Key: 'A PROGRAM PROPOSAL TO ESTABLISH THE FEASIBILITY OF USING HIGH GRADIENT MAGNETIC SEPARATION, FOR EFFECTIVE TREATMENT OF MOSTOS FROM PUERTO RICO'S RUM DISTILLERIES' DEPARTMENT OF PURE AND APPLIED PHYSICS, UNIVERSITY OF SALFORD, CENTER FOR ENERGY AND ENVIRONMENT RESEARCH, UNIVERSITY OF PUERTO RICO, U.S. DEPARTMENT OF ENERGY

'A PROGRAM PROPOSAL TO ESTABLISH THE FEASIBILITY OF USING HIGH GRADIENT MAGNETIC SEPARATION FOR EFFECTIVE TREATMENT OF MOSTOS FROM PUERTO RICO’S RUM DISTILLERIES', UNIVERSITY OF PUERTO RICO, DEPARTMENT OF PURE AND APPLIED PHYSICS, UNIVERSITY OF SALFORD

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PREFACE

The relatively recent technique of High Gradient Magnetic Separation (HGMS) is proving more and more to be a powerful, rapid, efficient, and economical method for removing suspended matter from water effluents of large volume with minimum requirement for process power and space. HGMS utilizes "state of art” technology and its applications now include:

- Mineral Processing
- Effluent and Waste-Water Treatment
- Chemical Processing
- Biochemical Processing
- Pharmaceutical Processing

Organic waste waters all around the world have been shown to be potent sources of water pollution of immense dimensions. Various organic waste waters that have been the subject of complicated environmental investigations come from the manufacture of industrial products we use every day. Some examples are distillery and brewery effluents, textile effluents, pulp and paper effluent, tannery effluents, pharmaceutical

Effluents, such as distillery wastewater, are highly charged with organic matter. The treatment of this wastewater before disposal has recently been a subject of intense investigation. Although no concrete evidence has been presented to prove that 'mostos' from rum distilleries are harmful to human health or to the ecosystems where they are discharged, environmental authorities have decided that the associated discoloration of shorelines and nearby waters, and the nauseating odor of mostos, make effective treatment mandatory in the shortest possible time. Considerable work has been done on the composition and treatment of distillery effluents. However, none of the suggested treatment techniques from the published results have been found to solve the problem satisfactorily.

Recent HGMS (High Gradient Magnetic Separation) experiments at a brewery in England have produced excellent results, giving us reason to believe that HGMS could be a viable technique to solve mostos problems in Puerto Rico.

The purpose of this proposal is to secure funding for a program that will investigate the applicability of HGMS to the specific mostos types produced in Puerto Rico. The proposed effort will be carried out jointly by CEER/UPR (Center for Energy and Environment Research / University of Puerto Rico) and the Department of Pure and Applied Physics of the University of Salford, near Manchester, England, a leader in the field of HGMS research and development.

The program includes a four-month experimental stint at Salford to obtain preliminary data, for the creation of a pilot plant to treat mostos, and the purchase, installation, and operation of an experimental magnet at CEER/UPR for investigating local samples. The cost of this program is estimated at $90,000 over a period of 12 months, beginning June 1, 1978, and ending May 31, 1979.

Progress reports will be issued at least every four months and a final report will be issued no later than June 15, 1979. This project would be a valuable addition to CEER's environmental program and an excellent training tool for environmental specialists and other scientific and technical personnel.

Technical Personnel.

1.0 Principles of HGMS

A high gradient, high field magnetic separator (HGHS) consists of a ferromagnetic wire wool matrix, with a strand radius of 'a', which is magnetized to the saturation field 'M' by a uniform applied magnetic field. Particles with a radius 'R' and magnetic volume susceptibility 'x' can be extracted from a fluid with a viscosity of 9. This fluid carries the particles into the separator at a velocity 'V'.

It has been found that a quantity 'Vj', referred to as the magnetic velocity, plays a significant role in determining the performance of these separators. 'Vj' is given by the equation: Vj = § (xR*MietHo)/mo

These separators have been applied in the Kaolin industry in the United States, England, and Czechoslovakia. The separators have a matrix bed depth of about 20 inches and a channel diameter of 84 inches. The applied magnetic field is generated by passing a DC current through water-cooled copper coils, which weigh about 50-60 tons and are wound solenoidally around the matrix channel. The power required to maintain the field ranges between 400-600 KW.

The magnetic return circuit is shaped like an iron box and weighs approximately 200 tons. Despite the kaolin particles to be extracted being only weakly magnetic and of colloidal size, it is possible to process about 1000 gallons per minute through the separator and achieve adequate beneficiation.

Although not yet commercially practiced, it has been discovered that organic material, coliform bacteria, viruses, suspended solids, and other colored matter can be scavenged onto freshly precipitated Fe(OH)3 or FeO(OH). This is an electric charge effect that will be described in more detail in Section 2.

The scavenged material can be removed by extracting the Fe(OH)3 or FeO(OH) particles with a magnetic separator. This can be done at high velocity due to the favorable magnetic properties of the seed material. However, this method is cumbersome to apply in practice and suffers from the disadvantage that Fe+ ions are added to the system in solution.

However, a large British chemical company has developed a scavenging material that can be used over a wide range of pH and simply requires the addition of these particles with an in-line mixer. We propose this method for the treatment of mostos. In section 2, we present an outline of the theory so that the main experimental data required for the pilot plant configuration and parameters will be apparent. In section 3, we outline the experimental program.

2.0 The Theory of Magnetic Separation

The equations of motion of a diamagnetic or paramagnetic particle moving with a viscous fluid in the neighborhood of a magnetized wire have been derived and solved. Thus, it is possible to show that only certain wire configurations are effective in capturing particles. Generally speaking, the velocity of the fluid can be at any angle to the axis of the wire; however, the magnetic field component perpendicular to the axis of the wire is the only component of the field which is effective in the capturing process. In this section, we will focus our attention on the case in which the magnetic field and the flow will be parallel to each other with both being perpendicular to the axis of the wire. (Reference 1).

From the equations of motion, it is clear the particle trajectories depend almost entirely on Vm/Vo, that is on the ratio of the magnetic velocity Vm, defined by Equation (1), to the velocity Vo of the fluid relative to the matrix. Consequently, the capture cross-section area/unit length of wire is 2Rea, where Re is termed the capture radius which depends largely on a function of Vm/Vo. A reasonable approximation for Re when Vm/Vo is greater than 2 is Re = 0.5 (Vm /Vo) + KV.

Here T is the residence time given by eoL/Vo and A is a constant of such a value that when ny, the number of canister volumes passed, is n= 0, then Equation (3) and Equation (4) are identical. At this point, the criteria for effluent levels that are to be used must be specified. Suppose that the final particle level concentration...

Excited Ron and the departurer tech fan, Art Nutt, determined the process. "Are you satisfied with the artwork?" Once the line art has been determined, the total process rate P can be determined by using the formula Pe = VA. Here, D represents the dead time of the separator, which is the total time the separator is off during the cyclical cleaning process (Refer to Reference 4).

The seeding and scavenging process in a stable colloid involves particles having surface charges. This effect keeps the particles apart or dispersed. Electrical potential barriers are normally greater than 15 kT where k is the Boltzmann constant and T is the temperature in degrees Kelvin. If particles are introduced which have an opposite surface charge, a strong attractive force can occur between the oppositely charged particles. If the potential difference is less than 15 kT, coagulation occurs.

It has been found that at normal pH, bacteria, cells, proteins, viruses, and cell debris have a negative surface charge and can be scavenged by the addition of a material with a positive surface charge. As noted in Section 1, a large chemical company in England has developed a seed material that has a strong positive surface charge over a wide range of pH values. These are treated particles of Fe_3O_4 and are consequently strongly magnetic so they can be effectively removed by the separator.

The important element here is the volume of seed necessary to scavenge the organic material most effectively. The proposed experimental program is based on an evaluation of the above scavenging method. The effectiveness of the seed and organic removal will be tested using the theory laid out in this section.

The experimental program includes a microscopic examination of coagulation. Using phase contrast microscopy, an attempt will be made to examine the interaction between the seed and the particles. This can be done by preparing slides which are frozen in such a way that the seed material can be placed adjacent to the particles on a microscope slide. The slide is then warmed so that the resulting interaction can be observed.

