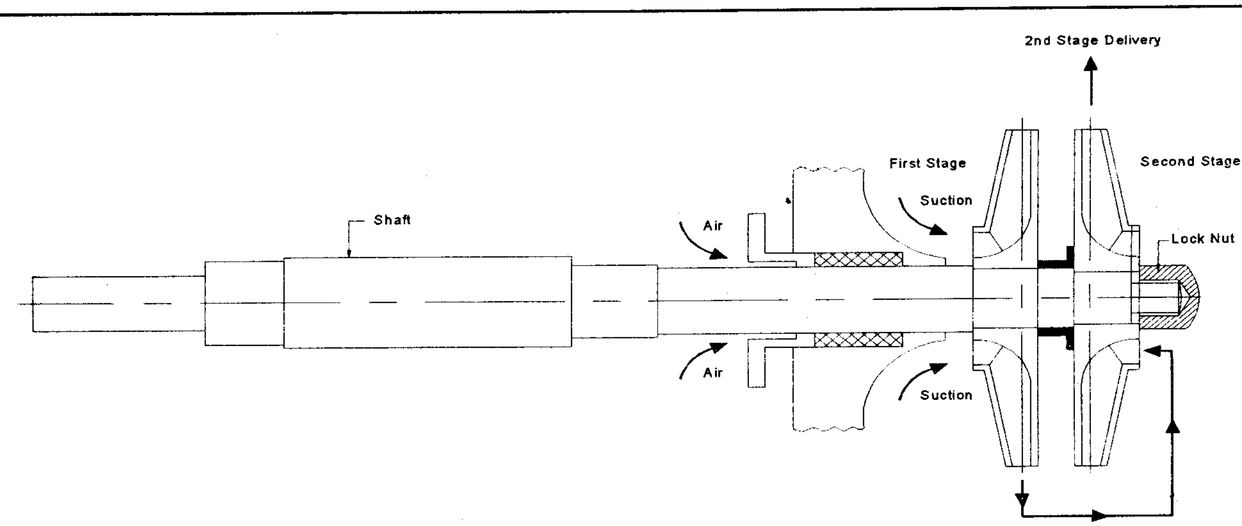

Fig. 6: Rotating unit of double stage high pressure pump.

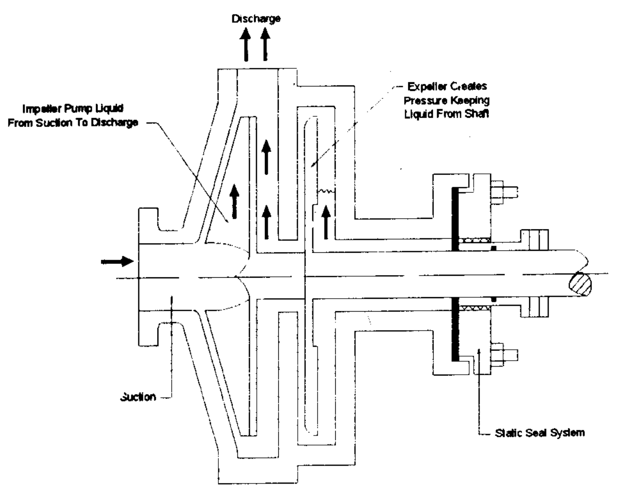

Fig. 7: Pumps with proven dynamic seal Top half illustrates operating condition Lower half illustrates static condition

The following actions were taken

- Shaft size was increased from 2.5" to 3"
- Rubber piston cup was strengthened with Aluminum stiffeners

With the above modification, failures of blow back valve were eliminated.

Modifications in high pressure liquor feed pump

White liquor is injected into the inlet chamber of the Pandia Digester. Since the Pandia Digester operating pressure is 10 kg/cm^2, a high-pressure pump is required to inject liquor into the digester. For this application a double stage centrifugal pump was selected. The failure rate of the pump was very high. The Mean Time between Failures was about 3 months. The major problem with this pump was the wide fluctuation in pumping which was also resulting in:

1) Vibration
2) Frequent failures of bearing
3) Frequent changing of gland packing
4) Very high rebuilding cost

Following observations were made on the pump:

1) As the liquor enters the first stage suction, air is drawn through the gland packing. Sealing water could not be given for this application since it would dilute the White Liquor. Due to air entrapment the discharge was fluctuating. Also slight wear in the gland sleeve was affecting the performance of the pump
2) At 3000 RPM the vibration level was abnormally high due to presence of air and fluctuation in discharge.
3) Being a pump with positive suction, the liquor leakage through gland was heavy.
4) Due to the vibration problem, bearing at the impeller side was frequently failing.

Following attempts were made to solve the above problems:

- Quality of the gland packing was improved to prevent air leakage
- Impeller - wear ring clearance was kept to the minimum

Despite the above, no improvement was seen in the failure rate.

It was then decided to change the pump from Double Stage to Single Stage Pump. The Single stage pump has lesser wear parts and also the air entrapment through the gland packing area is less. This pump was also designed to operate at 3000 RPM. To achieve the same duty conditions, the impeller diameter was higher and hence this created higher temperature in the bearing housing which resulted in frequent shaft failure near the impeller seating area.

With the single stage pump pumping fluctuations were avoided but there was no improvement in failure rate. These failures were attributed to the basic design of the pump that had a lower shaft size and corresponding bearings that were not adequate to meet the process conditions. As a further development we installed a new pump with the following features

- Higher shaft size with suitable bearings
- Modified bearing housing incorporating fans to dissipate heat
- Dynamic seal arrangement

Fig 6 and Fig 7 given below show the arrangement of the rotating unit of the Double Stage and Single Stage Pump with expeller arrangement respectively. With the installation of the above pump the operation of liquor feeding pump to Pandia Digesters is now reliable.

The following additional benefits have been realized.

- Pumping fluctuation is almost NIL
- Vibration is reduced to normal level
- There is no requirement of gland sealing water
- Gland packing is totally eliminated

CONCLUSION

Sustained efforts aimed at improving the performance of the Pandia digester in terms of availability and production resulted in improved running hours of Pandia Digesters from about 10 hours/day to 24 hours/day, the mean time between screw changes improved from about 400 hours to about 800 hours and the production rate improved from 3.0 tph to 4.25 tph.