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Design of a Novel Multi-Stacker Mechanism for Bearing Seal Pressing Station

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Abstract

In a bearing manufacturing company, stacker systems are important equipments used for handling bulk materials. In this work, a new multi-stacker arrangement has been designed to replace a conventional bearing seal stacker system. The new system can accommodate 720 seals at a time. This arrangement increased the time gap between two loading cycles to upto 2 hours as compared to just 10 minutes in the older setup. Similarly, the average machine idle time was reduced by more than 85%. This resulted in a productivity enhancement of over 7%. Thus, a multi-stacker mechanism proves highly beneficial to reduce man/machine interactions, worker fatigue and machine idle times in the bearing industry seal pressing machine productivity.

1. Introduction

A seal pressing machine is used in bearing industry to press seals on bearings to protect the bearings from foreign particles and leakage of lubricant. A seal stacker machine is a typical material handling equipment used to stack and feed the seal pressing machines. Like all stackers, it is a useful machine used to move bulk material for storage, assembly and waste removal [1].

Few papers were found in published literature dealing with this topic. VamsiKrishna and Porchilamban [1] developed and structurally analyzed a twin boom stacker masthead for better productivity. Sivasubramanian et al [2] designed a modification to the conventional semi-automatic stacker using CAE. Vianen et al [3] developed a simulation tool to reschedule the stacker-reclaimer operation to improve productivity of a dry bulk terminal. They achieved significant reduction in waiting times of cargo trains at the bulk cargo terminals. Miao et al [4] developed a tunnel stacker multi stage fork model using computer aided design. They improved the stacker stability and reliability using transient dynamic analysis in Ansys. Sahu and Bhatele [5] studied the performance of a stacker-reclaimer over long distance drive operations. Tian and Hu [6] optimized the hinge point position of luffing mechanism in a container reach stacker. Xiao et al [7] conducted finite element structural analysis of the trolly frame of a stacker-reclaimer running mechanism. Daniel et al [8] analyzed the resultant stresses in the pulley of a stacker-reclaimer. Singh and Parikh [9] implemented finite element analysis toreduce stacker weight by considering the stresses acting on the stacker base plate. However, they did not completely design a new multi stacker system for improving productivity.

In this paper, a novel multi stacker is designed using computer aided design to improve productivity aspects in a bearing seal application.

2. Existing design of a single stacker

An existing stacker-reclaimer system (Fig.1) is basically made up of a stacker column, a pneumatic pusher and a proximity sensor. Bearing seals are packed into the stacker column and are dropped onto a plate attached to the pneumatic pusher sequentially. In the extension stroke of the pneumatic pusher, the seal is taken to the b earing for the pressing operation by the seal pressing machine.

Fig 1. Existing single stacker mechanism

3. Design procedure for the multi-stacker

For improving productivity and minimize various losses, a new stacker design was conceived as follows.

3.1 Design Constraints

The first design constraint was regarding the available floor space as per the existing seal pressing machine. Next constraint was regarding the loading height. Accordingly, these parameters were fixed at 700X1000 mm^2 and 1000 mm, respectively. The third constraint was regarding the seal itself, with its diameter, width and weight having values 80 mm, 5 mm and 10 gm, respectively. Fourth constraint was concerned with cycle time (10 sec), which impacted the design of the pneumatic pusher stroke length (taken as 30 mm in the current design).

3.2 Components design

This design incorporated a total of 12 vertical columns instead of just one in case of existing setup. This was done to improve the time lag between two consecutive reloading cycles. Each column is designed to carry upto 60 seals. Therefore, the columns' heights were designed accordingly (300 mm).

A base plate was designed to support these 12 columns. Its diameter (560 mm) was selected based on three criteria. First criterion was to ensure appropriate inter-column spacing. The second criterion was to ensure adequate spacing between column and base plate edge. The third factor considered was the floor space constraints (mentioned in the previous section).

To hold the vertical arrays of the seals, a supporting plate was located beneath the base plate. The thickness of this plate was fixed at 10mm, to provide adequate support to the seal stacks.

MS 1144 was selected as the material for all of the above components, owing to its high machinability, strength, hardness and cost effectiveness.

Other components included an AC motor (in conjunction with a gear box) to rotate the base plate, a proximity sensor to sense the number of seals left in the current stacker, and a PLC panel to monitor and control the entire operation..

3.3 Design of rotary indexing table

A rotary indexing table design comprised of basically three elements – AC motor, gear box and cam-indexer.

3.3.1 Selection of AC motor

The total system mass (stackers+ base plate + seals) to be rotated was calculated to be 69.15 Kg. Therefore, the minimum power required for corresponding torque would be 0.107 KW. Thus, an AC motor was selected with appropriate safety factor, with specifications as detailed in Table 1.