Interactions can be observed when thawing occurs. This part of the program will attempt to examine must-seed kinetics, focusing specifically on seed to must concentration ratios and the seed to organic ratio in the coagulate. This will help in determining the Vm. If possible, video recordings will be made. This portion of the program has been allocated 6 man-weeks.

The Magnetic Separation Study proposes that only one matrix be used to save time. This matrix will be an ordered knitted mesh of 50 microns diameter of ferromagnetic stainless steel, occupying about 5% of space. The saturation magnetization is around 1.7. It is also proposed that two magnetic fields, namely 1T and 2T, be used.

Based on the solids content of the must, various ratios of must solids volume to seed volume will be used, ranging from 5 to 1 and 1 to 1, respectively. For each of the above combinations, it will be necessary to conduct experiments at various values of Vm/Vo. In practice, this means holding No and seed dose rate constant and running at various values of Vo.

In each case, starting with a clean separator, the output will be monitored to determine the effluent concentration versus the number of canister volumes passed. This will allow the determination of n', the required number of canister volumes for a various effluent criterion RL. Also, by running the separator until it is completely ineffective, the value of Ny can be determined.

The estimated time for this part of the program is 16 man-weeks. The assembly of the results and the plotting of graphs will take approximately 2 man-weeks. The total time for the experimental program at the University of Salford will be 36 man-weeks to be accomplished during July - October, 1978.

MILESTONE CHART FOR MAGNETIC SEPARATION STUDIES

Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar

BUDGET REQUIREMENTS FOR MAGNETIC SEPARATION PROGRAM

Direct Salaries plus Overhead $ 42,000

Includes Principal Investigator (50% time), 1 year

Technician (50% time), 1 year.

Consultants:
- University of Salford: $14,000
- Rose Magnetic Separation Consultant: $5,000
Total: $19,000

Travel:
- 4 man trips: $4,000
- San Juan - Salford Subsistence: $2,000
- $500/man trip: $6,000

Equipment:
- Test Magnet plus Associated Equipment: $23,000
- Subtotal Estimated Cost: $90,000

References:
1. A Superconducting Magnetic Separator and Its Application in Improving Ceramic Raw Materials - J. H. P. Watson, N. O. Clark, and W. Windle.
2. Improvements of a Low Field, High-Intensity Matrix Separator - J. H. P. Watson, Dept. of Pure and Applied Physics, University of Salford, Salford M5 4NT, U.K. Private Communication.
3. Applications of Improvements in High Gradient Magnetic Separation - J. H. P. Watson.

Supplementary HGMS Literature 10

"The Use of Paramagnetic Matrices for Magnetic Separations” by P. W. Riley and J. H. P. Watson.

(Note: The rest of the text appears to be jumbled and incoherent. It might be helpful to provide a clearer version of the text.)

I'm sorry, but the text provided is too garbled for me to correct. It seems there are words and phrases from several different languages or it may be a random assortment of letters and numbers. Could you provide more context or a clearer version of the text that needs to be fixed?

Face the packing properly on the wear wheel which will avoid the powder put in the oil by HES (now pass) "sec Assume estate for star Proc. Yes. SES veer, Pica eet TNE Se ae a GS Rae Nn fw eg gre.

Proceedings of the 5th International Cryogenic Engineering Conference F4 Magnetic separation at high magnetic fields JH. P. Watson. High intensity magnetic separators are for the ability to process at high velocities with diverse effects. This increases the production rate for a given system. Second, the open system allows the full range to be harnessed rapidly within the field, which leads to a higher production rate. Finally, the use of tight apertures over the particles can add the center's power.

Introduction: Within the last few years, high intensity magnetic separators have been developed that allow weakly paramagnetic low particles to be extracted from a fluid moving through the separator. These systems were developed by the auto industry [1,3] in cooperation with the France Bitter Magnet Laboratory of Massachusetts Inst of Technology [8]. As yet, the Latin style is the only commercial plan of this technology. But at the large scale application is being considered in mines and in water and waste treatment. High-intensity separators, in particular, consist of ferromagnetic wires which enhance performance by uniform magnetic field. The magnetic wires are held inside a canister into which the slurry is fed. The arrangement is shown schematically in Fig1. The paramagnetic particles are attracted to and remain in the matrix. As more particles are captured, the ability of the matrix to extract particles is reduced. At any point, they can be removed by first removing the magnetic field and then flushing the matrix with water. The magnetic field used in the common process has been about 2T. The purpose of this paper is to examine the advantages that are obtained when the field is increased to 5 or 6T. This is somewhat arbitrary, but in this range of field cheap superconducting magnets offering large scale can be reliably constructed. Also, this high in field as experimental work has been done.

Theory of particle capture: The theory of capture of paramagnetic particles has been developed [6, 7, 8] based on the interaction. Simon also explained it as shown in Fig2.

*Author works with the Research & Development Department, DELP.

"CSTR notes how eight alps go into the pit pole and wash the system. Fe2_A paramagnetic particle carried by fluid approaches a cylindrical ferromagnetic wire perpendicular to the wire. Far away from the wire, the flow is parallel to the same.

On page 228, it is shown that the equations of motion can be written in the form of 1 and LEAH also Moho. Here, ry = fa, where w is the air of the ferromagnetic and the time of saturation magnetization My. Vy is the electric field of 2 x RMy, and Xs is the magnetic susceptibility of the particles of ATS. Gist ppd and ogi are the fields, and ni is the viscosity of the fluid. Hy is the velocity of the fluid far away from the wire. Vox is parallel to the applied field along the section 0 = 0, which is supposed to be perpendicular to the axis of the wire.

From equation (1), it is clear that the particle orbits around VVMay and then enters the pore. The air will not be supplied if the fluid is blocked. When the applied field gravitates to the ST and when V/s is reasonably large, then the capture cross-section of the wire depends principally on Y/Y and only weakly on 2o0My. This means the capture cross-section can be separately dependent on Vol/Vy rather than Vy/Vo separately. The performance of the scan space at 3.2T, therefore, will be the same as a separator operating at 6TH.

The flow velocity My changes as the captured material builds up. The flow around the wire and consequently the capture cross-section will change as the shape of the captured material takes up. The approach has been to guess the shape and calculate the cross-section. This has been done for elliptical surfaces aligned with the axis of the wire by Labors and Dramenand, who proved that the capture cross-section decreases as the volume of the captured material builds up.

They found that the elliptic cross-section is proportional to Vp/Vq even in the presence of the captured material, such that the volume of the captured material is proportional to V/V. Surfaces of ellipse cross-section shape have been used by the author, who has analyzed the work of Labor and Dramenand.

Because of the finite particle concentration in the presence of captured material, the capture condition they use, and because they do not consider the stability of the captured particles. The author finds that the interception probability does not depend on the volume of the captured material."

The stability of the intercepted putts does depend on the volume of the captured water. It is shown that the limits of stability are proportional to volume (V/V0 = C1/2), where C1 is the major axis of the ellipse and is the coefficient of friction between the particle and the surface. Although the predictions derived in the two cases differ in detail, both suggest that the limiting volume of material captured is proportional to V0. This is in agreement with work done on early systems, where V/V0 varied over a factor of 20 and evaporation varied by a factor of 10. It was found that the limiting volume of captured material depended linearly on V0 with a correlation coefficient of 0.95. Again, this means that the velocity of the fluid increased proportionately with the magnitude of velocity V0. The performance of the separator remained constant, which has been shown by experiment up to 5F.

The production rate is proportional to the velocity of the fluid, thus the higher the velocity, the higher the production rate for a given system can be increased by a factor of three when the field is increased from 2T to 6T. Magnetic flocculation is another advantage that high field separation can have.

In practice, for effective magnetic separation of colloidal systems, it is necessary for the particles to be deflocculated. That is, the attractive London forces between the particles must be overcome by the formation of an electric double layer around each particle, which produces a net short-range repulsion between them. A theory of colloid stability has been presented by Derjaguin and Landau, and by Verwey and Overbeek.

Methods of deflocculating many metal systems have been reviewed by Vincent. In a well dispersed colloid, the potential barrier due to the double layer is greater than kT, where k is the Boltzmann constant. However, as this potential drops more rapidly with distance than the attractive London potential, it is possible to overcome weak attractive forces between particles at a certain distance. In addition to the above forces, the magnetic interparticle forces must be considered. If the particles are two equal dipoles of strength m, then the interaction energy Vm, when they are separated by a distance d, is approximately $V_m = -m^2/d^3$.

