

ACCUMULATING CONVEYOR SYSTEM

BACKGROUND OF INVENTION

The present invention pertains to an accumulation technique and a conveyor system utilizing the accumulation technique. The invention may be applied to an individual accumulation conveyor line or to a conveyor system made up of a plurality of accumulation conveyor lines having outputs merged at a merge assembly.

It is known to provide accumulation capability in conveyor systems in order to accommodate uneven throughput of articles in the system. For example, a conveyor system may receive articles on conveyor lines fed from loading doors in which trucks or other containers are discharged of articles at the loading doors. Some loading doors may be receiving articles, while others are not. Likewise, the conveyor system may be applied to a manual pick operation in which totes or other containers of articles are received along various conveyor lines at various intervals and are supplied to a downstream process. The rate of input of articles to the conveyor lines may be uneven. It is desirable to provide accumulation of articles along the conveyor lines. The conveyor lines may supply a merge assembly in order to combine the outputs of the conveyor lines prior to supplying articles to a downstream process, such as a sortation system.

SUMMARY OF INVENTION

An accumulation conveyor system and method of accumulating articles, according to an aspect of the invention, includes providing an accumulation assembly that is adapted to accumulating a plurality of articles into a slug of articles. The slug of articles has a nominal length. A transport line is provided that is made up of a plurality of tandem transport conveyors downstream of the accumulation assembly. A control is provided for the accumulation assembly and the transport lines. The control discharges individual slugs from the accumulation assembly and transports the slugs from the accumulation assembly with the transport conveyors. The control monitors slugs at the transport conveyors and accumulates slugs with the transport conveyors.

An accumulation conveyor apparatus and method of accumulating articles, according to another aspect of the invention, includes providing a conveying surface divided into a plurality of conveying sections. The conveying sections define

tandem accumulation zones. A control is provided that monitors articles on the conveying surface and operates the conveying sections to accumulate articles in the zones. The control operates the conveying sections with articles accumulated in the zones to form a slug by reducing gaps between the articles.

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10 zones. The control operates the conveying sections to form a slug by reducing gaps between articles in sequence from upstream gaps to downstream gaps.

 An accumulation conveyor apparatus and method of accumulating articles, according to another aspect of the invention, includes providing a conveying surface divided into a plurality of conveying sections. The conveying sections define
15 tandem accumulation zones. Article sensors are provided that are associated with the conveying sections and are positioned at interfaces of the conveying sections. A control is provided that monitors articles on the conveying surface and operates the conveying sections to accumulate articles in the zones by terminating operation of the conveying section when the associated article sensor senses a trailing portion of
20 an article at that conveying section. The control operates the conveying sections with articles accumulated in the zones to form a slug by reducing gaps between articles.

 The reverse-slug accumulation function allows accumulation in a manner in which it is both efficient and which allows for cycling on and off of each conveyor
25 section only once during the accumulation of a slug. This, advantageously, allows motorized rollers to be utilized to operate the accumulation zones although other types of drives may also find benefit from these aspects of the invention.

 These and other objects, advantages and features of this invention will become apparent upon review of the following specification in conjunction with the
30 drawings.

BRIEF DESCRIPTION OF DRAWINGS

 Fig. 1 is a top plan view of an accumulation conveyor system, according to an embodiment of the invention;

Fig. 2 is a flowchart of a method of accumulating articles, according to an embodiment of the invention;

Fig. 3 is the same view as Fig. 1 showing a plurality of accumulation conveying lines merged;

5 Fig. 4 is the same view as Fig. 1 illustrating details of an accumulation assembly;

Fig. 5a is a top plan view of a conveying surface useful with the invention;

Fig. 5b is the same view as Fig. 5a of an alternative embodiment;

10 Figs. 6a-6e are top plan views of an accumulation assembly illustrating accumulation of articles; and

Figs. 7a-7i are top plan views of the accumulation assembly in Figs. 6a-6e illustrating the elimination of gaps while discharging articles.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and the illustrative embodiments depicted
15 therein, an accumulation conveyor system 10 includes an accumulation assembly 18 for accumulating articles into slugs and a transport line 12 for transporting slugs and accumulating slugs as required (Fig. 1). A plurality of such accumulation systems may be combined and merged with a merge 14, the output of which is supplied to a downstream process 16 (Fig. 3). The downstream process may be a sortation
20 process, a palletizer, an automatic storage and retrieval system, a shipping function, or the like. Accumulation assembly 18 may be made up of a slug forming section 19 and a slug combining section 21. The slug forming section accumulates articles into slug portions. The slug combining section accumulates slug portions into larger slugs. The slugs are discharged from the slug combining section and transported by
25 transport conveyors 13 of the transport line to a terminal end 15 of the line. At the terminal end of the line, the slugs may be accumulated or may be discharged. If the transport line is feeding a merge, then slugs may be accumulated while the transport line of other accumulation conveyor systems is discharging slugs.

