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DESIGN AND DEVELOPMENT OF AN ACTIVE TRAP FOR HANDLING BRAKELINERS

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Abstract: Vibratory feeders are commonly used in industries for part feeding. The design of vibratory part feeders is complex and consumes more time. Sensorless part feeding (without the aid of sensors) is further challenging. Berretty et al (2001) discussed a sequence of mechanical barriers which either reject the disoriented parts or reorient the parts to desired orientation. They termed this as 'traps'.In this paper, an inexpensive trap was designed and fabricated for handling brakeliners. The efficiency of the trap was found to be 100% using Markov model as well as experimental results.
Keywords: Vibratory feeder, trap, brakeliner, Markov model

1. INTRODUCTION

Vibrating feeders are commonly used in industries for orienting parts [1]. Vibratory part feeders are more commonly used in industries such as food processing, plastic component manufacturing, automobiles etc. Beretty et al [2] demonstrated that a polygonal part could be oriented using fences placed along a conveyor belt. Berretty et al [3] discussed a sequence of mechanical devices such as wiper blades, grooves to filter polygonal parts on a track. They termed this as 'traps' and had a series of mechanical barriers (also known as gates) which either reject the disoriented parts or reorient the parts to desired orientation. The former type is known as passive trap and the latter as active trap.These traps are mounted at the exit of the vibratory feeder. Goemans [4] introduced blades, to feed 3D parts by reorienting and rejecting all but a desired orientation. The blade received identical polyhedral parts in arbitrary orientation as input and outputs parts in one single orientation. Ramalingam and Samuel [5] investigated the behavior of a linear vibratory feeder, used for conveying small parts. A tumbling barrel hopper was developed for feeding the components onto the track. The most important factor to be considered when selecting a part feeder is the type of parts to be fed. Feeder sizes and types are determined through a variety of factors such as: part size and configuration, part abrasiveness, condition of the part when handled and the required feed rate. The design of industrial parts feeders is trial and error process that can take several months [6].If the most probable natural resting orientation of the part is chosen as the preferred orientation, the need to re-orient parts would be minimized. Most probable natural resting is the orientation which has the highest probability of occurrence. Greater the number of parts in preferred orientation, higher is the efficiency of the part feeder [7]. In this paper, based on the most probable natural resting orientation of brakeliners determined by Udhayakumar et al [8], an active trap was designed and fabricated. The efficiency of the trap was evaluated using Markov model. The efficiency of the trap was found to be 100%.

2. PART CONSIDERED

A brakeliner as shown in Figure 1 was chosen as the part to be fed. The height of the brakeliner (H) was 22 mm, the width (W) was 18 mm, the length (L) was 67 mm and the thickness (T) was 4mm. It was made of asbestos based mixture and weighed about 8.83 g.

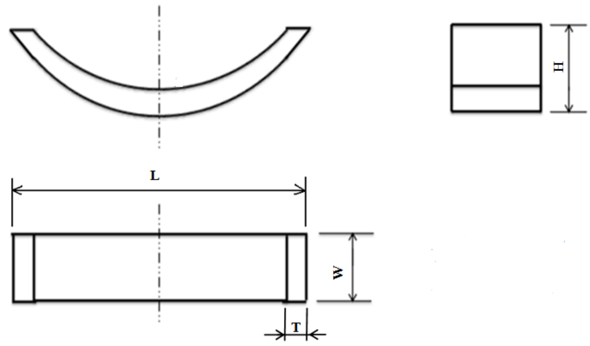

Figure 1. Brakeliner part

The eight natural resting orientations of the brakeliner is shown in Figure 2.