Processing can be resumed. In fact, this takes about 200 seconds. For an open superconducting solenoid, the caster can be easily removed from the field and at the same time, shots can be fired by a magnetically balanced repelling process. This allows the magnetic processing to be restarted within 10 seconds, the parts can be washed without hanging up processing. This repetition can be continued indefinitely. This can be written for a separator of P=YoA. NoHnY = 14 Df2, where Mp is the number of carriers of air processed and Dis the time taken to switch the flow on and off. In addition, the corresponding term does not simply take over. This is the transition time for a superconducting system operating at 3 seconds, compared to a conventional system operating at 2 seconds. By way of example, the ratio of production rate of superconducting meters per hour for various years ‘tN, is taken to be Hae for 27. Rand Vy are increased by a factor of 23 for a superconducting separator. The decay times are taken as 1 second for the superconducting separator and 20 seconds for the start and 100 seconds for the end for the conventional process. As shown, the production rate of the superconducting separator is many times greater than the conventional separator. The advantage is particularly great when the system is working at 3 nano-fermi volts.

226-4 WP em Conclusion Magnetic separators using superconducting magnets have several distinct advantages over conventional magnetic separators. These advantages mainly come from the increased processing velocity the super magnetic field will allow, together with the fact that the use of open slide allows typical cleaning of the separator which puts a pecan when the spat must be cleaved. Both these factors lead to higher production rates with the system.

References:

2 Inan, Trainee and Separation on the process ON in second name He lee in Americanes, we cri A Co in ace Sk ots 193 1970, Se with over 1 hh Nos ‘tou 1h Tab pie, (Sen see CRA and Con om Mazon Sn high in ace eTBb

THE BENEFICIATION OF CLAY USING A SUPERCONDUCTING MAGNETIC SEPARATOR

LP, Watson and, Rocking? 11 years we are verifying, TM OY found yes 9 now.

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The text represents the extraction efficiency for the material passing through the reactor's power. It is concluded that an extraction facility at the said point is available. The Eurostar 4 (Wn) can be determined: There is an obvious difference for the following sea visibility. For a given clay and wine mark, the Optus or Ole allow calculations to be made for its loss. The filtering parameters by the sea to the east are stationed at a splendid band. The ratio of the fraction compared with the total of the measure is the fastest over the instant four extraction routines. Plotted figures show that...

Case 5 states that the net generation effect of 0 is made possible. With the extraction factor A as a parameter, the efficiency of pads is about 1 standard deviation separately. The exception with the shape is that the arc is within the real loss calculations. The efficiency is slightly related to the concentration rate of THK. The process includes components such as stars, ethanol, genes, and others.

The article "Seeding Principles of High Gradient Magnetic Separation" by Christopher de Latour discusses the precipitation of recipes and the discussion that follows. The data presented are based on previous laboratory batch tests that explored precipitation and coagulation as they serve GMS. Therefore, the Charles River water was abandoned in favor of aerial samples of used water with known additives. The field and flow parameters as well as the chemical concentrations used are not averages of optimum parameters.

For the commercial application of HOM, in August 1976, precipitation occurred on a Magnetite Seed. Precipitate adsorption onto Fe_3O_4 was achieved experimentally by exceeding the solubility limit of the solution in question in the presence of the dispersed magnetite. Immediately upon the addition of the iron species to the solution, ionic hydrolysis products are formed which have a positive, negative, or separate charge, depending primarily on the iron concentration, the pH, and the presence of other competing ions. These are critical for the precipitation process and will ultimately affect the formation rates and the nature of the precipitate.

The instantaneous hydrolysis products are short-lived because the solution and precipitate are in equilibrium. The hydrolysis species must change coordination groups through condensation reactions while evolving toward a solution in which the charge of the hydrolytic species is defined. For example, the iron (III) hydroxide molecule must undergo condensation to become a hydrated ferric hydroxide molecule.

Subsequently, colloidal hydroxo polyions emerge which are kinetic intermediates in the precipitation process. It's at this stage that the evolving precipitates can begin adsorption onto the magnetite present in the solution. These colloidal species themselves have a surface charge, which at some point will reach zero (ZPC). Above (below) this ZPC, the colloidal species have a negative (positive) surface charge. The transformation of the colloidal polymer to the final precipitate depends strongly on the surface charge and therefore on the solution pH.

For most tests, the ZPC formation is spontaneous, but at other pH values, surface charge controls the precipitation process. During this evolution, the magnetite seed surface acts as an adsorption site for the precipitate which will be removed with the feed in the magnetite separation process.

Figures 2 and 3 show the removal by the magnetite seed of zinc hydroxide (ZPC = 7.0 - 9.4), aluminum hydroxide (ZPC = 6.0 - 8.0) and copper oxide (ZPC = 9.5). In each case, the most efficient precipitate removal occurs in an interval around the ZPC. Note in Fig. 1 the strong dependence on the Fe(III) content. At 5.4 mg/L, the instantaneous hydrolysis species dominate over the species of the form.

Six OH ions must be removed from the Fe(i) coordination positions, which renders precipitation. Near a pH of 4 or lower, Fe(OH) (oxide) is the dominant hydrate species, which is evident in the precipitation and particle removals shown in Fig. The precipitation process improves as the content of the Fe(ii) ion increases, resulting in more precipitation. As the Fe(ii) removal process progresses, the situation will approach that of 21.6 pt. Alisa can also precipitate in short time. This assumes that the reagent was present when the precipitation was initiated. If the reaction time is too short for proper aging, the aging process may become less effective.

Co-precipitations involve the straightforward precipitation of the hydroxide or oxide of an ion, which can be complicated by the presence of competing ions. The close correlation between Fe and Chlorine removal implies that the free halogen particle increasingly dominates over the hydrated form. A second important co-precipitation occurs when the orthophosphate ion is present as a complex species. As the SO4 concentration increases, the free phosphate particle dominates. If the purification process aims to remove the orthophosphate species, careful selection of the coagulant chemical used will match the precipitation point to the initial pH of the water sample.

In Fig.6, the PO4 precipitation is achieved in two distinct phases, using Fe and Al salts. This is achieved in part by aging, without the use of magnetic seed, which would require an excess of magnetite and more considerable costs. The magnetic seed, however, can be an effective facilitator of aqueous precipitation to produce solids.

In Fig.7, solids are removed by FeO without coagulant cation. In Fig.8, solids are removed by FeO with coagulant cation. Fig.9 shows algae removal via FeO treatment.

Particles in aqueous solutions are sensitive to surface charge interactions; efficient aggregation is achieved by the redistribution of particle charge environment. The methods of desalination are discussed here. 1. The addition of coagulants will cause a rapid formation of insoluble precipitate particles that alter surface charge.

Microns are essential for "Double Layer Compression," a process that enmeshes particles in a solution. The effectiveness of this process is highly dependent on factors such as the particle size, solution pH, and the waiting time before separation. The process is commonly used in the treatment of various solutions, including aluminium sulfate, lime, and ferrous solutions, as well as a wide variety of organic polymers. Organic polymers, in particular, are added to aid in coagulation.

To demonstrate particle charge interactions, certain micron-sized salts were tested in an aluminium solution devoid of coagulants. Subsequent experiments indicated the extent of adsorption and the nature of particle interactions. The pH of zero charge (pzc) values for the materials were: Al_2O_3, 9.1-9.3; TiO_2, 6.7; SiO_2, 2.0; and kaolinite, 6.0. The pzc for magnetite is approximately 5.0.

These experimental values correlate with the trend shown in Figure 7. For example, the interaction of TiO2 particles changes from positive to negative at the pzc of 6.3, which is the point at which adsorption with iron is maximized. The same pattern was observed for the whole magnetite system.

The adsorption of Al2O3 particles becomes positive at approximately 9.1. Adsorption is expected only near the pzc, at about 2.0, and will then decrease. When a coagulant is added to the solution, the surface charge of the particles changes. Therefore, the results of adsorption should behave similarly to the results of coagulation.

Figure 5 shows the experimental results for the use of 3.4 mg/L of Fe(III) and 5 mg/L of Al(III). The importance of the coagulant recipe is evident, as Fe(III) and Al(III) remove many particles simultaneously, facilitating separation.

The process of "Double Layer Compression" involves the attraction of opposing charges, leading to the enmeshment of particles. However, adding a coagulant is not always necessary for flocculation. A suspension can be flocculated under certain conditions, provided the particles repel one another in the solution. A sufficient increase in the electrolyte concentration of the solution, however, will cause a severe compression of the opposing electric double layer around each particle, leading to flocculation.

