DESIGNING A SPIRAL SPLITTER AT THE ZARAND COAL WASHING PLANT

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ABSTRACT

Spiral separator is one of the equipment is used in mineral processing plants. This equipment commonly are used for separation of minerals (coal, iron, chromite, gold, zircon, etc.). Spiral separator performance (yield and product ash content) in addition to factors such as percent solids and flow rate of the feed, largely depends on how the materials exit from the spiral. In other words, at the end of the spiral trough, valuable, intermediate and waste materials should be considered completely separate. Poor design of spiral splitters caused mixing the valuable materials with middle and tailing. This ultimately reduce the quality of the final product as much as 40 to 60 percent (depending on the amount of mixing between the product and tailing). The new design of the splitters and avoiding mixing the valuable materials with middle and tailing increased the product quality, with a final value of about 55 % better than previously obtained.

KEYWORDS: Spiral separator, Coal, Splitter.

Today spiral is one of the most efficient and cost-effective equipment in Processing of fine-grained particles (Das et al., 2007). Because of its desirable characteristics such as low installed cost, low energy demand and the absence of environmentally unfriendly chemical additive (Kapur et al., 1998), it has achieved considerable popularity for processing of minerals and coals (Holland-Batt, 1994). Because of these advantages, most processing plants are interested in using the spiral (Luttrell et al., 1999). Spirals are able to maintain high recoveries while materials are too coarse for flotation and too fine for dense-media separation (Das et al., 2007)

Spiral separators, also called spiral concentrators, are devices to separate solid components in a slurry, based upon a combination of the solid particle density as well as the particle's hydrodynamic properties (e.g. drag) (Mills., 1978, Holland-Batt., 1989, Matthews et al., 1998, Matthews et al., 1999, Matthews et al., 1999). The device consists of a tower, around which is wound a sluice, from which slots or channels are placed in the base of the sluice to extract solid particles that have come out of suspension (Fig. 1).

Fig. 2 shows the cross-section of the spiral trough. For all spirals, the mechanism of separation is the same and involves primary and secondary flow patterns.

The primary flow is essentially the slurry flowing down the spiral trough under the force of gravity.

The secondary flow pattern is radial across the trough. Here, the upper, more fluid layers, comprised of higher density particles, move away from the center while the lower, more concentrated layers of higher density particles move towards the center.
Finally, after separation process, splitter bars may be arranged to make cuts at three places along the spiral cross section, thereby giving up to three separate density separations, high, mid and low density materials (Fig. 3). Adjusting the splitters on the spiral troughs usually controls recovery and grade.

**REDESIGNING OF THE SPIRAL SPLITTERS**

**Defects in old designed splitters**

Splitters, had two major problems. As shown in Fig. 5, for providing a better rotation of the splitter, under and behind of the splitter a gap was intended. These gaps, results in Valuable mineral particles being dragged to the tails stream and vice versa, resulting in mineral loss in the tails, sacrificing recovery.
• High volumetric flow onto the spiral as shown in Figure 6 and 7 causing further problems. This spontaneous movement, not only disrupts the proper settings, but also it will continue until the splitter is completely closed. Closing the splitter, causes complete mixing of both the middle and concentrates.

Figure 6. Valuable mineral particles being dragged to the tails and vice versa

Figure 7. Incorrect design causes closed splitters due to high volumetric flow

Figure 8. The concentrate deflected onto the tail stream

Design process of new splitters

According to previous content, redesigning of a suitable splitter was requested. In the beginning, it was decided to install the splitters on the surface of spiral trough. Spiral Previous valves were fixed in place and all gaps between the two channel were sealed. The design was changed three time and every time the splitter was constructed and was installed in spiral. After identifying and resolving the design flaws, the next design was presented. To ease the work and possibility of changing in design, materials like wood and EPS (Expanded polystyrene) were used to build splitters. The first proposed design was a simple splitter that could be installed on spiral trough surface (Fig. 8).

Figure 9. The first plan for splitter

In this splitter, the previous problems were solved, but there was a new series of defects that must be solved. First, due to the short height of the splitter, if it needs to be closed, the high volumetric flow onto the spiral (dashed line in Fig. 9) causes the spontaneous movement of splitter. In this case, finally the splitter completely will be closed. Portion of the flow will pass over the splitter (overtopping flow) and another portion Will be redirected in to the tail channel (Fig. 9).

Figure 10. Spontaneous movement of splitter and overtopping flow in the case of a closed splitter
Secondly, due to the curved-shape of spiral trough cross-section, when splitter is closed, a gap is formed under the base of splitter. This gap becomes a way out of intermediate particles to the concentrate channel (shaded area in Fig. 10).

**Figure 11. A way out space created in the closed position of the splitter (shaded area)**

To solve the first problem, the length of splitter was increased. In order to create a slow shift in direction of flow, a curvature is designed in a side surface of the splitter. In previous designed splitter, the shape of splitter caused a sudden change of flow direction. This fast direction changing, exerted a large force on splitter that forced the closure of it. To solve the second problem, the base of splitter was constructed curved shape to fill the spiral curvature in cross section. The second proposed splitter shown in Fig. 11.

**Figure 12. The second proposed splitter**

After installing second splitter, it was found that because of the curved lateral surface of the splitter, the middle flow was too distracted and was led to the tail channel instead of middle channel. Therefore, to avoid this problem, not only the splitter length should be longer, but also it was necessary to channelise the shifted flow.

The third design for splitter was proposed to solve the problem of incorrect slurry direction. Figures 12 and 13 represent the views of this splitter. As it is shown in Fig. 12, the curvature in a side surface is designed just in the lower half. The upper half of the splitter designed just like the roof of the splitter to prevent overtopping flow. Putting a plate in the front part of the curve on the lateral surface of the splitter created a flow channel.

**Figure 13. The third splitter**

In addition, because of the curve at the base of the splitter, when the splitter is open the stream cutting does not do well. Putting a rubber to fill the curvature at the base of the splitter avoided the open space below the splitter in any case (open or closed splitter) (Fig. 13).

**Figure 14. Putting a rubber to fill the curvature at the base of the splitter**

In the fourth and final design of the project, two pieces of rubber were installed in the both side in the back part of the splitter. With these rubbers, particles do not pass through the gap behind the splitter. Due to the good stability and ease of turning, Teflon sheets were used to build the main body of the splitter (Fig. 14).

**Figure 15. The final design of splitter**
RESULTS AND DISCUSSION

The final splitters for controlling the grade and recovery in spiral was built. In the required number (60) of these splitters was built and installed for all spirals in Zarand coal washing plant. Figures 15 and 16, 17, show the splitters installed on spirals.

![Figure 16. Splitter is installed on the plant spirals](image1)

![Figure 17. A view of the splitter mounted on spirals](image2)

The following items are the features which is intended in this new design.

- Installation of the splitters on spiral trough surface improves flow cutting.
- New design and channelising the shifted flow prevents incorrect mixing of concentrate, intermediate and tail in the end of spiral.
- Teflon splitters have high resistance in corrosion.
- Side curvature in splitter prevents sudden redirection of flow.

![Figure 18.](image3)

CONCLUSION

Results from the installation of new splitters can be expressed as follows.

- The new design of splitters and avoiding of mixing in product and waste, the final value of the product quality was achieved about 55% better than before.
- New design solved the problem of mixing the valuable minerals (concentrate) and tail.
- New splitters adjustment is much more efficient and work with new splitters is much easier for operators.

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