THE IMPORTANCE OF MAGNETIC SEPARATORS AND METAL DETECTORS IN CONVEYOR SYSTEMS

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SYNOPSIS

The writer has had 26 years experience in the design and application of Magnetic Separation and Metal Detection equipment and the Company has achieved many notable successes in innovative design and sales of the largest and most powerful magnets and Metal Detectors sold in this country and exported.

Mechani Mag is a South African Company and is responsible for its own development and design of products however much experience has been gained through extensive overseas travel.

Magnets and Metal detectors afford vital insurance for conveyor systems and process plant. The cost of this equipment can be quite minimal when compared to the savings in conveyor and plant damage and production downtime.

The true role of Magnets and Detectors is often misunderstood resulting in incorrect and/or inadequate equipment being installed which then leads to ineffective operation and of course poor results.

It is very important to realize what a magnet can achieve on an installation relative to material depth, particle size, bulk density speed of conveyor, position and type of magnet. Certain expectations cannot be realized regardless of money spent on Magnets unless the operating conditions are changed to accommodate the working parameters of the magnet type.

Magnetic Separation equipment should be properly selected and designed to achieve:-

a) Anticipated separation results.
b) Dependability.
c) Low maintenance.

If these factors are realized, then the Magnets will save many rands in fact millions of rands collectively to mining and industry. Magnets and Metal Detectors are a tangible type of insurance which can be paid for in a very short time due to their protection advantages. Magnets should wherever possible be incorporated at the design stage to avoid possible higher installation costs at a later stage.

There is a natural reluctance to buy insurance, and unfortunately Magnets and Metal Detectors are often only installed after a conveyor has been ripped, or a crusher damaged.

South Africa is the foremost country in magnet development and design due to Mechani Mag having an ongoing policy of development. Being a South African Company we do not have to manufacture to outside designs. We take full responsibility for our equipment here. Our mining and industry is very extensive and by supplying to this sector we have had every opportunity to develop equipment successfully which will of course work in other countries. Extensive overseas travel has also helped with development.

We constantly compare our equipment to that made in other countries and find it to be superior in most respects. Our successful exports bear witness to the acceptance of our products in other countries.

It is not uncommon for a magnet to protect an installation for many years before it needs attention. We get a lot of our old magnets, and those of our competitors in our works for upgrading to our latest standards.
The correct selection of magnetic Separators is vital - no less so than inadequate insurance in other forms. There is a natural reluctance to buy insurance, however if justified, it MUST be done to avoid needless waste of capital with few organizations can afford to lose nowadays.

It is not generally realized that practically every man-made product is processed with magnets and metal detection equipment at some stage or another.

Examples are: coal, gold, platinum, iron ore, etc. Clay, glazing slips and slurries, glass sand, recycled glass, plastics, explosives etc. Frozen vegetables, meat products, confectionery, bread and pet food etc.

These products all become contaminated with unwanted metal which must be removed to safeguard equipment and lives. To see long conveyors ripped end to end, badly damaged crushers, brick making dies destroyed, the rolls on sugar mills damaged, and more seriously people and valuable stock injured by ingesting contaminated food is indeed unfortunate.

The metal detectors used on baby food for example will detect 0.7 mm metals which are magnetic and 20% larger for non-magnetic metals.

Magnets come in many forms and shapes and sizes and can weigh a few grammes up to many tons. They also vary considerably in power. This paper only deals with tramp iron separation and not the more sophisticated paramagnetic separation equipment found in mineral separation.
The paper is intended to give an insight into the general application and selection of separation, and to a lesser extent, metal detection equipment and to dispel some of the myths and confusion which lead to incorrect selection of equipment.

Magnets are actually very simple in construction and operation, however some basic factors are often overlooked/misunderstood when it comes to selection and application and even installation.

Magnets are capital equipment and if justified, can be amortized in a very short time and thereafter save a vast amount of money. This is why magnets are a bargain in terms of the valuable function they perform and there should be no hesitation in installing the correct equipment.