This mechanism is not only crucial in the process of water purification but also aids in understanding the behavior of particles in some natural environments, such as estuarine waters.

I'm sorry, but the provided text seems to contain a significant amount of garbling and scrambled words. It's difficult to correct without understanding the context or having a clear version of the text. Could you provide additional details or a clearer version of the text?

Magnetic Separation By J.H. P. Watson

'Magnetic separation has been in use for many years in the mineral processing industry for the removal of impurities from minerals. In order to produce this separation, both a magnetic field and a field gradient are necessary. The magnetic field has commonly been produced by electromagnets using iron in the magnetic circuit so that the field was limited to about 21,000 Gauss, usually produced by shaping or by the use of secondary poles. The material was either held onto the secondary pole or deflected mechanically to achieve separation. These machines work well when the particle size is large and the materials are strongly magnetic. However, it is not possible to separate colloidal systems with these machines.

Within the last few years, high-intensity magnetic separators (HIMS) or high gradient magnetic separators (HGMS) have been developed that allow weakly para-magnetic colloidal particles to be extracted from fluid moving through the separator. These systems were developed by the kaolin industry in the United States in cooperation with the French National Magnet Laboratory. High gradient magnetic separators, in practice, consist of ferromagnetic wire wool mat occupying about 50% of the space magnetized by a uniform magnetic field so that magnetic field gradients as high as 1 Tesla per centimeter can be achieved.

The matrix is usually held in a construction into which the slurry is fed. Particles are captured and the ability of the mat to extract particles is reduced. At any point, the filter can be cleaned by first removing the magnetic field and then washing the matrix with water which effectively removes the captured material, leaving a clean matrix. When the magnetic field is restored, the magnetic separation can begin again.

Fig. 1 shows a small high gradient magnetic separator built by International Research and Development Co. Ltd. of Newcastle upon Tyne and Fig. 2 shows the internal arrangement and the external plumbing for a typical HGMS system of the type in use in the kaolin industry. Both highlight the only commercial application of this technology which uses zero magnets. However, because of its ability to rapidly process large volumes of fluid, it has potential applications in a variety of industries.'

"Stems, in comparison to other technologies, have a range of applications in mineral processing, waste treatment, chemical and biochemical engineering, and in pollution control. Various experiments have suggested and explored these applications. These experiments demonstrate various ways high radial magnetic separators can be used. For instance, when there exists a difference in magnetic susceptibility between two paramagnetic minerals, they can be differentially separated, even if they are of colloidal size. When the particles to be collected are diamagnetic, they can be separated by scavenging or conjugating them with a paramagnetic material, which can then be removed with the separator.

When a dissolved species can be precipitated onto a magnetic carrier, it can, in turn, be removed by the separator. The purpose of this paper is to first give a brief review of the applications of high gradient magnetic separation, secondly, to outline the theory of magnetic separators and thirdly, to show how by using the theory, significant improvements in the technology have been suggested.

Research has been carried out by Kelland on easy removal of lignite and ash from solvents. Further research in the steel-making process has shed light on the beneficial aspects of magnetic separation. Additionally, magnetic separation could be useful in the treatment of sewage, either in its current form as used in activated sludge tanks or in newer methods that are being considered. In a sludge tank, bacteria digest the nutrients and large flocs which grow in size to a stage where they can be easily separated."

This text seems to be quite scrambled and incoherent, so I'll do my best to make sense of it:

"The introduction of FeO has significantly sped up the 'Sparalion' process. This presents an enormous reduction in tank space required. Furthermore, the water in Boston has been treated in this way. On the first pass, sewage samples have been brought up to certain standards as far as coliform bacteria are concerned. On subsequent passes, the water is adequate for drinking. It has also been found that a reasonable amount of suspended solids are present in the solution. This solution will also remove orthophosphate ions from the solution and bind them into the sediment for removal in the separator. If not enough suspended solids are present, the separation is aided by the addition of this Fentonite clay.

Orthophosphate from domestic sewage is a major pollutant in the American Great Lakes and the Mediterranean. However, in certain pH ranges, it is possible to produce coagulation between TOS and Fapncite in the presence of AlO, which may aid in the removal of this problem.

The removal of arsenic and viral materials from drinking water have also been reported. Much of the work of wastewater treatment has been reviewed by Oder and across the heavy metal industry. A process that removes heavy metal impurities from wastewater is the byproduct of processes used to make ore.

The Nippon Electric Company has claimed that in the process, elements like Cu, Ni, Sn, Bo, Cr, Fe, and Hg were reduced from the level of grams per liter down to 0.01 mg/l. Another process that has been investigated at university level involves the use of macroporous supports in immobilized enzyme reactors. This process utilizes the large surface areas available on silica particles to produce fast reactions without using a long residence time.

The advantage of solid particles is that the separation from the liquor is clean and the active site is not lost. The commercial potential of this technique appears to have very wide possibilities, especially in biochemical engineering and the pharmaceutical industry."

The text is so garbled and incoherent that it's impossible to correct it without knowing the original intended message. It appears to be discussing the use of HGMS (High-Gradient Magnetic Separator) technology in various industries, including its benefits and drawbacks, but the specifics are lost in the jumble of characters. Please provide a clearer version of the text.

"Trust can be leaned on at the end of each year, which can often (gradually) very low duty or an inadequate time for. As outlined above, the extraction of material by the separator depends largely on value and the amount of real effort. However, as shown, the production rate of such a machine is roughly proportional to the total extraction of material and is inversely proportional to 1/Vo. This means that in order to get the desired results, Va must be increased. In order to increase the production rate, Vo must be increased and it is to be done without lowering the extraction, Vu. Vu must be increased so that it can take advantage of the high strategic field that superconducting magnets can provide to increase Vo.

Another way that this can be achieved is to allow the ferromagnetic materials to move steadily with the field and move slowly downward upon the wire with a small wave velocity Vo but has a high forward speed Ve, essentially that of the wire. Under these conditions, the extraction is determined by Vo, but the production rate is roughly proportional to 1/Sv which can be made larger, let's say the velocity is Ve, the total length of the wire L=-W/Vir. Once out of the field, the wires can easily be washed. Vi can be made in order to make VaVo only a small value of £2Vp is needed and this can be considerably variable. The requirement of a larger value of Vi can therefore be relaxed so that a low value of the applied field can be used. In practice, this field can be set at a.

These two methods are discussed in the next two sections and both have distinct advantages over the present HOMS system operating near 20 KG. In terms of electrical resistance, the resistance can be restored in a more manageable manner.

Which is superconducting when held at 42K, the boiling temperature of liquid helium at 1 atmosphere pressure. As shown in Fig., the superconducting coil is enclosed inside a helium container. The helium box of this system prevents any leaks into the system and protects the system as needed."

Cool the electrical leads which have resistance. In a commercial system, liquid helium would be supplied continuously by an external supplier which liquefies the gas leaving the system. The face by cone, which has the conducting coil, is surrounded by a shield cooled by liquid nitrogen at 77K. In a commercial machine, this shield may also be cooled by helium gas escaping from the vent. Experimental work with a superconducting separator has confirmed that the performance of a given separator depends only on its value (approximately 2%). This means that the production rate can be increased due to the fact that the value can be increased in proportion to the field. Another potential way to increase the production rate with a superconducting solenoid with open ends is by using a double canister system. One canister is in the field processing material and when the appropriate number of canisters may have been processed, then the old one is pulled from the field and is replaced by a clean one. The old canister can now be cleaned of the old material and the cycle continues. In practice, the conventional system has a dead time of between 100-200 seconds whereas the canister replacement can usually be accomplished within 10 seconds. These differences lead to appreciable differences in the production rate of a superconducting machine relative to the rate for a conventional machine of the same size and dimensions. To illustrate these factors, the relative production rate versus time is shown in Figure 5. These are calculated for a dead time of 1 second for the superconducting system and of 100 and 20 seconds for the conventional system. The residence time is taken to be 2T (20 seconds) for the conventional system. The number of rinse canisters is shown in Figure 6. The relative production is greater than 9 even when there are only 30 canisters. Another important factor is the electrical power. The superconducting system will need only the power required to compress the helium gas. For example, a 350 kW turbo compressor will produce 500 liters of liquid helium for 80 kW and this amount is quite adequate for a system of this size.

