RECYCLING OF SOLID WASTES IN MINING AND METALLURGY

Vaisberg L.A. D.Sc. Zarogatsky L.P. Ph.D.

Mekhanobr-Tekhnika Co.3, 22-nd Liniya, St.Petersburg, 199106, Russia

ABSTRACT

During the 20-th century alone the mankind has accumulated hundreds of millions tons of metalliferous wastes. Such wastes as ore processing mill tailings feature metals content exceeding that in low-grade ore deposits whereas metallurgical slags contain as much as 20 to 40 per cent of metals. Unfortunately, the mill tailings contain metal-mineral aggregates that are difficult to separate and metallurgical slags contain metal pieces which are likely to damage crushing equipment. The way to utilize and recycle such industrial wastes was open by invention of vibrating crusher-mills. The new crushers are capable of liberating metal-mineral aggregates without any risk to be damaged. The crushers when included into processing flowsheets containing vibrating screens, vibrating classifiers , magnetic and electrostatic separators will form plants , either stationary or mobile ones,.for processing such wastes.

INTRODUCTION

The end of the 20-th century saw such a dramatic accumulation of metal wastes aggravated by radical renovation of machinery that the world community felt an urgent need to recycle them. Despite the complexity of the problem (dissection of ship hulls, shredding car junk, recycling electronic scrap) the process turned out to be by far more profitable than recovering metals from ores. The situation is aggravated by the fact that high-grade deposits are being progressively ousted by low-grade ones that require ever greater costs to develop.

The rapid growth of the planet's population, which has already crossed the six billion threshold, and the accompanying industrial boom have proved the current metal recycling approach to be inadequate for the ever growing industrial needs. That is why the rate of development of the new deposits shows no sign of slowing down.

When low-grade deposits are commissioned the requirements to commercial minerals recovery become more rigorous than ever. And yet, the equipment and ore preconcentration methods have barely changed over the last 150 years, although the state of art in the ore beneficiation domain has perceptibly progressed.

PROBLEMS

By the end of the 20-th century the recovery of non-ferrous and precious metals from ores is known to be within 50 to 80 per cent range. It follows that concentrator tailings and dumps must contain such an amount of valuable metals that more often than not exceeds their initial content in low-grade ores. Heavy losses of metals are largely explained by the presence of large amounts of non-liberated metal-mineral aggregates in the product leaving preconcentration stages, by overgrinding down to - 20μm size and by granulation effect. Granular-shaped particles are hard to separate and the bulk of them tends to go to dumps.

Thus processing of the above-mentioned wastes especially of gold mining operations is likely to become a profitable business provided a new ore preconcentration method be employed ensuring selective liberation of ore minerals with no overgrinding.

Coal concentration tailings which are taken to coal refuse dumps contain 20-30 per cent of residual coal .Such dumps are easily combustible and besides they contaminate ground water.

Another problem confronting mine-and-mill complexes is processing of rubber wastes including truck tyres, conveyor belts and mill linings. The total mass of truck tyre wastes is far greater than those of car tyres and both present a valuable raw material for rubber recycling.

Copper and aluminum slags are known to contain up to 30 per cent of metal. To process them, special furnaces are designed or alternatively special presses are used the latters capable of extruding not more than one third of the metal contained there.

One more problem is regeneration of refractories. The process is complicated by the presence of metal scrap which must be separated. The problem is aggravated by the risk of overgrinding , since the inclusion of fine particles deteriorates the product quality.

The problem of foundry sand regeneration also deserves a particlular consideration since the regenerate has to meet strict size distribution specifications to provide for required gas permeability in moulding. It means that no pellet-shaped particles are allowed to be found in the regenerate.

Large mining and concentrating companies employ numerous service personnel numbering tens of thousands of people who have their own families which all together form large urban communities of up to100 thousand people and more. Like all the other urban communities these industrial centers face the problem of municipal and industrial refuse disposal.

The refuse incineration plants need much energy and create new environmental problems.

SOLUTION

The solution of all above mentioned problems was found by implementation of a new ore preconcentration method based on the use of vibrating crushers.

