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DEVELOPMENT OF A SEMI-INDUSRIAL LOW-COST MAGNETIC INDUCTION SEPARATOR FOR THE RECOVERY OF DOMESTIC AND INDUSTRIAL WASTES

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1.Introduction:

In Algeria the production of municipal solid waste is valued at around 14 million tons per year In due to urbanization, population growth and the economy ,so it will reach 20 million in 10 years, with an urbanization reaching 88% in 2028. This growth will be a challenge for the Algerian authorities to invest in collection facilities, transport and processing and move away from scenarios reserved for sites landfill. This situation has drawn government and non-government agencies to the need to develop efficient methods for recycling metals. The magnetic induction separation method otherwise named eddy current separation could be an effective solution for recovery non-ferrous metals from domestic and industrial wastes [1],

2.Materials and method

The rotary drum type is now the most widely used in the eddy current separation process, as it does not present many design constraints. This technique can separate granular mixtures comprising insulating, ferrous and non-ferrous particles of different sizes, by allowing the realization of a magnetic field distribution, which acts selectively on the particles according to their magnetic nature. The generated radially distributed magnetic field (Figure 1(a)) passing through the particles induces currents inside them, we call them eddy currents. The effect of such eddy currents is to induce a secondary magnetic field around the non-ferrous particles. This field reacts with the magnetic field of the inductor drum, resulting in a combined force; motive and repellent that literally ejects the conductive particles. Combined with the speed and vibration of the conveyor belt, this repulsive force provides the energy necessary for efficient separation. The result of the operation is to collect non-ferrous particles of one type of material (AL, CO, ZN…..) in a compartment and the insulating particles (plastic, wood, glasses ….).

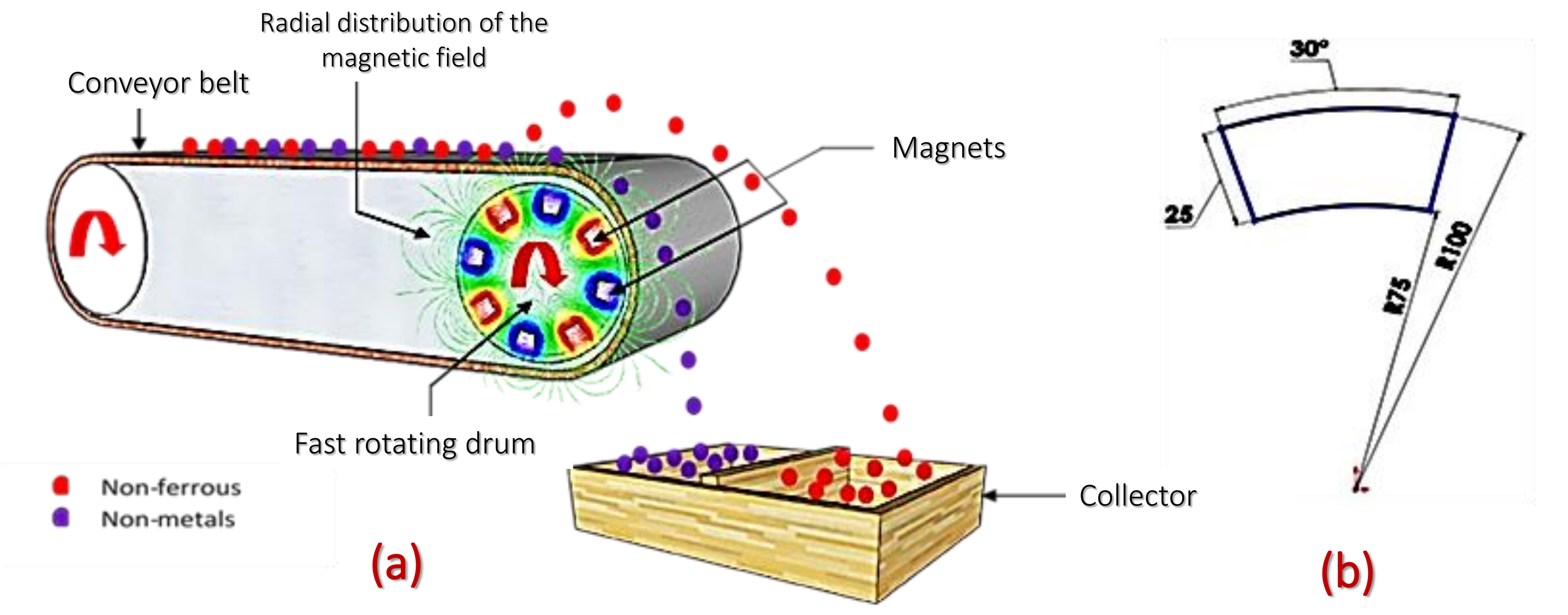

Figure 1: (a) Principle of eddy current separation.(b) Dimensions of the magnet with respect to the rotating drum diameter (mm).

