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Eco Issues in Bulk Materials Handling Technologies in Ports

This paper deals with eco issues in bulk materials handling in ports. Solid, free-flowing materials are said to be in bulk. Bulk materials handling is very difficult, because it incorporates all the features of liquids, gasses and mass solids. Energy efficiency, dust emissions in nearby environment, dust explosions, jamming, noise, handling of hazardous materials and protection of materials from contamination are issues that will be considered in this paper. Here are also presented possible solutions for some of these issues.

***Keywords**: Ports, bulk materials handling, eco issues, eco efficiency*

1. Introduction

Environmental awareness becomes increasingly important in every aspect of human's life: politics, economics and everyday life [1]. Current developments present new challenges for ports and terminals. Environmental aspects reflects in:

- climate change
- scarcity of space
- globalization
- improved quality of life
- hunger for energy, consumer demand
- ecological market economy - combining economy and ecology

According to [1] forms of environmental impacts in ports particularly relevant for manufacturers of handling equipment are:

- noise and light
- exhaust gas
- dust
- space
- energy wastage;

Other forms of environmental impacts in ports are:

- waste
- excavation work and removal of the excavated material
- loads hazardous to the environment
- refueling
- disposal of wastewater from the ships

Considering that most of our energy resources are based upon fossil energy sources and therefore necessity of implementing environmentally friendly technologies in bulk materials handling industry, there is still an enormous potential to save energy and costs as well [2]. Since most of the energy is consumed by electric motors big costs and energy savings can be achieved by energetically optimizing drives.

In order to properly present port handling systems there is performed certain systematization of port handling equipment shown in Figure 1.

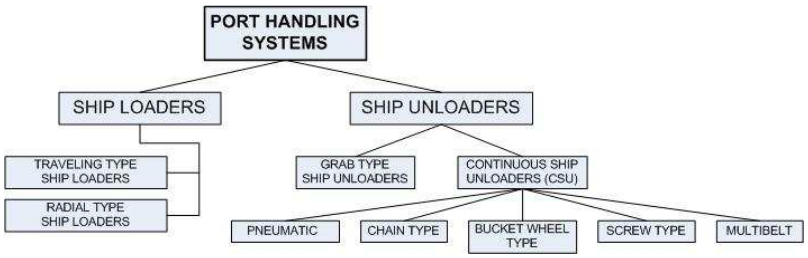


Figure 1. Systematization of port handling equipment

In port handling systems the grab unloader is the machine that is most widely used, in conjunction with the correct grab and environmental hoppers [3, 4]. By using different grabs for each product helps avoid contamination and ensures safety. It also helps the user to be quicker and increase efficiency.

The main problem with using grabs to fill soybean meal (SBM) is that the filling of the grab is difficult and time wasting. Also the discontinuous operation is more difficult to patrol and requires constant attention from the operator. Because the need for a hopper grabs also need dedusting system.

This paper deals particularly with continuous ship unloaders (CSUs).

Most recent high-capacity dockside coal ship unloaders have tended to be of the continuous bucket-elevator or screw types, while grab cranes have found favor for open-sea and mid-stream floating coal transshipment facilities.

When using a chain type CSU for unloading non-free flowing materials like SBM, the problem can come in the feeding of the material into the conveyor and therefore there is the tendency to make a hole. The use of bulldozers is also required for the feeding process. The use of feeders such as attached scrapers solves this problem, but makes equipment heavy and consequently expensive. In

addition, movement of the cargo with a scraper and chain conveyor generates dust, Figure 2.

Figure 2. Chain type CSU at clean up

The main disadvantages of screw type CSU with feeder are the price, weight, wear and the possibility of jamming if foreign material enters the screw-system.

The normal pneumatic system is suitable for free-flowing materials and it moves dry granular materials with significant reductions in product degradation and/or system wear. The pipe system makes a hole in the material, while a bull-dozer then pushes the material feeding the nozzle. Simple systems, such as cutting devices, make the hole bigger but also need to use bulldozers to get a reasonable unloading rate. When unloading SBM it has to be equipped with digging device.