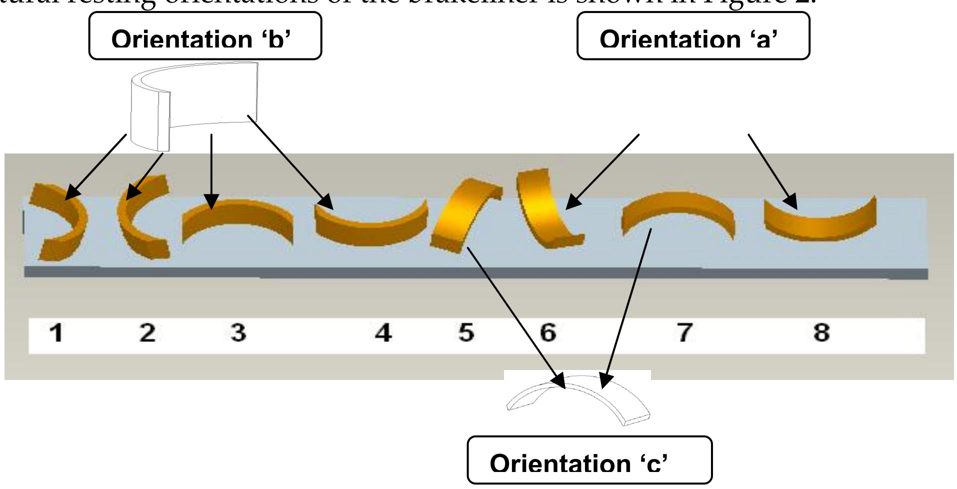

Figure 2. Categorising the orientations of brakeliner

Out of the eight orientations, the similar orientations (based on their resting faces) were categorised into same family and were named as orientations 'a', 'b' and 'c' as shown in Figure 2. The orientations 6 and 8were similar and rested with their open side facing towards sky. When orientation 6 was rotated horizontally with respect to the resting plane, orientation 8 was obtained and vice versa. Hence, orientations 6 and 8 were grouped as orientation 'a'.Most probable natural resting is the orientation which has the highest probability of occurrence. If the trap was developed in such a way that it was able to feed the parts with most probable natural resting orientation without any disturbance, then the efficiency of the system would be high. Hence, the most probable natural resting orientations (orientations 6 &8) determined by Udhayakumar et al [8] was considered as the desired orientations for the trap to be developed. This meant that any incoming orientation of brakeliner had to be converted to orientations 6 and 8 in the trap.

3. DESIGN OF TRAP

Berretty et al [2] discussed a sequence of mechanical devices such as wiper blades, grooves to filter polygonal parts on a track. They termed this as 'traps'. They discussed several gates of trap such as balcony, gap, canyon, and slot.Active traps convert any orientation of the part to the desired orientation whereas passive traps reject the disoriented parts. The sequence of placement of passive and active devices depends on the orientation to be obtained as output.Several configurations of the trap were designed, studied and the best among them is shown in Figure 3. The gates used in the trap were wiper blade, guiding block, edge riser and slot as shown in Figure 3. The movement of parts on the trap was through vibrations provided by a vibratory feeder.

The working of the trap (Figure 3) is discussed below:

- ✓ Wiper Blade had a broader entry but a narrow exit. Whenever the parts with orientations 1, 2, 5 and 6entered the wiper blade, they got guided along the blade profile and were forced to enter the narrow region. To pass through the narrow region, the orientations 1, 2, 5 and 6 got converted to orientations 3, 4, 7 and 8.