A method 50 of accumulating articles begins at 52 by accumulating articles
30 with slug forming section 19. As will be set forth in more detail below, the articles in the illustrative embodiment are accumulated with gaps between the articles. Articles are discharged at 54 from slug forming section 19 to slug combining section 21. In the illustrative embodiment, gaps are reduced from between the articles beginning from upstream gaps and progressing toward downstream gaps, as will be

described in more detail below. The slug portions are combined at 56 with slug combining section 21. As illustrated in Fig. 1, slugs are accumulated with slug combining section 21 by moving a conveyor surface 29 thereof in order to accommodate the incoming slug portion. Thus, the slug "grows" from the upstream portion of the conveying surface 29 without substantial gaps between the slug portions. This provides a slug, which either has no gaps or controlled gaps between the articles.

After a slug portion is combined with a developing slug at 56, it is determined at 58 whether a complete slug has been formed with the slug combining section. If not, control returns to 52 for additional articles to be accumulated and the slug portion discharged at 54 and combined with the growing slug at 56 until an entire slug is formed. When it is determined at 58 that an entire slug has been formed, the slug is discharged at 62 to transport line 12 and transported sequentially by transport conveyors 13 to terminal end 15. Photo sensors 26 at the transport conveyors determine which transport conveyors have slugs accumulated thereon. The slugs accumulate from the transport conveyor adjacent terminal end 15 upstream to other transport conveyors in a sequential manner. It is then determined at 62 whether transport line 12 is to be discharged, such as receiving a discharge signal from a system control (not shown). If it is determined at 62 that the transport line is not discharging, slugs accumulate on the transport conveyors at 64, as previously described. If it is determined at 62 that the transport line is in a discharging mode, transport conveyors 13 are actuated to discharge slugs at 66. Because articles and slugs of articles are positively conveyed, such as with belt conveyors, throughout the accumulation conveyor system, gaps may be introduced, if desired, and maintained throughout the process. This not only avoids the build-up of line pressure, which can cause side-by-side articles as well as knocking of articles together, but also is capable of maintaining any gaps established between the articles throughout the accumulation process. Moreover, it is contemplated that transport conveyors 13 may be operated at a particular speed in order to accumulate slugs and operated at a second, higher speed in order to discharge the slugs of articles from terminal end 15, such as to merge 14, or the like.

Slug forming section 19, in the illustrative embodiment, is made up of a series of tandem zone conveyors 24, which, in the illustrative embodiment, are belt conveyors 22. The zones are numbered 1-8 for illustration purposes. The belt

conveyors may be arranged in a straight line, as illustrated in Fig. 5a. Alternatively, the zones may be arranged in a turn, as illustrated in Fig. 5b. The conveyor zones define a conveying surface 20, which conveys articles from a gapping conveyor 28 through the slug forming section. The gapping conveyor introduces a gap between articles in order to allow articles to be individually measured and handled. In the illustrative embodiment, a 60 percent speedup is provided in order to provide significant separation between the articles. However, selection of degree speedup would be within the skill of the ordinary artisan and may vary with application. An object sensor 26 is provided between the interfaces between adjacent conveyor zones 24. In the illustrative embodiment, the photo eye is aimed at an angle in order to sense the leading edge of an article in the upstream zone and the trailing edge of an article in the downstream zone. Outputs of object sensors 26 are supplied to a control 27. Outputs of control 27 are supplied to motors operating the individual belt conveyors 22. As described in the previously referred to co-pending applications, such belt conveyors may advantageously be driven with a motorized roller. This provides for compact configuration. However, it should be understood that other drives may be utilized for the belt conveyors and other types of conveying surfaces, such as driven rollers, and the like, may be used for the zone conveyors. In the illustrated embodiment, zone conveyors 24 are illustrated at .5 meters in length, but may be of a greater or lesser length. The build length of slug forming section 19, in the illustrative embodiment, is 3 meters.

Slug combining section 21 is made up of a series of tandem arranged slug handling conveyors 23 which make up a conveying surface 29. One or more object sensors 26 may be arranged along conveying line 29 in order to monitor slug portions being combined into a growing slug. In the illustrated embodiment, slug-handling conveyors 23 are 1 meter in length, but may be other lengths. Moreover, conveying surface 29 may be a single, longer conveyor extending the length of the slug combining section. The length of conveying surface 29 is intended to equal a nominal length of the slug being developed. In the illustrative embodiment, a 6-meter nominal length of the slug is utilized, although other lengths may be selected.

The length of each transport conveyor 13 is generally equal to the nominal length of each slug, which is the same length as conveying surface 29 of slug combining section 21. Thus, each slug may move from the conveying surface 29 to a transport conveyor and accumulated on a single transport conveyor 13. However,

transport conveyors could be shorter in length with a slug accumulated on more than one transport conveyor.