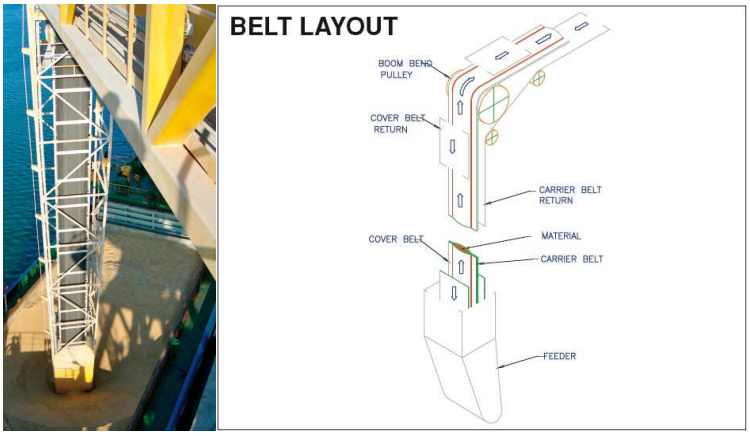


Figure 3. Multibelt type CSU

The design of multibelt CSU, Figure 3, allows unloading almost all material left in the ships hold, leaving only approximately 5 ton that needs to be lifted out [5]. The feeder has a dust collection system as do all transfer points on the multibelt.

2. Energy efficiency

Energy efficiency means using less energy inputs while maintaining an equivalent level of economic activity or service [6]. An example is the black-box, Figure 4, consideration of energy efficiency in a company in an economic way [7]:

$$\text{Energy Efficiency } \left[\frac{\$}{\text{kW h}}\right] = \frac{\text{Net Production Value } [\$]}{\text{Prime EnergyInput } [\text{kW h}]}$$

Figure 4. Energy efficiency in economic way

In the field of port handling the unloading equipment caused by far the main part of the energy consumption [8]. Thus, process of ship unloading offers also the greatest energy and costs saving potential. The calculated life cycle costs for different types of continuous ship unloaders (CSUs) are shown in Figure 5, 6.

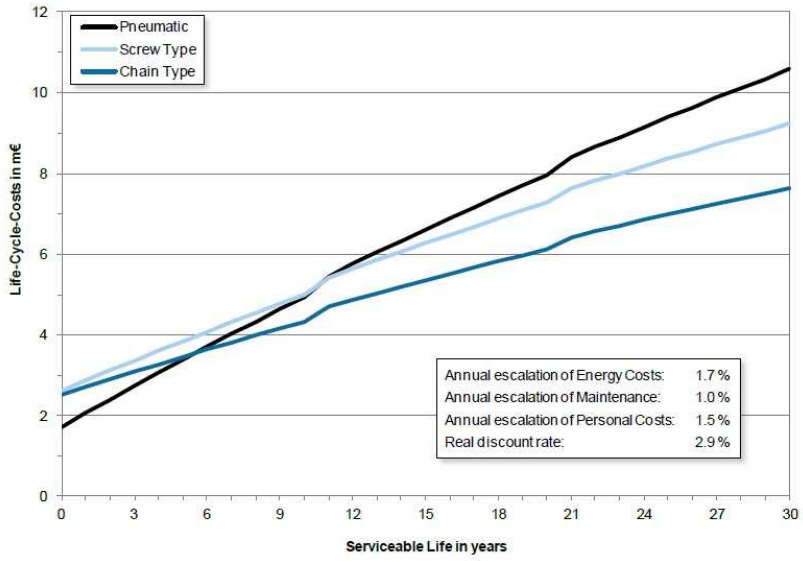


Figure 5. Life cycle costs of different kinds of ship unloaders

	Pneumatic	Screw Type	Chain Type
Acquisition Costs	1,700,000 €	2,600,000 €	2,500,000 €
Average Capacity	60 %	75 %	80 %
Power consumption per ton	1.4 kWh/t	0.9 kWh/t	0.4 kWh/t
Maintenance costs (first year)	70,000 €	56,000 €	53,000 €