The prototype invented is our own design, which is a separator, intended for sorting the constituents of mixtures of plastic materials, ferrous and non-ferrous metals using aerodynamic forces and a rotating magnetic field of immense intensity, which only performed after a series of experimental benches. The installation weighs approximately 350 kg and has the dimensions of 180 cm x50 cm x120 cm (Figure 2(a)) on which improvements have been made to the permanent magnet drum which constitutes the driving part of the system [2].

This rotary drum have the particularity of having 24 permanent magnets in the shape of a tile (Figure 1(b)) with alternating polarity N-S and high intensity mounted with symmetry, thus providing perfect adhesion to the rotating drum. Otherwise, it uses plastic cylinder for treadmill drive in order to avoid electrical heating currents. The pole wheel (1) position is inside a head drum of a conveyor belt (2). This drum consists of a shell made of composite material, magnetically inert, with high mechanical and chemical resistance. The rotation speed of the magnetic drum is independent of the speed of the conveyor, which can reach a speed of 3000 rpm; the whole is based on a metal frame (3) to ensure system stability during separation.

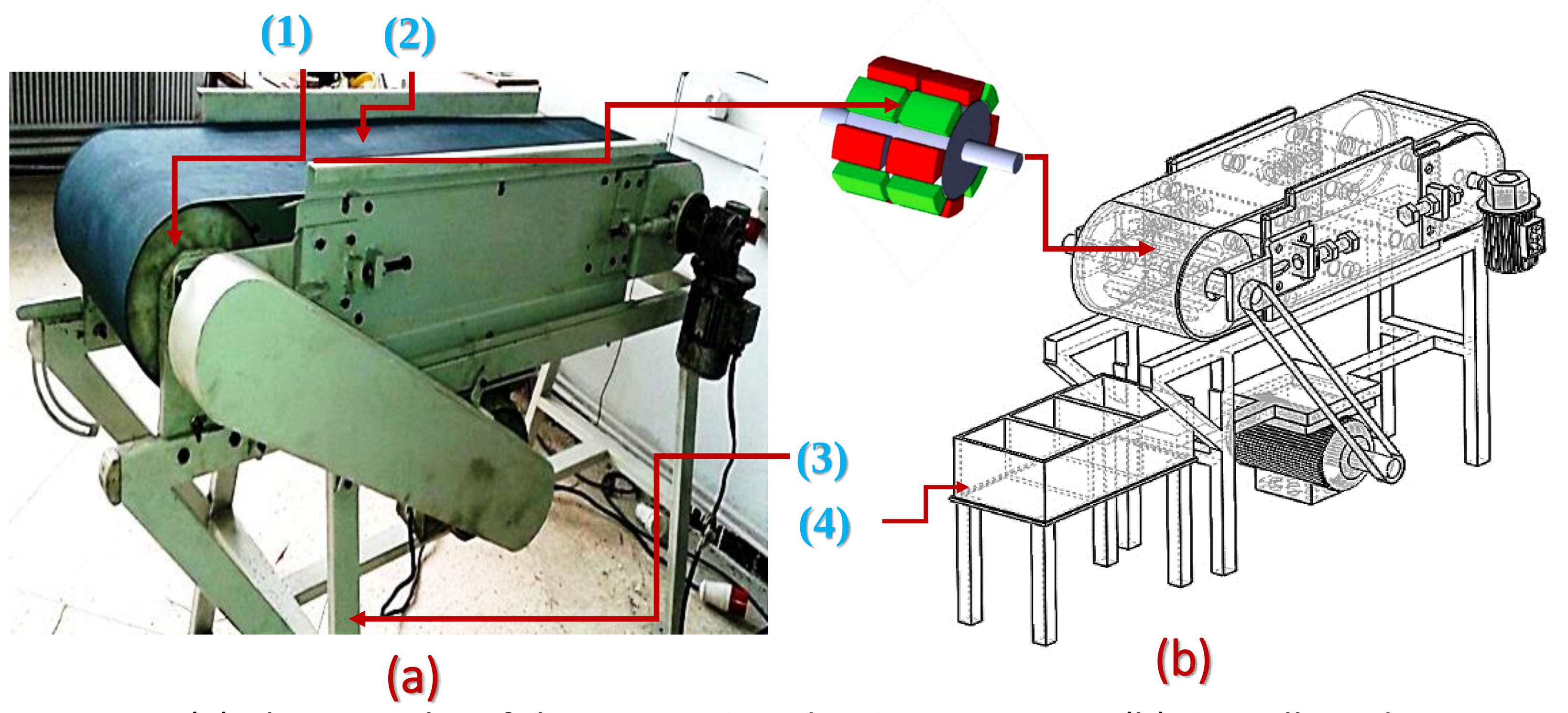

Figure 2:(a) Photography of the magnetic induction separator. (b) Overall 3D descriptive diagram.1-Permanent magnet drum, 2-conveyor belt, 3-metal frame,4-recovery header.