Accumulation assembly 18 further includes a feed conveyor, such as a gap-adjusting conveyor 28, upstream of conveying surface 20 which is supplied by articles, such as from a charge conveyor 30 (Figs. 6a-7i). Gap-adjusting conveyor 28 provides a speed increase in order to ensure that a physical gap is present between the articles. The gap is in order to allow the leading and trailing region, namely an edge, of each article to be detected by photo-eyes 26. Gap-adjusting conveyor 28 may be operated in a start/stop fashion with a speed increase from charge conveyor 30 in order to ensure the presence of gaps between articles. Alternatively, gap-adjusting conveyor 28 may be made up of a plurality of meter belts, which are operated according to variable speeds in order to ensure gapping between the articles. In the illustrative embodiment, gap-adjusting conveyor 28 is a fixed ratio, such as 160 percent, of the speed of charge conveyor 30.

Slug forming section 19 of accumulation assembly 18 is operational in an accumulation mode 34 (Figs. 6a-6e) and a discharge mode 36 (Figs. 7a-7i). Accumulation mode 34 may begin with conveying surface 20 empty, as illustrated in Figs 6a. With the conveying surface 20 empty, a first article A1 moves from gap-adjusting conveyor 28 and propelled by zone conveyors 24 which are operating continuously until article A1 reaches downstream zone 1, at which time the zone conveyor for zone 1 discontinues operation when it senses a trailing edge of article A1 by the photo-eye 26 at an upstream location of that zone. The zone conveyor for zone 1 may discontinue operation immediately upon sensing the trailing edge of article A1 or after a delay. A second article A2 moves from gap-adjusting conveyor 28 and transported by the zone conveyors upstream of zone 1 until article A2 reaches zone 2 and the trailing edge of article A2 is sensed by the photo-eye at an upstream portion of zone 2. The articles continue to accumulate in this fashion, as seen in Figs. 6c-6e, with an article in each zone. A particularly long article that is longer than each zone conveyor may be accumulated in two or more zones within the principle of the present invention.

When all of the zones are full, as illustrated in Fig. 6e, the slug-forming portion of the accumulation assembly enters a discharge mode 36 (Figs. 7a-7i). In the discharge mode 36, the zone conveyor 24 of zone 6 is operated until the leading edge of article A6 is detected by the photo-eye for zone 5. Either through a skewed

orientation of the photo-eye, as illustrated in Figs. 5a and 5b, or because of a delay built into the cycling off of a zone upon accumulating an article therein, or both, a controlled gap, which may be selected to be as small as desirable, may be provided between articles A5 and A6. As soon as the leading edge of article A6 is detected by the photo-eye 26 of zone 5, the zone conveyor of zone 5 is actuated on. This results in the leading edge of article A5 being detected by the photo-eye of zone 4, as illustrated in Fig. 7c. At that time, the zone conveyor of zone 4 is actuated on, resulting in the leading edge of article A3 being detected by the photo-eye for zone 3, as illustrated in Fig. 7d. At that time, the zone conveyor for zone 3 is actuated on, resulting in the leading edge of article A4 being detected by the photo-eye for zone 2, as illustrated in Fig. 7e. At that time, the zone conveyor for zone 2 is actuated. When the leading edge of article A5 is detected by the photo-eye for zone 1, the zone conveyor for zone 1 is actuated. Once a zone conveyor is actuated in the discharge mode, it may remain operational thereby moving the slug along the conveying surface without introducing further gaps between the articles. The accumulated portion is discharged from the conveying surface 20, as illustrated in Figs. 7g-7i.

If desired, the slug forming portion 19 of accumulation conveyor 18 may enter the accumulation mode concurrently with forming a slug portion during the discharge mode 36. This is illustrated in Figs. 7e-7i. In particular, as a slug portion is formed and moved forward, new articles may be accumulated on the emptied zones behind the slug portion.

When all articles have accumulated into a full slug, the head of the article at zone 1 will block an article present photo-eye 42. This will signal the control of the system that the slug portion is ready to be released. Release may occur immediately or may be delayed, if necessary, in order to sequence the output of the slug portion to slug combining section 19. The delay may occur before or after the slug portion is formed. During the release of the accumulated slug portion, the zones occupied by the current slug portion will activate sequentially or simultaneously, releasing the slug portion downstream to the slug combining section and allowing the next round of articles to occupy the zones. Once the accumulated slug portion has been completely released and all zones have been rebuilt, the discharge cycle may be repeated. As a slug portion is released to slug combining section 19, it is combined with prior slug portions already on conveying surface 29. This is accomplished by

indexing conveying surface 19 at the same rate the slug portion is released from the slug-building portion. Once an article sensor 26 senses that a complete slug S has been formed, the slug is released to transport conveyor 12 where it is transported to terminal end 15 for discharge or accumulation with other slugs.