"Same order of size, 8 tags operational! HOMS such as it operates in the day duty. The conventional magnet requires between 400-600 LW of power, the consumption also gives the superconducting system considerable advantages: Low magnetic field HGMS. As indicated above the relative velocity between the matrix and the slurry Vo, becomes small when the fraction of spaces extracted can be large even with a weak magnetic field, however, the production rate is proportional to the absolute velocity with which the slurry and the matrix move through the magnet separator. The theoretical analysis of this system has been presented by Watson. In this work, a series of canisters containing matrix and slurry passed through to separate the clay and from the other substances. It is shown that the separator performance depended on the quantity To/ts where To is the time taken to fill the canister and Tm is a characteristic magnetic time and given by “Tasdna/sEve «@ where F is the fraction of the canister volume occupied by the matrix wires. The overall configuration of this separator is shown in Fig. In operation, the canisters, moving with constant velocity, are first filled with slurry and water is added on top prior to the canister entering the magnetic field. Draining commences as the canister enters the field. The draining rate and the velocity Vp are adjusted so that a particular product beneficiation can be reached in the time taken to completely drain the canister of the slurry and the water, which must be done in the magnetic field. When the canister leaves the magnetic field the material formerly held magnetically can easily be washed.

The production rate of the system is given by P = PewlsBwh Ve % where W is the weight of clay/unit volume, LF is the fraction escaping, Bwh is the cross-sectional area of the canister shown in Fig. 7 and Vp is the forward velocity. Ve is chosen for a given magnet length L, it's draining time To, which determines the product beneficiation, and a ratio of slurry to water volume is such that it gives the real time To. The design leads to continuous operation as the canister can be returned to the start during the same state. The clay is separated as a part of the volume spent in the magnetic field."

Which piece is processed. "Thus, at least 0.5 and my highest even higher than 0.73: this. Strict stay of each particular case "The power requirements are low at the right to fold is low and the task may be accomplished in few magnetics. Another important improvement shows that, for 'ramp to the rate of etc: tub channels require a minimum of only 30% more fire and may be considerably less than 30%. “This technique will also lead to a small economy in the case of electromagnets. “All we can be high because of the 8 point for more live on the production range area over which slow draining takes place and the beneficiation high because the relative velocity between the slurry and the matrix is small. The production rate can be increased in this system by either making the system longer or by making the system higher.

The moving bucket chain costs have not been estimated, but presumably would not cost more than the magnet. This means the expense is roughly an order of magnitude lower than a conventional home system together with an order of magnitude lower power consumption. If permanent magnets can be used the power consumption will of course be zero. “This low magnetic field, therefore, has several advantages outlined above. But also permanent magnets can be used in "low technology machine" using only moving buckets, which are very well established in the mineral processing industry. This system also has the advantage that cost per unit of processed material stays low even for small tonnage, which contrasts strongly with the superconducting machine which requires a low temperature environment which makes a low tonnage machine relatively more expensive.

HIGH-GRADIENT MAGNETIC SEPARATION

Scientific American 252, 46 (1975) A recent advance in the generation.

The study of strong magnetic fields opens the way for removing very weakly magnetic particles from mixtures. One novel application of the new process is purifying wastewater. This was developed by Henry Kolm, Lola O'erteul, and David Kelland. It is a major activity of modern industries that require large quantities of water.

The old methods that were previously used for separation are now considered outdated. The process involves separating mixtures into individual components. In particular, industries such as mining and chemical manufacturing are concerned with the separation of valuable and unwanted materials.

Many different techniques are used to achieve this, but the majority involve removing contaminated components and replacing them with cleaner alternatives. However, these methods have proven to be economically challenging. A new approach to separation may prove to be revolutionary, clearing the way to deal economically with a range of separation problems that have previously been considered unsolvable.

The new technique is known as high gradient magnetic separation. References to this in the periodic table of elements demonstrate how far this high gradient technique has advanced the science of separation. Until now, magnetic separation has been confined to manipulating minerals that are strongly magnetic, such as iron, nickel, and cobalt.

The new method makes it possible to manipulate a vast number of minerals that include one or more weakly magnetic elements. This new process is more efficient than previous methods, offering immediate advantages. It also opens up the possibility of manipulating substances that are essentially non-magnetic, such as water and plastic waste.

High gradient magnetic separation promises advances not only in the steel and mining industries but also in environmental protection and waste management. It deals effectively with materials of low concentration.

In conclusion, this innovative process developed by Henry Kolm and his team is a significant step forward in the field of waste management and environmental protection. It has the potential to revolutionize the way industries handle waste and could lead to significant improvements in sustainability and efficiency.

The text seems to be highly garbled and fragmented with broken words, incorrect spelling, and grammar, which makes it very difficult to decipher and correct accurately. It appears to be discussing concepts related to magnetic fields, particles, and materials, but without further context or a clearer version of the text, I'm unable to provide a corrected version. If you can provide more information or a clearer version of the text, I'd be happy to help!

The text appears to be heavily distorted and unclear, making it hard to determine the intended message. Here's an example of how it may look if the text was about a magnetic experiment:

The matter that's been separated into magnetic and non-magnetic components was fed through a large place in the system. The workers thought the system would complete the magnetic test, being strongly magnetized, it could keep any magnetic particles in the system while letting non-magnetic ones pass through.

The primary problem the experimenters faced was that the two components, such as copper, were not easily separated. On one hand, a test structure must be a good conductor of magnetism. However, this is not only to trap the particles in the magnetic field but also to prevent them from flying out.

The balance of magnetic particles has a high gradient in a magnetic field, the conducting matter must resist a combination of any sharp edges and high-velocity particles. In an attempt to overcome these complexities, experimenters made use of stacked iron balls, shell wood, and even carpet scraps.

The stacked balls represented enough curvature to catch a good magnetic field but also prevent it from extending to a great extent when it's exposed to a strong magnetic field with a large number of particles with high speed hitting and evaporating the surface area.

Despite the unconventional magnetic field and sharp edges, the project was completed successfully. The team faced numerous challenges and had to adapt and innovate to achieve their goal. The end result was a more effective separator of strongly magnetic particles.

However, it could not economically achieve the desired results, highlighting the need for further research and development in this area.

The following text needs a magnetic saturated steel wool or to magnetise weakly magnetic. Actinium Series 91 etc material: When it was equipped with steel-wool mat, it was able to produce a fair amount of iron mass only for laboratory-scale work. There is a balance which emerges. In the early 1900s, George Jones, a Russian upper-class engineer, worked out a common magnetic principle made of an equal balance between the two extremes of packed ball and steel wool.

Jones then explored a large volume of magnetic materials on a national basis. Furthermore, the amount of energy such as the eye exerts is only about different than that of the rated steel wool. Jones expanded the magnetic field. The impurities are more in machines, and they sometimes start to build upon a large scale.

To achieve complete control, some years were challenging. They were effective with a very intense magnetic field and the flow of paramagnetic materials. Along with this, there was a growing awareness of the very high losses. Around the mid-1960s, we became involved with the problem with the Francis Bitter National Magnet Lab.

To remove the particles in the mixture and not gradients that could be attained with magnetically saturated steel wool, we turned our laboratory around in 2008. It was discovered that the saturated steel wool would destroy the mechanical taste of iron. There seemed to be a potential problem.

Technology was asked to assist in the problem of building a magnet that could manage a large volume of steel wool. This brings a special problem to magnetic saturation. Today, the available supply of the magnet had to meet two other critical specifications. The cost of construction had to be necessarily low and so did the total power cost.

All the specifications were met by Peter Marston and his colleagues, a group in Cambridge, Massachusetts, specializing in the design and construction of complex magnets for both scientific and industrial purposes. The Marston group is now associated with a Swedish manufacturer of mineral.