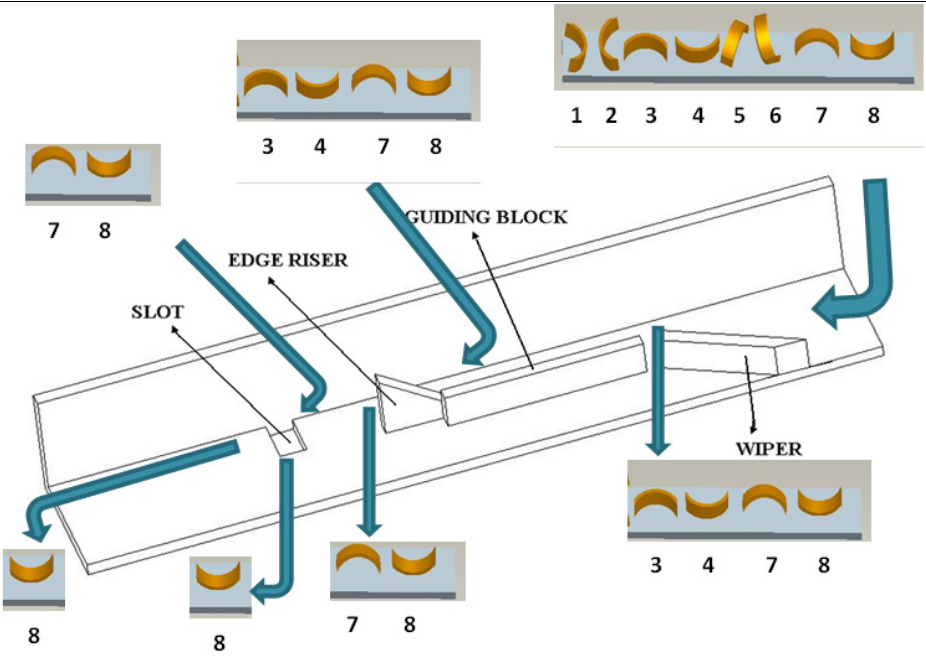

Figure 3. Working of trap

- ✓ The width of the guiding block was narrow enough just for the parts to pass through and hence the parts were unable to change their orientations. This ensured that all the parts with orientations 3, 4, 7 and 8 reached the next gate without change in orientation
- ✓ The parts with orientations 3,4,7 and 8 entered the edge riser. Parts with orientations 7 and 8 were left undisturbed by the edge riser because the gap between the track wall and the edge riser was sufficient for them to pass through. But the parts with orientations 3 and 4 could not pass through since their width was more than the gap and hence they had to move over the edge riser. When a part with orientation 3 moved over the edge riser, its center of gravity fell outside the base and hence toppled and changed to orientation 8. Similarly, when a part of orientation 4 moved over the edge riser, it got converted to orientation 7. The outgoing orientations 7 and 8 moved to the next gate i.e., slot.
- ✓ When parts with orientation 7 passed over the slot, they fell through the slot whereas parts with orientation 8 were not disturbed. When a conveyor was placed below the slot, the part that fell through the slot landed on the conveyor in orientation 8.
- ✓ Parts with orientation 8 remained undisturbed throughout the trap and fell on the conveyor at the exit of the trap in the same orientation.

Hence, the output from the trap was always orientation 8, which was the desired orientation.

The guidelines followed in the design of traps are discussed below:

- ✓ The angle of inclination of wiper blade angle, θ_{wb} (as shown in Figure 4) and edge riser angle, θ_{er}(as shown in Figure 5) for the effective function of trap for conveying brakelinerwas determined experimentally as 35^0 and 8.5^0 respectively.

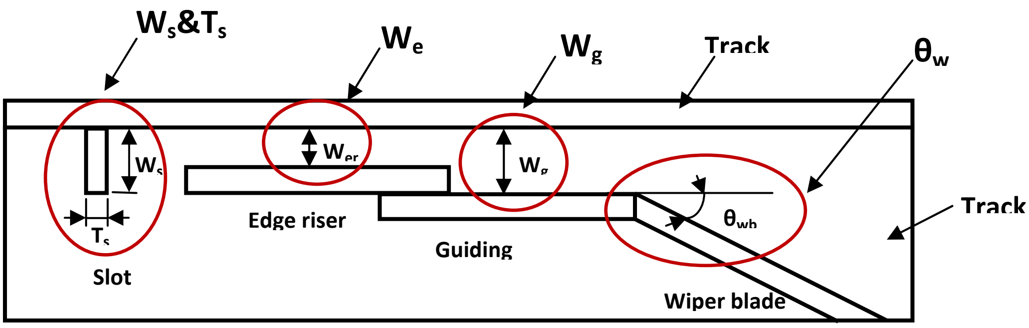

Figure 4. Top view of trap

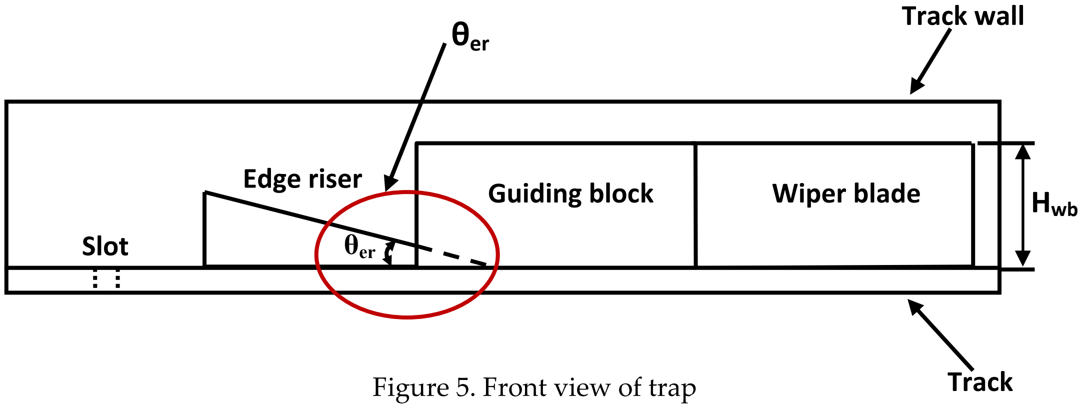

Figure 5. Front view of trap

- ✓ The gap between the wall and the guiding block (W_{gb}) (as shown in Figure 4) had to permit the parts with orientations 3, 4, 7 and 8 to pass through them. The edge riser was placed in such a way that the part rode over it even before it crossed the guiding block completely.Providing a clearance of 2 mm and taking into account of sheet thickness (t_s) of the edge riser, W_{gb} is given by Equation (1).