Table 1. AC motor specifications

Specification	**Type/Value**
Supply Voltage	230/400 V
Frequency	50 Hz
Power	0.18 Kw
Horsepower	0.25 HP
Speed	1360 rpm

Torque	3.5 Nm
Make	Rossi

3.3.2 Gear Box Selection

For gear box design, the required output speed was 35 rpm. The motor shaft speed was 1360 rpm, which had to be reduced to 35 rpm using gear box. Therefore, the required gear ratio was calculated to be 40:1. Table 2 gives gear box specifications.

Table 2. Gear Box Specifications

Specification	**Type/Value**
Make	STM service point
Type	Single reduction
Size	1.54"
Gear ratio	40:1
Power	0.18 kW
Input speed	1360 rpm
Output speed	34 rpm
Output torque	100 Nm
Weight	5 kg
Efficiency	70%

3.3.3 Cam-indexer mechanism

A cam-indexer mechanism was designed to facilitate the sequential removal of seals by means of a pneumatic pusher. The design was aimed to meet the loading requirement of the entire stacker system (96.36 Nm) and its incremental movement. Subsequently, a cam type indexer with dynamic torque capacity of 100 Nm was selected (details in Table 3).

Table 3. Cam indexer specifications

Specification	**Type/Value**
Make	Autorotor, VaianoCremasco, Italy
Number of Stations(S)	12
Index angle(B^0)	270^0
Dwell angle(Bp^0)	90^0
Static torque	100 Nm
Dynamic torque	100 Nm

Figure 2 shows the assembly of the rotary indexing table.

Fig.2 Rotary Indexing Table Assembly(Source [10])

Figure 3 exhibits the design drawing of the new stacker system

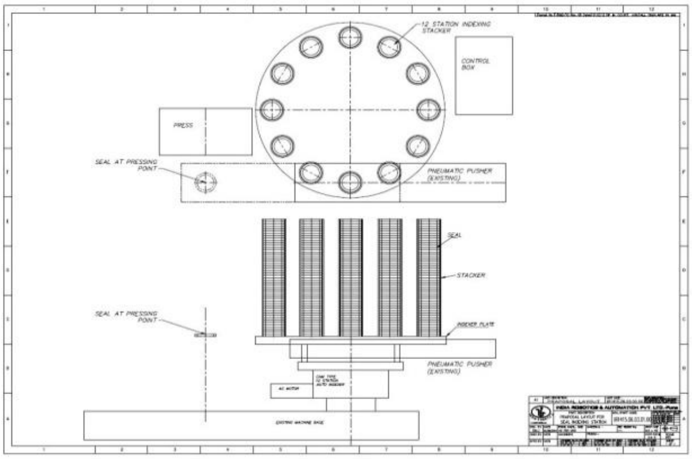

Fig.3 D drawing of the new multi stacker system

Figures 4 and 5 show the assembly and exploded views of the novel CAD model.

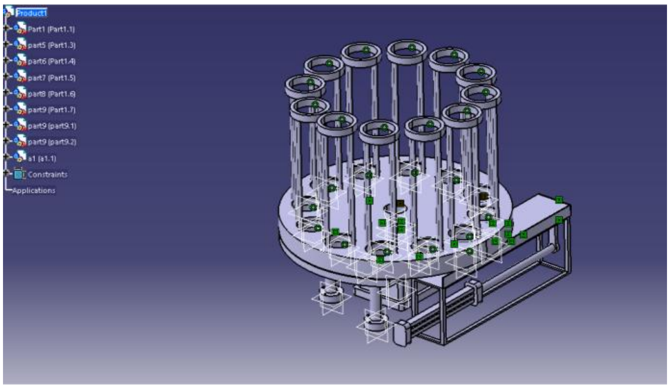

Fig. 4 CAD model of the novel multi-stacker

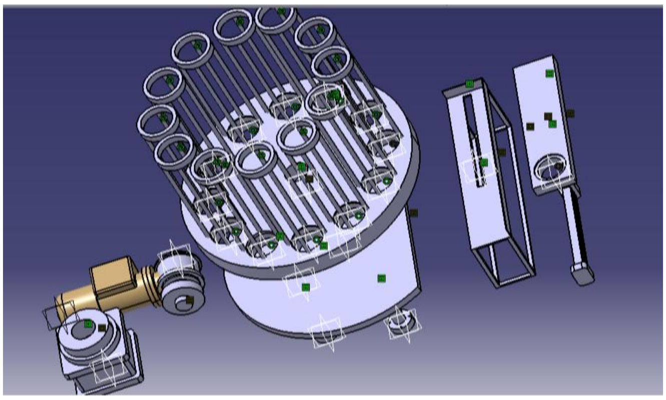

Fig. 5Exploded view of the multi-stacker model

4. Results and Discussions

The novel multi-stacker was manufactured / assembled as per the above mentioned design as shown in figure 6. Thereafter, suitable observations were recorded to compare relative performances of single stacker versus multi stacker as follows.