The method proved to be highly efficient for processing tailing dumps containing metal-mineral aggregates and pellet-shaped particles which are hard to separate by known methods. The method in question will help separate even metal particles as fine as 1-2 µm in size from a bulk of overground material when a vibroconcentrator is included into the flowsheet.

Shown in Fig.1 is the flowsheet of a 50 t/h gold-recovering mobile plant. A vibrating jaw crusher can be installed at the head of the process if the feed ore contains lumps over 70…100 mm. Extraction of precious and other metals from comminuted wastes is carried out by means of a hydraulic vibroconcentrator which, unlike Knelson concentrators, can recover up to 95 per cent of metal including particles approaching 1 µm size. In this case there is no need to employ concentration tables.

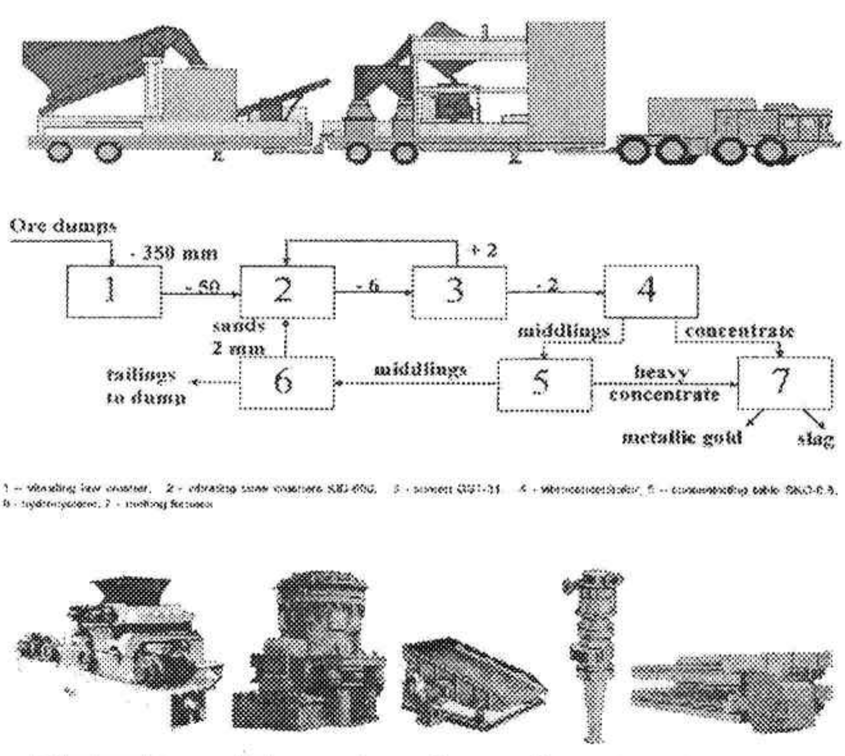

Fig.1. Mobile installation for processing ore dumps.

Fig. 2 presents the basic flowsheet of a coal dump processing. These dumps can be processed on compact installations of up to 10 t/h capacity with low power consumption. The fine crushing vibrating crushers incorporated into the flowsheet yield a product finer than 3 mm where coal is ground finer than the gangue. The gangue particles are encapsulated in coal powder which product can be used for manufacture of building blocks.

Fig.3 shows the flowsheet of a rubber waste processing line. It includes a shredder for cutting large-size pieces into 100 mm shreds. Next follows a series of crushing stages in special high speed hammer crushers yielding 2 mm crumbs from which ferrous magnetic and textile cords are separated. The resultant material is mixed in rolls with addition of a modifier. The modifier consists of 15 components with natural rubber as a matrix. Modifier consumption per a ton of regenerated rubber averages 50 kg, i.e. 5% of total rubber volume.