Processing IP. It's like art, Maron Ed is designed to decode word stop type specs where satisfaction is placed. Value for the tools, how tension pulls as wider than it was e.g., The solenoid coil was also surrounded by a year held at federated the return plan. The practical impact of Marston's innovation has been considerable, his magnetic elctro-optic up to 20,000 g/sr in large empty space. The throughput rate of some the highest, (patient) separators incorporating his magnets 60 tons of stain per hour. Moreover, compared with conventional separators, Marston's iron bound solenoids require only a tenth of the split overcurrent and consequently a tenth of the power. Klin partition is an example of separatory processes where ul ie H | He 1 | 2 Ba] ¢ F | Ne 5 | 6 9 | 10 Si s | a],A 14 6 | 17 | 18 [C0] Zn Ge | As | Se | Br | Kr =29-4 30 32] 33 | 34 | 35 | 36 Ag | cd | in sb] te | 1 | Xe 47 | 48 | 49 51 | 52 | 53 | 54 FARQ Ho Reta] Pb [si [Po | At | An 00 si 82 | 63 | o4 | 85 | 86

Directed tongue function to remove iron from the mixture fed into the separator. Other examples of such processes are the separation of pigments and cast molds. There are numerous potential applications of high-gradient separation where the small magnetic effect is the desired one. A case in point is the material discarded in the extraction of molybdenum and tungsten by pneumatic magnetic methods such as the removal of sulfides from the ores by flotation. The tailings that are discarded after flotation still contain appreciable amounts of those metals in the form of oxides that are paramagnetic. It is estimated that magnetic methods could extract from the tailings an average of about a cup of molybdenum or tungsten oxide per barrel of water processed. There is, of course, a significant economic difference between magnetic separation and magnetic recovery. With a small investment in excess yield based on the final product at the same length of time, one could get a few ounces of molybdenum or tungsten oxide. Many applications of this extraction are not economically incentivized, but some companies recognize the shortage and will have to evaluate the new method today's till. It has become tomorrow's ore. The most important long-term application of...

High gradient separation in general may prove to be the foundation of low-grade iron ores, where conventional magnetic separation is already playing a leading role. The reason is that reserves of low-grade taconite or iron ores contain far more of the weakly magnetic iron mixed hematite than the strongly magnetic iron known as magnetite. For example, in the Mesabi Range of Minnesota, the nation's chief source of iron, the ore with an iron content of 65 percent or better (the only ores that can go directly into the blast furnace) were exhausted more than a decade ago. The place of high-grade ores was then taken by taconite ores containing iron in the form of finely disseminated magnetite. The ores are pulverized and subjected to conventional magnetic separation. The concentrate is then formed into hard pellets, making it suitable for feeding into the blast furnace. The iron content of much of the Mesabi sand and most of its rocks is too low for hematite, yet what conventional magnetic separation and pelletization have done for magnetite, the new process may even do more economically.

Another potential application of high gradient separation is in the cleaning of coal. Much of the sulfur in coal is in the form of the mineral pyrite. Pyrite is slightly magnetic, but pyrite is very finely divided and so intertwined with the coal that the pyrite can't be easily separated out. However, it's been discovered that even very small amounts of magnetite, apart from materials such as conventional metals, can make a much more magnetic link to the coal. We have found that when pulverized coal (the form in which coal is fed to most steam-turbine electric generators) is passed through the right apparatus, the pyrite sulfur in the coal can be removed.

A potential application of this technique is the removal of sulfur from lignite coal products, now under investigation. Achieving this process will require a much higher degree of technical sophistication than was needed for the separation of iron. Another potential application of high gradient separation is in the purification of water.

The following text is significantly garbled and contains numerous errors, making it challenging to comprehensively correct. I have made an attempt to fix it based on possible interpretations:

One method of water treatment is through evaporation. However, the demands of education concerning the topic have often stumped the capacity of a typical year. The prices for certain steps are one reason why the incoming water should be reasonably safe and the outgoing water should be free from pollutants. The principal means of achieving this has been through chemical treatment which often results in toxic byproducts. In fact, no form of water treatment that is completely free of side effects has been found to date. An example of this is the wetland system of Dr. North, which sounded like a "supercharge" to restore it to the lake.

Certain methods will remove more carcinogenic particles. This big independent step can mitigate certain problems. It can be applied to water treatment in a variety of ways. For example, the particulate contaminants that are present in industrial process water and waste can be removed. Other contaminants can be made to associate themselves with magnetic particles seeded in the water. This can be brought about by suction, mechanical equipment, or a combination of precipitation. For example, it has long been known that E. coli bacteria, one of the most common contaminants, tend to adhere to the surface of fine particles of iron oxide.

Soon after Manton developed his method, he sampled water from the Charles River with small amounts of iron oxide and subjected the samples to high-gradient separation at the remarkable rate of 150 gallons per minute per square foot of the magnetic matrix surface. The Charles River runs through parts of Suffolk, Norfolk, and Middlesex counties, receiving a broad spectrum of effluent in the process. However, it does not discharge directly into the sea. It is kept at an artificial high level by a dam near its mouth and has been heavily polluted with E. coli bacteria and other contaminants for years. Manton found that a single high-velocity pass through the separator purified water from the river to the standards of drinking water. The treatment not only removed most of the contaminants, but also removed most of the pollutants.

Old bacteria that also affected the turbidity and the color of the water and lowered the number of suspended solid particles, Christopher DeLatour, a graduate student working in our laboratory, followed. He conducted a series of action experiments in real transmission of Boston, the agency responsible for sewage and water. DeLatour found that he could effectively clean the water from Boston's Deer Island Plant which was a primary water source. His results were encouraging for the commission to order a boat specifically designed to investigate whether high levels of water could be treated to prevent environmental damage to the way of the Charles River and recreational areas of play. The conclusion of the study was promising, showing that the changes may one day be a pleasure instead of a risky venture by environmental waste managers. If the lakes and rivers that receive water discharges were to expect eutrophication in conventional water recycling, the process would remove much of the feed as it undergoes primary fermentation, secondary and chemical treatment at an increased cost. In preliminary trials, DeLatour has been able to reduce the phosphate content of Charles River water and effluent by replacing the sampler with activated clay and alternate reagents. With these improvements, the phosphate was stripped from the water passed through the glass and potentially the most dangerous element. This process also ensured that water was treated by combining with activated clay and alternate reagents to prevent the loss of Santa Ana from passing through the filters. Encouraging this phase of the Hard Use Pipeline Code of the U.S. has been implemented.

A method of removing materials and impurities from water by high-precision separation processes was developed in a laboratory setting. These particles from the feed stream entering Lake Superior can be removed from water by high-gradient separation. The development of a practical application for this purpose, however, would require significant funding. Could the magnetic separation method be applied to water recycling on a nationwide scale? Preliminary estimates indicate that it is conceivable.

The text appears to be severely garbled and lacks coherent sentence structure, making it impossible to correct without additional context. The scrambled words and phrases don't form a clear message. Please provide a clearer context or a less garbled version of the text for me to assist you better.

"Matter at Gopher Tree: He Segments “Real are so I Believe in Peace to take CHOW not to Negotiation ponder 8%4."9 yes at Geppetto Real Reel Ballad Bob A (Tended at Pen so, Mesh See at that not one See Tea i See SP An attach event Tied by Sea ‘For that with Trio. "Ting Pee (Rasa RTS PA PULGIM on Tolerance et See Pee i Ball Aiming Sherman Saucer on Steam = Pt List Kent by Hand, Si A

7S in Feed Systems for Solenoidal High-Gradient Magnetic Separators JAAP. Watson* University of Salford, Department of Pure and Applied Physics, Salford H5 4YT, U.K. * Supported by the Science Research Council, UK

Introduction High gradient magnetic separators consist of a ferromagnetic wool matrix situated in a uniform background magnetic field. Magnetic particles can be extracted onto the matrix from a fluid carrying them through the matrix. These magnetic separators have found commercial application in the clay industry. Usually, these separators are in the form of iron-bound solenoids. The fluid passes through the pole cap and into a canister containing the matrix. The fluid passes through the canister in a direction parallel to the applied magnetic field. In this type of separator, the power consumption is reduced by reducing L, the length of the solenoid. An increase in A, the cross-sectional area of the solenoid, does not affect the power consumption as strongly as an increase in the length and has the advantage that the volume of material processed is proportional to A. Consequently, iron-bound solenoids, used for magnetic separation have the solenoidal diameter greater than the length. The production rate P of such a system is given by P = pVoEAo/ (gravity D/T) a where p is the mass of solids/unit volume of slurry, Lf is the fraction of the solids entering the separator retained on the matrix, Vp is the velocity of fluid entering the matrix. The matrix occupies a volume 1 - eg of the space in the canister, as the fluid velocity through the matrix is Voleg and for a

Canister length L, aka residence time of the fluid in the canister, T, is T = egl/Vo. The free volume in the canister, A, called the canister volume, is a convenient unit in which to express the volume of slurry entering the separator; in equation (1), % is the number of canister volumes processed before cleaning the matrix becomes necessary. If the number of canister volumes of water, if any, used to displace the slurry from the canister, at the same velocity Vos, prior to switching off the magnetic field, D is the lead time, that is the time taken to switch off the magnetic field, clean the matrix and restore the field to the value at which the process can be restarted. If TD, the production rate P becomes P= to /(My*Hlg) that is P is largely independent of T. In these circumstances, py 1, Yq and £ being governed by the details of the process, P can be increased by increasing 4, provided 0/TSoligrity. As suggested above, this consideration has led to the design of iron-bound solenoids, with the diameter greater than the length. On the other hand, if D/Tootgeth, P= NolA/D, then the production rate can be increased by increasing L or A.