Figure 6. Data of ship unloaders

The higher costs of pneumatic unloaders are not only caused by the higher power requirement of those machines, but result also from the less averaged capacity and the therefore longer unloading time. A comparison of the similar effective unloaders of screw and chain type shows the cost benefit, caused by the lower power requirement. Speaking of multibelt type CSU, the conveyor runs vertical and horizontal without a transfer point up to the discharging point [5]. The belts run inside the air box that has a special seal to minimize air losses. The low power consumption of multibelt CSU compared to any other continuous unloader makes it possible to work with 0,25 kWh/ton.

3. Dust

Speaking of dust in port handling systems, dust emissions causes [9]:

- Indirect costs related to the cleaning of surrounding areas
- Contamination of nearby urban areas with many nuisances
- Direct or indirect damages to other goods in ports and their installations

Grabs are most commonly used for unloading bulk materials, and dust is without a doubt the major unavoidable consequence of this technology.

The alternatives are CSUs. Here dust control engineering can be divided in three main areas:

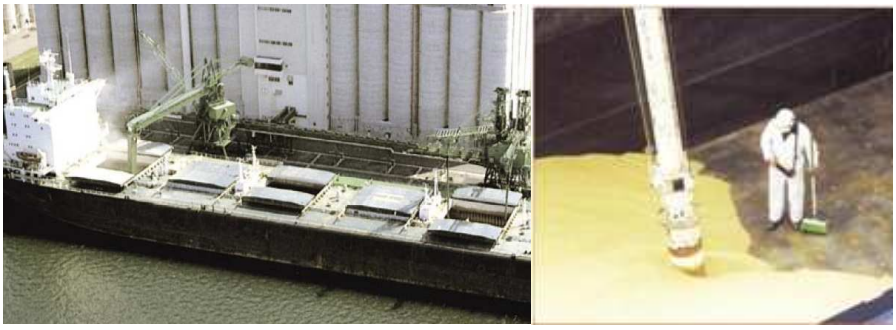
- In the hold: to lift the products into the CSU
- In the unloader, all along their conveying
- In the delivery or the interconnecting point to the trucks, the wagon or the quay side conveyor.

The principle of the mechanical systems is that a rotating device will either directly lift the bulk material into the vertical arm (chain or screw type) or scrape around to feed the twin-belt system. When the intake booth is sufficiently deep within the bulk material there is no dust, but if the height of the materials surrounding these rotating parts is not sufficient the mechanical devices will agitate the material with ambient air and this turbulence will blow dust into the nearby environment.

This phenomenon usually occurs during cleaning when the rotating device has reached the lowest layers of the material close to the hold bottom and the auxiliary equipment is not working adequately in order to ensure sufficient bulk material height around it.

It should be noted that the amount of bulk material remaining in the hold during the cleaning process is rather more important with mechanical systems in comparison to pneumatic unloaders, and it is therefore necessary to put more and heavier auxiliary equipment like bulldozers in the holds, Figure 7. This is also the origin of dust, Figure 8. The dust makes it also difficult to work on the engines and precaution should be taken to avoid dust explosion. The main problem is that there is not a 100% solution that removes the need for a person to enter the ship's hatch [3, 9]. Cleaning in the hold is the major health concern, also. Thus, auxiliary equipment drivers must normally wear a face mask.

Figure 7. Use of bulldozers when cleaning in the hold



(a) mechanical CSU generating dust (b) pneumatic CSU – no dust

Figure 8. Operating mechanical and pneumatic CSUs

During continuous conveying of the unloader dust is easily controlled through standard filtering systems such as those commonly found in the grain industry. Two main filtering techniques that exist are jet pulse system and a low pressure fan (less than one bar).