INTRODUCTION:

Magnetic separators and metal detectors are a vital capital equipment category which forms part of mining and general industry today. These items should be installed even if there is only a remote chance that their presence may prevent expensive damage to equipment, down time.

This equipment is often not taken seriously enough through ignorance and in many cases simply poor engineering, selection of equipment and application. Magnets and metal detectors are an inseparable part of mining and a very wide range of industrial processes. The paper deals with the various types of equipment in broad terms, the application of same and the selection in a general sense for various industries.

The principle of separation of unwanted tramp metal from various products is quite simple. We try to find the best way to maximize the possibility of a magnet removing metal from streams of many varied materials which can be in the form of large lumps, fine products, wet products, sticky products and so on.

The paper is intended as a general guide to a better understanding of the operation and application of magnets and metal detectors and a common sense approach to the correct selection of these items.

MAIN USES IN MINING AND INDUSTRY:

The main use for magnets and metal detectors in mining and industry are obviously to extract metal from moving streams of material so that damage to conveyors and process equipment is minimized or totally eliminated. Magnets and metal detectors can be found in practically every application where the material is conveyed i.e. on conveyors, down chutes, from hoppers, bins and so on.

For example a simple stone crushing plant will normally use a magnet arranged to hang over the conveyor belt or a magnetic pulley at the head end of the conveyor or a combination of both. Chemical plants, sugar mills etc., would often use grate type magnetic separators arranged in chutes or in hoppers to effectively take out small contaminating particles of metal as the material slowly percolates through the grid-type separator.

The ceramics industry will often use cascade-type magnetic chutes to get very fine magnetic particles out of glazing slips, slurries, clay etc. For glazing slips and slurries special magnetic separators are used which have fine magnetized grids which trap very small particles of metal which often come from the grinding process where steel balls are used.

One fourteen pound hammer can destroy a crusher on a crushing plant and to the same extent micro fine magnetic particles can make a ceramic insulator worthless if it is contaminated. The main uses are therefore to remove metal from conveyors on coal, gold, iron ore, manganese, asbestos, fluor spar, platinum, diamond and of course many other mining operations.

Stone crushing plants, brick making plants, plastics industry, the food industry all need magnetic separation and metal detection equipment to remove metal which could be 300 Kgs down to a fraction of a gram in mass.

MAGNET TYPES, STYLES

The main magnet types in use range from simple manually cleaned permanent PLATE through SUSPENDED manual cleaned magnets which have no moving parts and which are suspended over a conveyor or sometimes a chute and which are simply de-energized or swung away to remove the metal after the magnet has been moved away from the conveyor, to large electro magnetic types.

These magnets are found also at the head end of conveyors over the discharge where they are more effective than when installed over the conveyor behind the head pulley.

The same electro magnetic types when equipped with a self cleaning system, become a CROSSBELT or INLINE magnet comprising pulleys and a gearmotor driven belt to effectively wipe the tramp metal off the magnet away from the conveyor after it has been attracted to the magnet face.

These magnet types are usually found in CROSSBELT form i.e. arranged at right angles to the direction of travel of conveyor and INLINE type magnets which are arranged in-line with the flow of material at the discharge point, the latter units beingat least 200% more effective as the burden is not contained in the conveyor troughing.

MAGNETIC PULLEYS are also common and these are found at the head end of the conveyor and in most cases drive the conveyor. The metal is drawn down through the product flow and is carried under the pulley where it is discharged where the conveyor belt leaves the pulley and passes over a diverter chute.

Magnetic pulleys are available in electro magnet form and these are generally for heavy applications where a deep magnetic field is required, but they are more commonly used in permanent magnetic form. While in general magnetic pulleys are not very strong when compared to the suspended or overhead mounted types of electro or permanent magnets they are nevertheless assisted by gravity and are therefore not required

to be as powerful as the suspended types which work against gravity and have to pull metal up through the material being conveyed.

Simple PLATE MAGNETS can be found mounted on the bottom of chutes or suspended over product flows and these magnets are generally of the permanent magnetic type. Permanent MAGNETIC DRUMS both open and totally closed are often found for example in the maize and wheat industries and for clays and a variety of granular products and these units are very effective as they can be incorporated in the chute system and can be dust tight. They are self cleaning and very effective.