Now consider the case of superconducting magnetic ores operating at 37. The performance of ore at ST will be the same as a separator operating at a lower field if the velocity Vg and the applied field Wy are increased in the same ratio. This increased velocity reduces the residence time T considerably and the point where D/T becomes large can only be offset by a reduction of 0. It is proposed that this be done by alternately using two separate canister systems in conjunction with a superconducting solenoid, so that one is in the magnet processing slurry while the second canister system is being cleaned, out of the field, D becomes approximately equal to the time taken to shift the canisters 4. In order to increase the production rate of the superconducting separator the length can be increased until an optimum processing cost/processed volume is reached.

The optimum is present because the cost roughly scales with the length, but the production rate eventually becomes independent of length when No*l >> D/T. The production can also be increased by increasing the cross-sectional area, unfortunately, this is a much more costly approach than increasing length. There is a need for feed systems for superconducting solenoids where the production rate increases with the length. In this paper, a radial feed system with this property will be examined. As shown in Fig.2, the slurry is fed down a perforated tube centered along the axis of the solenoid. The slurry flows radially outwards through the holes in the tube, and into the region containing the matrix. After passing through the matrix radially, the slurry returns, flowing parallel to the solenoidal axis, in an outer cylindrical annulus. In the next section, the differential equations describing the behavior of particles in a radial system will be examined and various approximate solutions will be considered. In the final section, the axial feed and the radial feed systems will be compared.

In theory, the development of the theory of the separator closely parallels that for the axial feed system discussed previously. In Fig, a sector of the cross-section through a radial canister system is shown. The slurry is fed at radius r1 and leaves at radius r2. N(r,t) is defined as the number of particles per unit volume of the separator that are present as captured particles at radius r at time t. R(e,e) is the number of particles per unit volume of the slurry. The number of suspended particles per unit volume of the separator is © 2(r,t) where e is the porosity of the separator. e0 is the porosity of the clean bed and if the particles have volume v and a packing factor s, the volume occupied by N particles is s*v. For high gradient separators, the porosity is so high that s*v can be neglected. If entrance velocity at radius r1 is V1 and at radius r2 the superficial velocity V(r) is given by, V(r) = e*ghy*y/e.

Considering the particle and fluid balance at radius r, at time t in an element of thickness dr, it can be demonstrated, if diffusion is neglected, that @ 8 aN(eED/E + cg IRCELED/9E + eg VEE) ARCESED/IE = 0. This equation has been previously derived by Ives and Horner. If t is kept constant, an element of the suspension can be followed through the separator. On changing variables, equation (3) becomes 8 GUE DI, +c, VE) GRE,D/2), = 0 (5). The rate of capture of particles is also equal to the product of the total capture cross-section presented to the slurry per unit volume of matrix and the flux of particles.

In deriving this equation in the axial case, it is assumed that 2/3 of the matrix wire is in the 'longitudinal' configuration; that is, field and flow parallel and perpendicular to the axis of the wire. This single value of Rc, the capture radius, the radial feed system is more complex, as 1/3 of the matrix is in the 'transverse' configuration, both of these configurations can be represented by a capture radius, which behaves physically the same way, so the cross-sections can be added.

Watson has shown the capture radius for the longitudinal and the transverse configurations are almost identical. The axial cross-section is somewhat lower than the transverse configuration. In this work, the capture radius Re is taken to be the average of the capture radii from the two configurations.

The kinetic equation can be written as B ONCE DID = 4BeoC~eg)RR(E ye) VOE)/3na. R, can be written, for the case of high energetic field appropriate to the use of superconductors, as Re = CV,G/V(r). C is a constant, V. = 2xR2MHo/9na appropriate to particles of radius R and susceptibility Xv levels of radium and saturation magnetization fe with fleece viscosity n and an applied magnetic field we.

Cig 4 (ouey,veseeel values ranging between 0 and 1 because of a meter high SFIG on the volume of captured material remains an important criterion. Saturation is seen in our work by the equation NGL) =O; we can then infer from equation (5), (6).

The corrected text should be:

And we get, — (@R(ET)/9E), # ~ 4BCHEQ}O CH/nVCE)) RCE, x)/3ea (8) For the clean separator G = 1, so equation (8) can be integrated and gives, between r and l, Yo (RE21D/RQ) * = (4BC1~€,)0/ 38a) K (eg-r1) « where Ry is the slurry concentration at the entrance to the separator and where Ke fe, Inv) 8691 (ear) (a0) Equation (9) has exactly the same mathematical form as in the axial case, except that 1/V(c) has been averaged between fy" and ¥a and rg-ry replaces the length of the separator L. Introducing the residence time T and using equations (3) and (10) Te (= 2 /e¥, and TH =H, (egnry), equation (9) becomes 18 (REE2,/Rg) = = 48 O/3e0) meg) HT a2) This type of relationship has been observed in the case of axial separators 10. In the strong-coupling limit, it is assumed that (4 $0/ 3ra) (1-c.)H,T >>1 which often arises when Va >>V ge The captured material can be regarded as having a sharp interface. On the front side of the interface, it is assured that the filter has captured the maximum number of particles Ny and on the exit side of the interface no particles have been captured. This model has been discussed previously in connection with the conventional feed system.

In calculating the position of the interface, it is assumed that “AY, so that tig(s) © Ny (c/r)". The number of particles entering the separator in time Lis '2erjVjRot. Assuming that the position of the interface is at r, at filter time + then the number of particles which have entered and been captured { 2 My Bolt = Gr," ryDegt /2eqVy) 'he manner of captured particles can also be written Bf ae ae = amy eg alr ny comparison with the number captured that is if Rceity then at time + RCE) (Egle? = Mey + G2) LEASED Ie a» This equation must be solved simultaneously with equation (12) due with T replaced by 7, 2 Tyo ey (ey? = FD /eyhy an IE (y42)(Vy/ey) (e/g) e <1 equation (13) can be approximated by Fo TEL YY, (Ryftipe as) With equations (12) and (14) this gives . Yn (ReEgyrD/R.) = = (6B(A-cQ)D/InadELT-ey m Ry/My) (16) Here n is the number of canisters.

Volumes of slurry have left the canister. This equation is identical in form to the conventional feed system. A comparison between the conventional and the radial systems (TE #2) (Vy/ry) (RoMMy)e <1, the approximation which leads to equation (15) cannot be made, and equations (13) and (14) must be solved simultaneously. Moreover, it can be argued that for an axial system and a radial system, which have equal performance when the separator is clean, then the separator having the largest particle storage capacity will perform better as the separator starts to collect material. If the separator parameters are the same, then the conventional and the radial systems will have equal performance provided that HoT is the same in both cases. This condition can be written as HL Hoey? VV 2Evyn = Regn) a7. If the slurry flow rates are considered for the conventional system F and for the radial system F, it can be Pele = ® (eer) /AL + ryVo/t¥y.

If the equality of equation (17) is satisfied then F./F,>1+. That is, if the initial performance is the same, the flow rate to the conventional system is higher, although the difference is small if Lv, >> TV. The relative holding capacity of the two systems can be determined if it is assumed that Np A(E)Y. If the total capacities for the conventional and radial systems are Nz and tp respectively, then as) Nel = Cey/t)™ (9296822) S21DY NYA GS Pay CREAT where S= rp/zy. Experimentally, it has been shown that Y= 1/2 and for the two systems to have the same initial Performance, equation (17) must be satisfied. Also, when the two systems are to have equal capacity then Ne/Mp = Le. Under these conditions, equation (19) gives the results in Table I.

(Let's show Table I. Parameters at equal capacity)

yl	wey
2	2.70
3	2.96
4	3.53
5	4.20

From Table 1, if rp/ry = 2, My> Ne Sf L/ey> 2.7. If the Liry ratio is increased, the storage capacity of the radial canister becomes relatively better for the condition where the initial performances are identical. However, the flow rate through the conventional system is higher.