3.Experimental results

The new semi-industrial magnetic induction separator developed is a multifactorial process offering the possibility of adjusting several parameters such as : Rotation speed of the rotating cylinder, Rotation speed of the conveyor belt, Position of the collector, type and mass of the processed material. In order to put in advance influence of this factors affecting separation performance, a set of experiences was performed for rotational speeds of the permanent magnet drum ranging from 400 rpm to 1200 rpm at a constant of conveyor belt speed equal to 30 rpm.

The mixtures considered in these experiments are described as follows

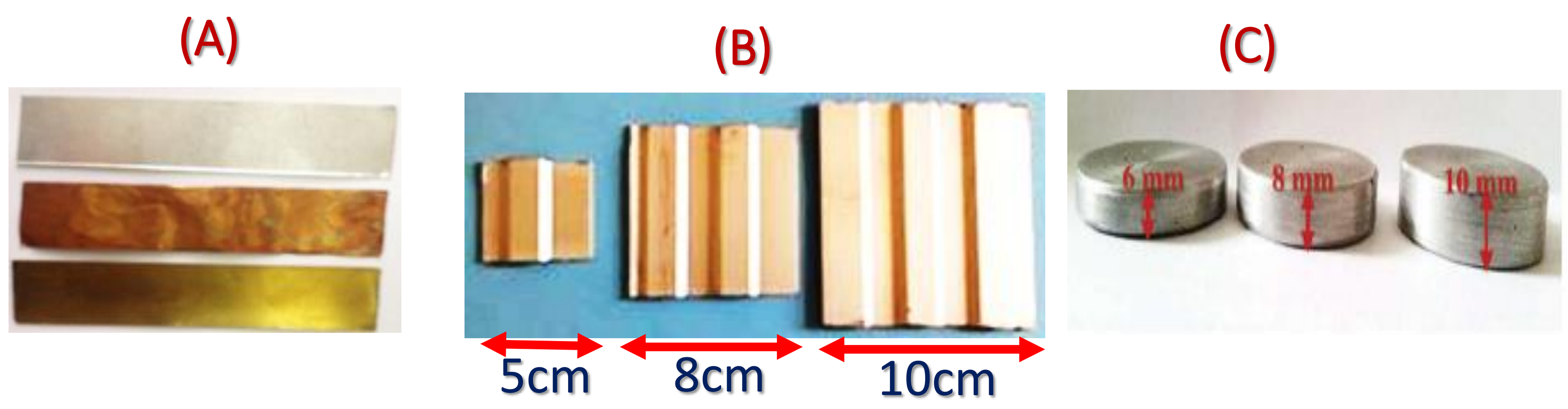

Figure 3: Shape and size of the non-ferrous mixtures.

-**Mixture A** : To highlight the influence of the conductivity of materials, 3 identical rectangular pieces were used (bronze, aluminum and copper)(Figure 3(A))

-**Mixture B** : The mixture considered is a set of 3 square aluminum pieces of 5cm, 8cm and 10cm per side(Figure 3(B))

-**Mixture C** : Containing aluminum cylindrical non-ferrous metals with a constant estimated diameter of 40 mm for different thicknesses: 6 mm, 8 mm and 10 mm(Figure 3(C))

The separation efficiency of the device is evaluated by measuring the projection distance d (in cm) of non-ferrous metals, Figure 4(a, b and c) show the results for the mixture (A), (B) and (C), respectively.