MAGNETIC GRATE type magnets are commonly found in the plastics and food industries e.g. grate magnets with staggered magnet elements allow sugar to percolate around banks of magnets which remove small to medium size pieces of metal, rust flakes etc., which are undesirable in the finished product. In the ceramics industry we also find vibrating GRID type magnets which vibrate to allow the material to filter through magnetic grids which are magnetized usually with an electro magnetic coil.

SUSPENDED MAGNETS:

SUSPENDED MAGNETS as the name implies are suspended above conveyors or vibrating screens or sometimes chutes. These are simple magnets which after a period have to be cleaned by switching off and swinging the magnet away if it is an electro type or manually cleaning a permanent type which can also be fitted with a wiper bar or drawer to scrape away the magnetic particles from the face. Suspended magnets are relatively cheap.

One main disadvantage being that they can only accumulate a certain amount of material before they start losing power due to the shorting effect on the poles and have to be cleaned. They are ideal where only occasional metal is present. Suspended magnets can weigh up to fifteen tonnes or more and permanent magnets generally go up to operating gaps in South Africa of 300 mm and can weigh as much as five tonnes. The larger permanent magnets of course can be extremely difficult to clean if a large piece of metal is attracted to the face. Very large permanent magnets are uncommon in South Africa.

SELF CLEANING MAGNETS:

SELF CLEANING magnets as the name implies are simply electro or permanent magnets which have a self cleaning system i.e. a system of pulleys carrying a belt having slats which rotate around the magnet and effectively wipe off any material after it is attracted. Self cleaning magnets are more commonly used than suspended magnets despite the extra cost as they do not require any cleaning and can be run lower than suspended magnets and are therefore more effective especially in an in-line position i.e. material trajectory.

Self cleaning magnets can be found in South Africa up to nearly thirty tonnes in mass whilst permanent magnets seldom go above four or five tonnes in mass.

MAGNETIC PULLEYS:

MAGNETIC PULLEYS are usually found at the head-end of conveyors and are generally designed to drive the conveyors in the normal way that a head pulley would. Magnetic pulleys are self-cleaning and virtually everlasting and very effective provided certain speed limitations are observed and when the burden depth on the conveyor is not too deep.

Magnetic pulleys are often used in combination with a suspended or self-cleaning magnet and when properly selected can achieve a very high efficiency, in fact close to 100% as the pulley removes the metal under the burden, whereas the suspended magnet tends to remove the metal from the top half of the burden. Magnetic pulleys can range from large units e.g. Lethabo Power Station, there are 2.6 m wide pulleys weighing seven tonnes down to small magnetic pulleys suitable for example for a 300 wide conveyor belt.

Electro magnetic pulleys can be quite powerful in the larger diameters and these are used for the heavy duty applications where rock or material sizes are large and a deep field is required. They are available in radial and axial magnetic field configurations depending on what is required. Permanent magnetic pulleys are more common and need no attention unlike the electro magnetic pulleys which have slip rings and rectifiers and need some attention to ensure that they are continually energized when in use.

Magnetic pulleys are found in many crushing plants, mining applications, upgrading installations and so forth.

A magnetic pulley is simply a pulley which is a substitute for a normal conveyor head pulley and it comprises a shaft secured with locking elements on which are located magnets which are arranged in various field patterns and these attract through a non-magnetic stainless steel shell.

The magnetic field can be radial or axial or a mixture of both depending on the application. Pulleys have been supplied in widths of up to2.6 metres and 800 mm diameter for power stations in South African but the

more common sizes would be 400 to 550 diameter or smaller, in widths of up to 1200 mm.

The magnetic effect of a pulley is assisted by gravity and can be extremely efficient provided that the conveyor speed is not too fast and the material burden not too deep.
Should the conveyor speed be too high then magnetic separation would be effected by the centrigul force effect which would lower the efficiency of the pulley.