At the exit(s) of the conveyor (mechanical or pneumatic CSU), the materials have to be delivered with a minimum of dust emission. The most common devices to achieve this for trucks and wagons are simple telescopic loading pipes, Figure 9, and similar pipes, with an integrated air suction fan and filter.

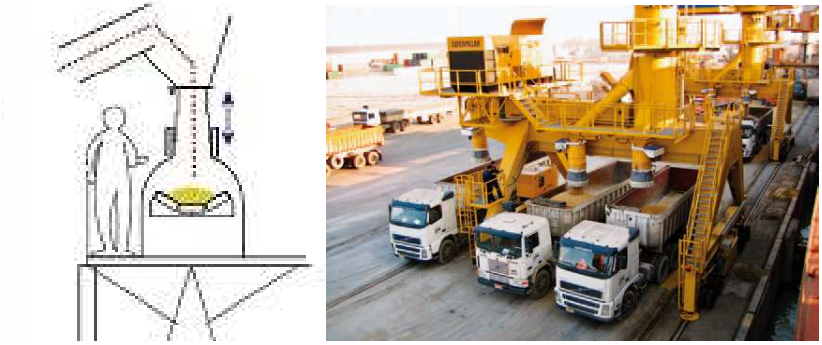


Figure 9. Telescopic loading chute

4. Jamming

Foreign materials are affecting all continuous systems and can cause operations stop [5]. Screw and chain may jam with foreign bodies and the belt can be damaged at the multibelt. Foreign body sensors and automatic stops minimize the problem.

Figure 10. Pneumatic type CSU with digging device

Another solution for reducing the problem of jamming from foreign materials is use of pneumatic CSU with feeder [3, 4]. It can also be equipped with an additional kick-in and -out and a slewing system so as to reach the areas under the ships hatch, Figure 10. The system is also said to be environment friendly, emits little noise and reduces dust by sucking it back into the system.

5. Dry bulk shipping container liners and bulk bags

Another way of transportation of bulk material is in discrete loads in bulk bags, Figure 11, canisters and containers. It is especially suitable for hazardous materials and dust control.

Figure 11. Waterplex Big Bags and liners for shipping containers

Waterplex dry bulk shipping container liners provide bulk transportation with minimal packaging, reducing cost, safe and hygienic transportation of dry goods, protection of materials and food stuffs from contamination, dust control for sensitive environment [10].

6. Conclusion

In port handling systems the advantages of the multiple use of a grab for different products, even fertilizer, are strong if a multipurpose discharging is needed, but when using grab for SBM handling, filling the grab is difficult and time wasting. Besides it is discontinuous operation and needs dedusting system also.

The advantage of chain type CSU is the relatively low power consumption, especially when large capacities are needed. Screw type CSU with feeder is suitable for SBM without the intensive use of bulldozer to feed the unloader. The main disadvantages of screw type CSU with feeder are price, weight, wear and the possibility of jamming if foreign material enters the screw system. Pneumatic conveying systems move dry granular materials with significant reductions in

product degradation and/or system wear. The pneumatic unloader has the same disadvantages of the chain unloader but has the ability to take all of the material out of the ship and is dust free. With addition of feeder and kick-in and –out and a slewing system pneumatic CSU can reach areas under the ship's hatch and handle SBM without operational stops because of jamming with forign materials, emits little noise and reduces dust by sucking it back into the system. The bucket wheel type continuous ship unloader is lighter than the bucket chain type one because it has a compact digging element with high digging capacity and a rubber belt type elevating conveyor with high speed. Its power consumption is also lower because unloading can be achieved only by the rotating and tilting of vertical arm at the top of the boom. In addition, the dust pollution can scarcely be occurred because of airtight construction from the digging element to the jetty transfer point. The belt and conveying material running at the same speed is an advantage of the multibelt because less wear is caused by abrasive products like soybeans and less breakage or degradation of sensitive products like corn and rice. Another multibelt advantage is the low weight compared with other systems. The main advantages of multibelt dynamic counterweight – e-balance system are weight economy and constant feeder pressure independent of the feeder position.

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