- 5 Changes and modifications in the specifically described embodiments can be carried out without departing from the principles of the invention which is intended to be limited only by the scope of the appended claims, as interpreted according to the principles of patent law, including the Doctrine of Equivalents.

What is claimed is:

1. An accumulation conveyor system, comprising:
an accumulation assembly adapted to accumulating a plurality of articles into a slug of articles, the slug of articles having a nominal length;
a transport line comprising a plurality of tandem transport conveyors downstream of said accumulation assembly; and
a control for said accumulation assembly and said transport line, said control discharging individual slugs from said accumulation assembly and transporting the slugs from said accumulation assembly with said transport conveyors, said control monitoring slugs at said transport conveyors and accumulating slugs with said transport conveyors.
2. The accumulation conveyor system of claim 1 wherein said transport conveyors have lengths substantially equal to said nominal length.
3. The accumulation conveyor system of claim 1 wherein said accumulation assembly accumulates articles with or substantially without gaps between the articles.
4. The accumulation conveyor system of claim 1 wherein said control accumulates slugs at the transport line from downstream transport conveyors to upstream transport conveyors.
5. The accumulation conveyor system of claim 4 wherein said transport conveyors accumulate slugs at a first speed and discharge accumulated slugs at a second speed that is higher than said first speed.
6. The accumulation conveyor system of claim 1 wherein said accumulation assembly comprises a plurality of conveying sections defining tandem accumulation zones and wherein said control operates said conveying sections to accumulate articles in said zones and form a slug by reducing gaps between articles in sequence from upstream gaps to downstream gaps.

7. The accumulation conveyor system of claim 1 wherein said accumulation assembly comprises a slug forming section and a slug combining section, said slug forming section forms slug portions and discharges slug portions to said slug combining section, said slug combining section combines slug portions into slugs.
8. The accumulation conveyor system of claim 1 including at least two of said accumulation assemblies and at least two of said transport lines, each downstream of a respective one of said at least two accumulation assemblies, said system further including a merge for merging slugs from said transport lines and a downstream process downstream of said merge.
9. An accumulation conveyor apparatus, comprising:
 - a conveying surface divided into a plurality of conveying sections, said conveying sections defining tandem accumulation zones;
 - a control, said control monitoring articles on said conveying surface and operating said conveying sections to accumulate articles in said zones, said control operating said conveying sections with articles accumulated in said zones to form a slug by reducing gaps between articles.
10. The apparatus of claim 9 wherein said control starts and stops individual ones of said conveying sections no more than once during an accumulation cycle.
11. The apparatus of claim 9 wherein said control forms the slug concurrently with discharging articles from said conveying surface.
12. The apparatus of claim 9 including a slug combining section downstream of said conveying surface to combine slugs into larger slugs.
13. The apparatus of claim 9 further including a transport line comprising a plurality of tandem transport conveyors downstream of said accumulation assembly, wherein said control discharges individual slugs from said accumulation assembly and transports the slugs from said accumulation assembly with said transport conveyors, said control monitoring slugs at said transport conveyors and accumulates slugs with said transport conveyors.

14. The accumulation conveyor apparatus of claim 9 wherein said accumulation assembly forms a slug by reducing gaps between articles in sequence from upstream gaps to downstream gaps.

15. The accumulation conveyor apparatus of claim 9 including at least two of said conveying surfaces, said apparatus further including a merge for merging slugs from said conveying surfaces and a downstream process downstream of said merge.

16. The accumulation conveyor apparatus of claim 9 further including article sensors associated with said conveying sections, wherein said article sensors are positioned at interfaces of said conveying sections, wherein said control monitoring articles on said conveying surface and operating said conveying sections to accumulate articles in said zones by terminating operation of a conveying section when the associated article sensor senses a trailing portion of an article at that conveying section.

17. The apparatus of claim 16 wherein said control operates said conveying sections to discharge articles by initiating operation of a conveying section when an associated article sensor senses a leading portion of an article upstream of that conveying section.

18. A method of accumulating articles, comprising:
providing an accumulation assembly and accumulating a plurality of articles with said accumulation assembly into a slug of articles, the slug of articles having a nominal length;

providing a transport line comprising a plurality of tandem transport conveyors downstream of said accumulation assembly;

discharging individual slugs from said accumulation assembly and transporting the slugs from said accumulation assembly with said transport conveyors, including monitoring slugs at said transport conveyors and accumulating slugs with said transport conveyors.

19. A method of accumulating articles, comprising:
- providing a conveying surface divided into a plurality of conveying sections,
 - said conveying sections defining tandem accumulation zones;
 - operating said conveying sections to accumulate articles in said zones;
 - operating said conveying sections with articles accumulated in said zones
- thereby forming a slug by reducing gaps between articles.