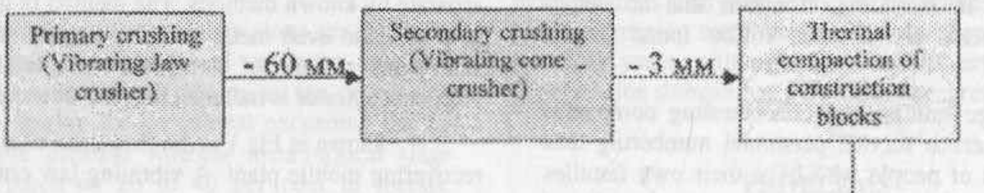

Fig.2 Flowsheet for production of consruction blocks from coal dumps

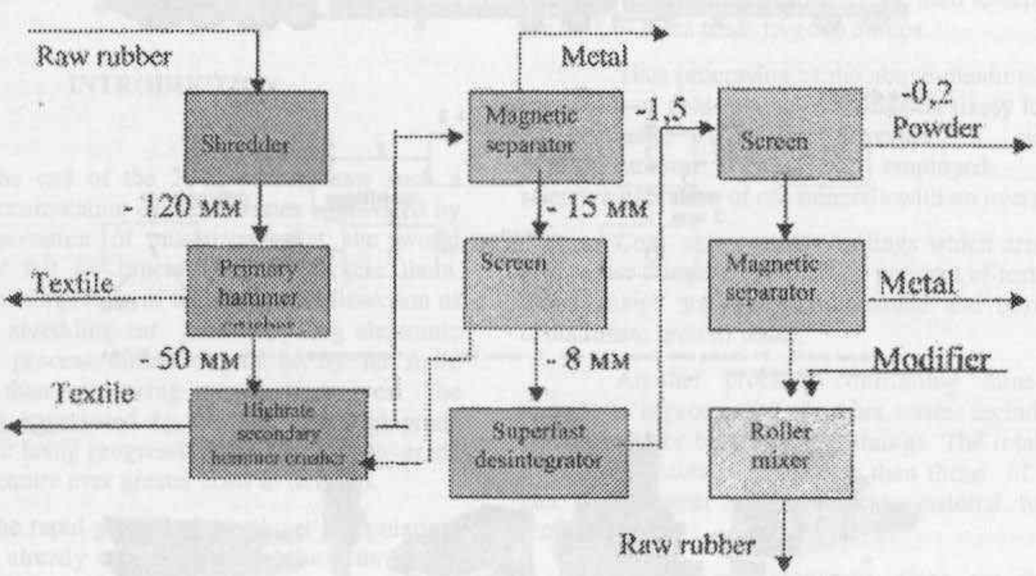

Fig.3 Flowsheet for processing rubber wastes

Articles manufactured from the regenerate retain 75% of original rubber physico-mechanical properties while admixture of 6...7 per cent of natural rubber will bring this figure up to 92 per cent. The plant consumes about 300 kW power at 2.5 t/h capacity and occupies within 500 m^2 of floor space.

The price on the world market for the uncured rubber thus produced ranges from US$800 to US$1500 a ton while the production cost runs within US$250/t.

Fig.4 shows the flowsheet of a slag processing plant.