$$W_{gb} = (W + t_s + 2)\ \mathrm{mm} \quad (1)$$

  If the clearance was provided more, then the parts moved away from the wall and were not be able to reach the edge riser properly for reorientation.
- ✓ The parts with orientations 7 and 8 had to pass through the gap (W_{er}) between the wall and the edge riser without any disturbance, as shown in Figure 4. So, providing a clearance of 2 mm, W_{er} is given by Equation (2).

$$W_{er} = (W + 2)\ \mathrm{mm} \quad (2)$$

  If more clearance was provided, the parts moved away from the edge riser and were not reoriented properly (or) took a longer time for reorientation.
- ✓ The slot had to filter the part with orientation 7. Hence, the thickness of the slot (T_s), as shown in Figure 4, had to be greater than the thickness (T) of the part. Providing a clearance of 2 mm, T_s is given by Equation (3).

$$T_s = (T + 2)\ \mathrm{mm} \quad (3)$$

  If more clearance was provided, the parts of orientation 8 got stuck in the slot.
- ✓ The width of slot (W_s) had to be in such a way that it permitted the whole width of the part(W), as shown in Figure 4. Providing a clearance of 2 mm, W_s is given by Equation (4).

$$W_s = (W + 2)\ \mathrm{mm} \quad (4)$$

- ✓ The height of wiper blade (H_{wb}) and guiding block (H_{gb}) had to be greater than the height of the part (H) to prevent the parts climbing over them due to vibration, as shown in Figure 5. A clearance of 2 mm would be too low and hence, a clearance of 5 mm was provided. H_{wb} is given by Equation (5)

$$H_{wb} = H_{gb} = (H + 5)\ \mathrm{mm} \quad (5)$$

- ✓ The length of wiper blade, guiding block and edge riser had to be greater than the length of the part (L) to ensure that the gate was completely in contact with the full part and performed its function effectively.

4. MARKOV MODEL

To determine the probability that a part entering into the trap in a particular orientation would end up in the desired orientation, Markov model [9] was used. The probability of parts entering in different orientations at the entry of trap and their probability of reorienting at various gates were considered. Based on the probability of parts in desired orientation at the exit of trap, the efficiency was calculated.