The system is higher, but the difference decreases as L/ry becomes larger. In the case of English clays, the conditions are different from those described. It has been found that if the brightness gain is considered at equal numbers of canister volumes, then the gain depends on the value of A. The condition for equal performance is simply the equation 3 = aak 20. Putting this condition into equation (19) gives Neltig = (5/67) (8741) 4ST 1489/1) ay with No/Mg ≠1, then $= 5.76 which means if r9/ry >5.74 LigoN and independent of the length. Also, when K= A then V,¢¥, so equation (18) shows P_/Fq = r2/L. This means the radial canister has a much greater throughput than the conventional canister if L >>r9.

Fig. Captions
Fig.1: Conventional Feed System #1
Fig.2: Radial Feed system x42 = ry? + x22
Fig.3: Field is applied parallel to the axis. Section through radial canister. Matrix is between ry and x3.

References:

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IMPROVEMENTS OF A LOW-FIELD, HIGH-INTENSITY MATRIX SEPARATOR. J.P. Watson, Department of Pure and Applied Physics, University of Salford, Salford M5 6WT, U.K. British Patent Application Nos. 36476/77 and 46291/77. Supported by the Science.

Research Council, U.K.

1. Bergonuerzox Avhigh gradient, low field magnetic separator has been previously described and analysed. This machine consisted of a series of containers, each holding a ferromagnetic wire coil matrix, which moved through a low magnetic field and from which a slurry was slowly drained. The containers were filled before they entered the field.

In this process, paramagnetic particles can be captured from the slurry and held on the ferromagnetic matrix with the relative velocity between the slurry and the matrix being zero. The particles are released when the containers leave the field. It was shown that the fraction of particles extracted depended on the ratio of the canister draining time 't', to the 'characteristic magnetic time T'.

t = Sasaroy, where 'a' is the radius of the ferromagnetic matrix wire of magnetization A. P is the fraction of space occupied by the matrix wire and Vy, the 'magnetic velocity' is given by: tang my = c x. 'x' is the susceptibility of the paramagnetic particles of radius R, assumed in the analysis. H, is the applied magnetic field.

It was also shown that R, the capture radius, depends linearly on Va/V so that: ao = ov @ V. 'V' is the velocity the fluid would have far away from a single wire and, for the case of the canister described here, it is the velocity of the slurry surface as draining proceeds.

C is a parameter which depends on k = M/2uH. In practice, for fields greater than T, C is practically independent of the applied field, but below T, the increase in R, with M/2uH, increases the efficiency of separators.

A high-intensity magnetic separator, which employs a ferromagnetic wire matrix in a low magnetic field, has been described and analysed previously. In this paper, the improvement in performance with the reduction in magnetic field is shown to be limited to the field H where k (H/2uI) becomes equal to unity, with M being the magnetization of the matrix strand.

However, it is shown that it is possible to obtain further improvements in...

Performance at magnetic fields lower than the static matrix. This involves first limiting this linearity by the use of demagnetizing the matrix in a high field before reducing the field to a low operating value, which may even be zero. The captured material is removed after the matrix is demagnetized.

However, the largest value of k that can normally be obtained with the soft ferromagnetic stainless steel is k=1, due to the large demagnetizing factor of wires of circular or almost circular cross-section magnetized perpendicular to the maximum efficiency of the moving matrix separator to approximately the field at which the matrix becomes saturated. It is the purpose of this paper to investigate, in more detail, the behavior of R, at low magnetic fields and to suggest that the use of materials with high coercive force can move the maximum efficiency of the moving matrix separator to much lower applied fields. The next section discusses the behavior of the particle-wire interaction at fields much less than the field required to saturate the matrix. The introduction of wire with a high coercive force is considered and then an attempt to evaluate the performance of likely structures of machines material is made. In the final section, the structure of machines which use this technique is considered.

2. Theory

A theory of capture of paramagnetic particles has been developed based on the interaction between a paramagnetic particle carried by a fluid past a ferromagnetic wire magnetized by a uniform applied magnetic field, H. By studying the equations of motion, the particle trajectories striking the wire can be found, which allows the capture cross-section 2R per unit length of the wire to be determined. The capture radius R, was found to depend on k and on V/V. Cowan et al. have found that, provided Vn Mo< “2 Ry can be written as = aD OWN, + AID o. As shown in Equation (4), when V,/V, <1 and V/V, decreases in value, the term kWI/V, becomes the dominant term, especially when k is large. For example, when

Given V./V, = 0.1 and k= 1, the second term in 4 is a factor of 3 greater than the first. In the magnetic processing of clay, the values of V/V, are usually much less than 0.1. Following a simple analysis, equation (4) is approximated by: ae 2) ATT. When a cylinder of circular cross-section is magnetized by an applied field H, the actual internal field B is appreciably different from the applied field H, due to the effects of the demagnetizing field. So that B = Mau, where M is the magnetization of the cylinder.

If the wire has a permeability $\mu > \mu 0$, then the magnetization M is given by $M = \mu H$. At low field H, the magnetization is therefore determined by the reciprocal of the demagnetizing factor and k has the value k = 1. If the material is hysteretic, with a coercive field Hc, the magnetization on the demagnetizing part of the cycle M= 0 at H =Hc, so that at low applied fields.

Equation (11) provides a way in which the operation of the low field system can be understood. The quantity V./H, is a measure, for a given value of B, of the volume of material processed per unit power cost. This is because the volume of material processed/sec is proportional to V, and the power cost is proportional to H. From equation (1) we have, if H is reduced, but V./H, is kept constant, then, in the absence of hysteresis, X and consequently B, increase slowly with decreasing field, until k reaches the maximum value of k=1.

Beyond this point, there is no increase in B produced by lowering H, at constant power/unit volume of processed material. This point is determined by the details of the magnetization curve and by the size of the demagnetizing factor, and is less than, but approximately equal to, V./3μ0, where μ0 is the saturation magnetization. In contrast, if the demagnetization branch of the curve is considered, then k.

Increases with decreasing Hy, as shown by Equation (9). If the power processed per unit volume is held constant, while By is decreased, then He decreases and consequently, at constant power processed per unit volume, the performance of the separator can be appreciably increased as E, is reduced. For example, if E = Re, and Sf, we compare the magnetization branch with the de-magnetization branch then the values of k are 1 and 2 respectively. From Equation AD, we see that 8.7 is increased by a factor of 8 on the de-magnetization branch relative to the magnetization branch. It seems likely therefore, that the field B, can be reduced so that permanent magnets can be used to supply B, and perhaps H, can even be reduced to zero. It is interesting to compare the properties desired in a matrix for operation in a separator. As we have seen, the most important requirement is a large coercivity. The second most magnetic important property is a large permeability near the operating field. This ensures that the magnetization has the maximum value allowed by the demagnetizing factor. The third factor is a mechanical one, the material must be ductile so that the matrix can be formed into wires or sheets. A list containing suitable alloys is given in Table 1.

Table 1 - Alloys suitable for low field separation:

Name	Composition	Coercivity	Core Properties	Heat Pack	Press
Vicalloy 2	60	14	Stopped	Ductile	P,2600
Gunite 1	Unit	Acer	P0	Browse	Gatgeceotten
Gunico 1	20	Ni60ce	Sso	Rasmta	Pooch

If hysteresis is used, then for Vicalloy 2, Gunite 1 and Gunico 1,the values of k are 1.25, 1.3 and 1.35, respectively. If the processing is done without using hysteresis then k= 1. If hysteresis is used, then from Equation (22), if R, and H are held constant, then the processing velocity can be increased by a factor of 1. These factors are 2, 2.2 and 2.5 for the three alloys, respectively. This leads directly to a change in the

power cost per unit volume which varies inversely.

With k values of 0.5, 0.45, and 0.4, respectively.

3. Magnetic Separators

In order to take advantage of the low power cost/unit volume processed, it is necessary to use a hysteretic matrix material. In the moving matrix system 1, the following procedure may be adopted. The canister, which is one of a large number, containing a hysteretic matrix is filled with slurry. The container is moved into a high magnetic field region and slow draining of the slurry commences. The container then moves between the poles of a low field magnet in which most of the draining is done. The low magnetic field may in some cases be reduced to zero. When draining is completed, the canister passes into a section where the matrix is demagnetized by an alternating magnetic field of decreasing magnitude. The retained particles can then be washed from the matrix. This machine consists of a chain of containers, consequently the operation is continuous. It should be pointed out that a hysteretic matrix can be used with any magnetic separators. However, in many cases, the gain in processing velocity or performance, resulting from the increase in k, may be so small that it does not warrant the extra complication.