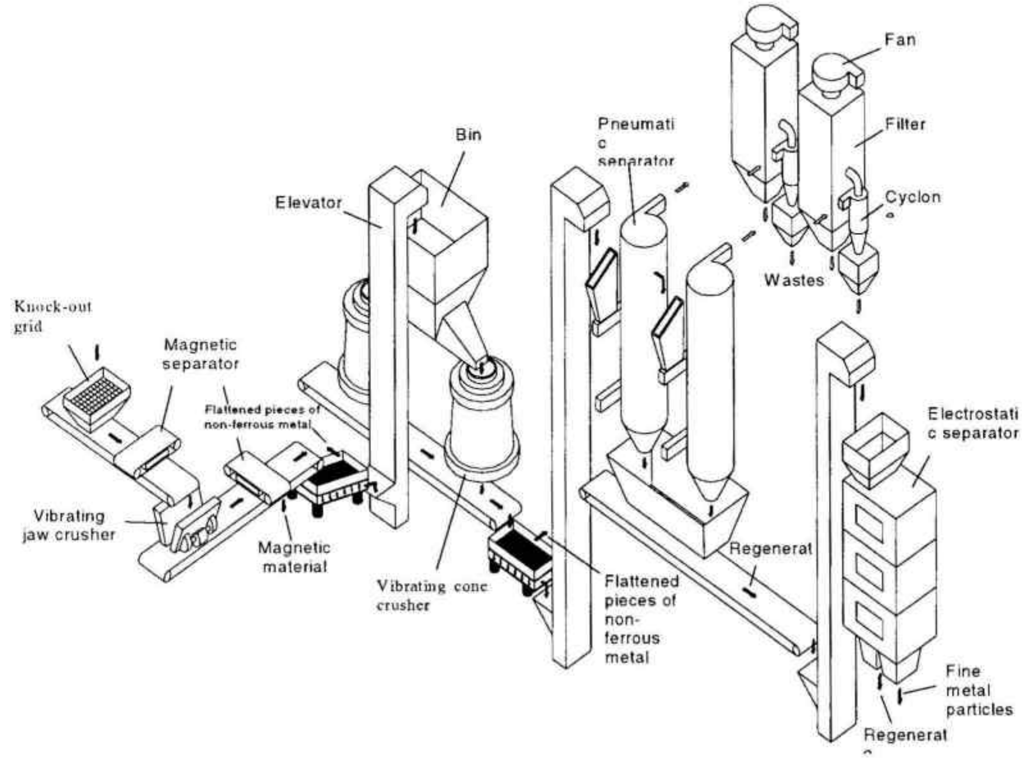

Fig.4. Flowsheet of a line for regenerating casting sands, slags and refractories.

Fig. 5 presents a flowsheet for municipal refuse processing. It demonstrates that on the basis of modern crushing, grinding, classifying and separating equipment it is possible to make up modular plants capable of efficient processing solid wastes without resorting to incineration furnaces.

Non-sorted organic solid wastes may be converted into compost fertilizer by means of special bacteria. Thus the refuse will be completely recycled. The pay-off period of such a plant is 22 months.

RESULTS AND DISCUSSION

As shown in the above flowsheets all the processes of treating wastes are based on the use of vibrating equipment the principal of them being the vibrating crusher-mills whose reduction ratio reaches 30-40. The flowsheets provide for a selective liberation of multi-component minerals decreasing overgrinding by two or three times with no pelletizing effect reported. When used for metal containing waste treatment this technique ensures recovery of up to 90 per cent of all the residual metal.

The above equipment can be incorporated into stationary or mobile or portable processing plants of 5, 10, 20, 30 or 50 t/h capacity. The great advantage of such flowsheets is that they can do without any rod, ball planetary or centrifugal mills, since all precon-centration steps, including fine wet or dry grinding, can be effected by means of vibrating crusher-mills with adjustable crushing force whose reduction ratio reaches 30-40.The flowsheet provides for selective liberation of multi-component minerals, decreasing overgrinding two-threefold with no palletizing effect reported. This technology is capable of recovering up to 90 per cent of residual metals.

The process of foundry sand regeneration involves the use of vibrating crushers featuring adjustable crushing force. Such crushers are capable of attriting water soluble glass and polymer binders. The rege-nerate thus obtained is practically identical to the original sand. The binder particles which are finer than 50 μm in size may be later used as coagulants for precipitation of impurities from liquids.

In coal tailings processing the method provides for obtaining a coal-gangue powder which is used for manufacture of building blocks. This product after pressure moulding and hot compaction is formed into building blocks equal in size to 4 standard bricks.They are twice as strong as foam concrete, their thermal conductivity being almost the same.

The regenerate obtained after rubber waste processing can be used in mining and metallurgical industries for production of rubber lining for ball mills,rotors for sand pumps, impellers for flotation machines, liners for bins and chutes etc. It can also be used for manufacture of new tyres for cars and household articles.

CONCLUSION

In conclusion it should be stated that the application of the above technology and the respective machinery incorporating controllable vibrating drives (including crushers, mills, elevators, multi-deck screens, concentrators, even flotation machines) makes it possible to reduce by half the power consumption and all the other operating costs as compared to the conventional equipment.

The equipment implementing the vibrating drive principles provides possibilities for universal approach to the object of selective liberation of solids contained in municipal and industrial wastes. Owing to this new approach it became possible to simplify the processing flowsheets and ensure the most complete recovery of valuable components providing at the same time for significant saving in power consumption, floor space and other relevant costs

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