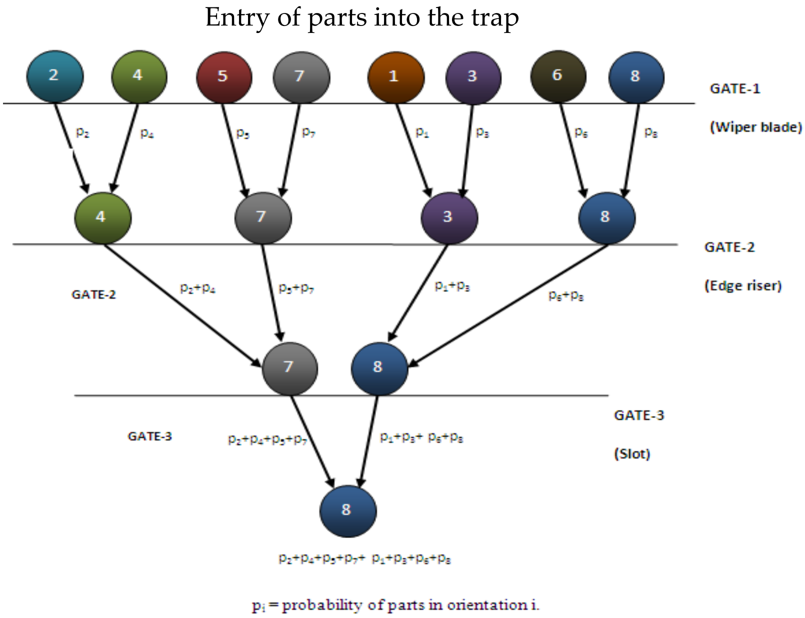

Figure 6. Markov model representing the efficiency of gates in the trap

If $p_1, p_2, \ldots p_8$ correspond to probability of parts with orientations 1 to 8, that enter the trap respectively, then it could be observed from Figure 6, that all the incoming parts were converted to preferred orientation at the exit of trap.All the eight orientations of the brakeliner with probabilities p_1, $p_2 \ldots p_8$ (where $p_1 + p_2 + \ldots + p_8 = 1$) were provided as the input to the trap as shown in Figure 6. At gate-1 (wiper blade), orientation 2 got reoriented to orientation 4. So, at the entry of gate-2 (edge riser), the probability of parts with orientation 4 was $p_2 + p_4$. Similarly, at the entry of gate-2, the probability of parts with orientation 7, 3 and 8 were $p_5 + p_7$, $p_1 + p_3$, and $p_6 + p_8$ respectively as shown in Figure 6. At gate-2, all the parts of orientation 4 got reoriented to orientation 7. So, at the entry of gate-3 (slot), the probability of parts with orientation 7 was $p_2 + p_4 + p_5 + p_7$. Similarly, at the entry of gate-2, the probability of parts with orientation 8 was $p_1 + p_3 + p_6 + p_8$.At gate-3, all the parts with orientation 7 got converted to 8. So, at the exit of gate-3, the probability of parts with orientation 8 was $p_2 + p_4 + p_5 + p_7 + p_1 + p_3 + p_6 + p_8$. Hence, the efficiency of the proposed trap was found to be 100%.

5. EXPERIMETAL TEST

The trap was fabricated using acrylic plastic (Figure 7) and was mounted on a vibratory feeder as shown in Figure 8. Thousand random orientations were provided as input to the trap and the output was orientation 8 in all the tests. Hence, the efficiency of the trap was found to be 100% experimentally. This trap employed mechanical barriers and no sensors and hence inexpensive.

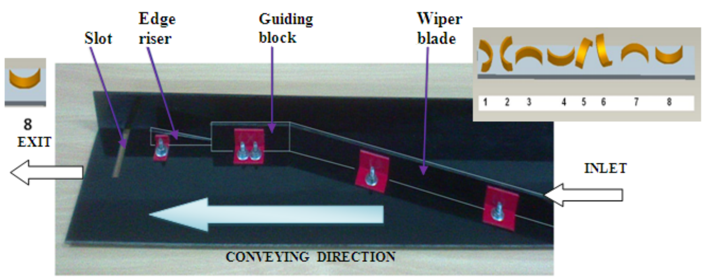

Figure 7. Fabricated trap

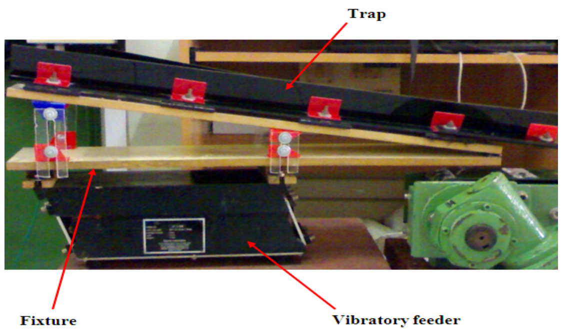

Figure 8. Trap mounted on vibratory feeder

6. CONCLUSION

An active trap was designed and fabricated for handling brakeliners, such that the output of the trap was always the desired orientation. The efficiency of the trap was found to be 100% using Markov model. The trap was fabricated using acrylic plastic and the efficiency of the feeder was experimentally found to be 100%. Since the trap had only mechanical barriers and no sensors, the feeder is less expensive. In future, a methodology to design and develop sensorless part feeders based on part's geometry could be developed.

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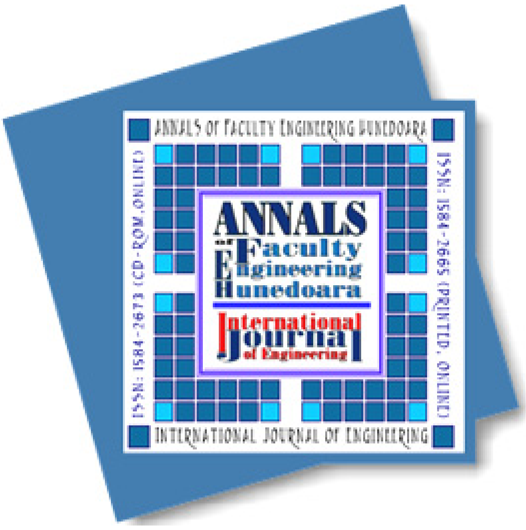

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