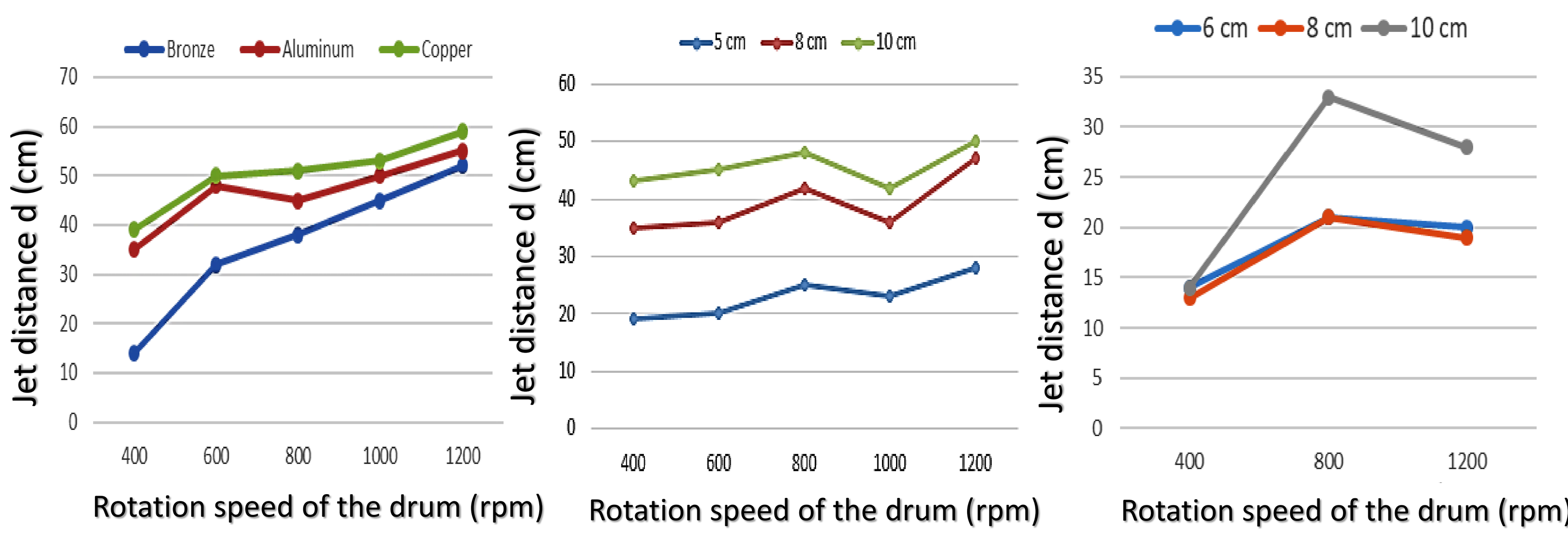

Figure 4: Jet distance d according to the drum rotation speed for the mixture (A), (B) and (C)

These results show, that increasing the frequency of the variable magnetic field generates strong inductions of swirling currents giving birth to repulsive higher forces which are relatively proportional with the higher conductivity ' Mixture A'. For the 'Mixture B' the projection distance is high at 50 cm for a square particle shape compared to an estimated distance of 28 cm for cylindrical shapes 'Mixture C'. This is due to the strong circulation of the induced current in the large surfaces. From our experimental tests, we deduce that the repulsive forces allowing effective separation tend to increase with the increase in the variable magnetic field generated by the permanent magnet drum.

4.Economic feasibility analysis of the investment

The weak cost of designing for such installation compared to the international market, is an economic opportunity allowing us to reuse secondary subjects in several industrial fields in order to ensure materials relatively rare with reasonable prices.

The cost of the ECS process as described in this paper comprises the following:

- Conveyor belt: €300.
- Magnets: €256 (€16/unit price).
- Motor of the magnetic drum: €350.
- Motor of the conveyor belt: €150.
- Collector: €200.
- Power box: €200.
- Manufacturing costs: €2000.

In African countries, manpower is available and not so expensive, and in Europe the cost of such a machine is higher than €30,000 unlike a locally produced separator costing around € 3500; witch is a very reasonable investment price for economy such as an african country In addition to the reduced manufacturing price of this type of installation [2], the local availability of maintenance expertise is a major advantage offering great feasibility of such a process in the local non-ferrous metal recycling market that will have a very significant impact on the country's economy.

5.Conclusion

The performance of magnetic induction equipment sorting of ferrous and non-ferrous fractions is directly linked to compliance with a Controlled granulometry of the waste stream. The eddy current prototype with rotary drum illustrated in this paper has successfully tested and proven its effectiveness in recovering non-ferrous metal with difference sizes, shape and conductivity classification of each one. Comparing to the low cost of manufacturing this type of separator to the gain it can bring from-recycling precious metals witch can be used in different industrial field. this investment will ensure new raw material resources.

6.Refferences

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