4.1 Manual interruption times

Firstly, manual interruption times were collected (Table 4). These readings indicate the number of times a worker has to reload the stacker in the given time period. Table 4 clearly shows the advantage of a multi-stacker system. It can be shown that the manual interruption times were reduced by more than 90% owing to the novel design.

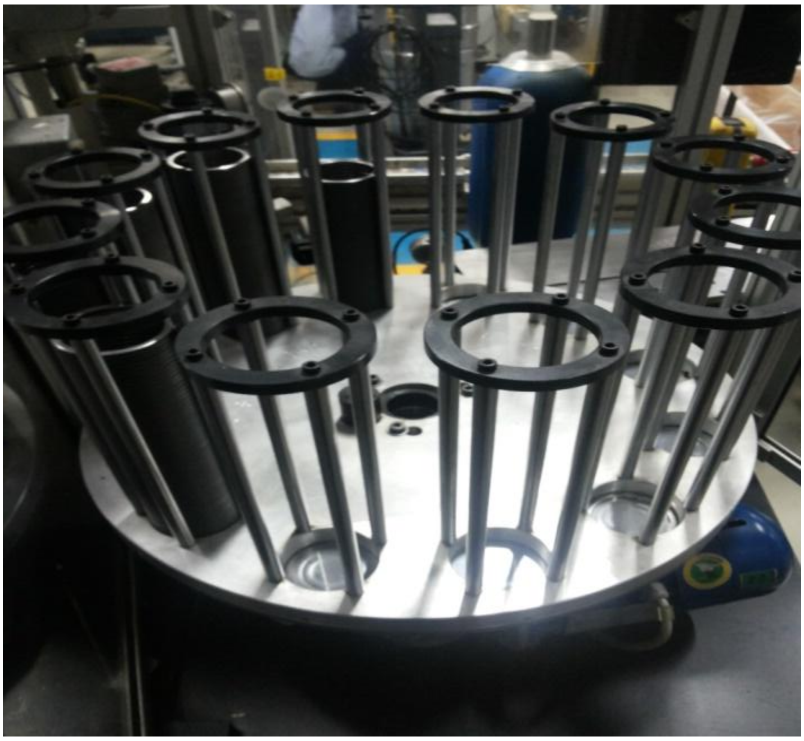

Fig. 6: Manufactured Multi-Stacker System

Table 4: Comparison between Single-Stacker and Multi-Stacker in terms of manual interruption

Time	Single-Stacker	Multi-Stacker
8 am-9 am	6	1
9 am-10am	6	0
10 am-11 am	6	1
11 am-12 pm	6	0
12 pm-1 pm	6	1
1 pm-2 pm	6	0
2 pm-3 pm	6	1
3 pm-4 pm	6	0
4 pm-5 pm	6	1

4.2 Machine idle time

Table 5 shows the idle times recorded for single and multi-stacker over a 9 hour shift. Again, the multi stacker design reduces machine idle time significantly, by over 85%.

Table 5: Comparison between Single-Stacker and Multi-Stacker in terms of machine idle-time

Time	Single-Stacker	Multi-Stacker
8 am-9 am	325 sec	62 sec
9 am-10am	256 sec	0
10 am-11 am	312 sec	65 sec
11 am-12 pm	405 sec	0
12 pm-1 pm	332 sec	58 sec
1 pm-2 pm	282 sec	0
2 pm-3 pm	135 sec	73 sec
3 pm-4 pm	188 sec	0
4 pm-5 pm	278 sec	54 sec

4.3 Productivity

Table 6 shows the bearings sealed per hour for single and multi-stacker over a 9 hour shift. Here, the multi stacker design enhances the productivity of the bearing seal press 7%.

Table 6: Comparison between Single-Stacker and Multi-Stacker in terms of productivity (Bearings/hour)

Time	Single-Stacker	Multi-Stacker
8 am-9 am	295	318
9 am-10am	301	324
10 am-11 am	296	318
11 am-12 pm	288	324
12 pm-1 pm	294	319
1 pm-2 pm	299	324
2 pm-3 pm	312	317
3 pm-4 pm	307	324
4 pm-5 pm	299	319

5. Conclusion

The conventional single stacker mechanisms being used for pressing seals on bearingshave shortcomings like shorter time periods between consecutive loading cycles leading to more worker fatigue, higherman machine interaction and less productive system. The designed novel multi-stacker equipment works more efficiently and effectively at required speed as compared to the single-stacker equipment. All the components were designed in a way such that they could carry the load and moments during working conditions. Design calculations of base plate, gear box, AC motor and cam indexer were done to meet the requirements of a more productive mechanism. By using such multi-stacker equipment, it is possible to reduce the manual interruption and machine idle-times significantly. The production capacity (per hour) of the novel stacker was also enhanced with multi stacker mechanism as compared to the single stacker system.

6. References

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