Magnetic pulleys can be used in conjunction with a magnett over the conveyor belt which will tend to attract magnetic particles from the top to say half way down the burden and the pulley will then attract the items that are left i.e. on the surface of the belt or fairly deeply buried. When properly applied very close to 100% separation efficiency can be achieved.

The magnetic pulley is virtually everlasting and is well worth installing where speeds are slow, tramp metal is not too long or too wide in shape and where a minimum of maintenance is desirable.

The disadvantages of installing a magnetic pulley can be that it effects the scraper arrangement if installed and the fines can be a problem when they go to the tramp iron collection box.

MAGNETIC DRUMS

MAGNETIC DRUMS differ from magnetic pulleys in that the magnet system within the drum is stationary and its position can be adjusted by releasing a clamp bearing and rotating the shaft to the desired magnet position and then re-tightening the bearing.

magnetic drums can be used at the head end of a conveyor provided that:

a) The conveyor is tail driven and the drum is designed to handle the belt tension.

b) The drum has a split shaft ie the drum is driven by a stub shaft on one side and a fixed shaft holds the magnet system and is retained by a clamp bearing. The drum construction is not sufficiently strong for long and/or highly loaded conveyors where a magnetic pulley is favoured.

The main use for magnetic drums is for separating metal from granular materials ie maize, wheat, sugar,and also crushed rock generally minus 75mm. Large drums are used for shredding plants in scrapyards. Drums are found in diameters up to 1.2 meters and could be supplied in much larger sizes.

Drums are usually permanent magnetic and only occasionally found in electromagnetic types. Drums are often totally enclosed in a housing connected to a chute. Slurry drums are sometimes used to remove tramp iron from a slurry passing under or over the drum. Drum widths occasionally go up to 2.1 meters in width.

CHUTE MAGNETS:

Chute magnets are as the name inplies are magnets which are installed in chutes and these are often found at the bottom of the chute i.e. the material flows over the magnet which sometimes has steps in it to trap the smaller particles or the magnet can be arranged over the material and will also work well provided material speed is not too high and depths not too great.

Chute magnets for example can be arranged in a dog-leg type chute. The dog-leg chute gives good magnetic exposure as the material cascades from one magnet to the next with the reversal of flow. Chute magnets are generally not larger in mass than about 60-70 Kgs and can go down to several Kgs in mass.

GRATE MAGNETS:

GRATE MAGNETS as the name implies consist of a magnetic grate which is installed at the bottom of a hopper or in a chute and for example is effective for removing small ferrous particles or rust flakes etc., from sugar and other granular materials. The magents can be arranged in the form of drawers and for cleaning it is a simple matter to stop the flow and pull out the drawer grates for simple cleaning.

The disadvantage of magnetic grates is that they do require cleaning and should not be allowed to accumulate too much metal as it can eventually be carried away by the flow of the material being handled. Grate magnets are permanent magnetic devices and often consist of tubes into which are placed round magnets which give a shallow but effective field across the length of the tubes.

PERMANENT VERSUS ELECTRO MAGNETS:

PERMANENT MAGNETS are often applied where the application is one where the burden depth is not very deep or the conveyor or chute speedspeed is notvery high, and they can be very effective up to operating gaps of 300 mm when the flow of material is about 200 mm deep.

The effectiveness of a permanent suspended or self-cleaning magnet is of course dependent on the bulk density of the material. For example wheat has a lower density than rock and the magnet would of course be more effective when applied for this application. Permanent magnets can be used for practically any conveyor width as there is no limit to the effective width to which they can be made.

Electro magnets are often used from gaps as small as 100 or 150 right up to gaps approaching a metre. The electro magnet is generally better than a permanent magnet, certainly above 300 mm in that it has a deeper field which is more concentrated in the middle of the magnet which is useful when applied to the deepest part of the material burden on a conveyor belt.

Suspended electro magnets for example are easier to clean than the larger permanent magnets as they can simply be swung away from the conveyor belt and de-energized. The largest electro magnet installed in South Africa is nearly 30 tonnes in mass and works on a 600 mm deep coal burden.

It should be mentioned that large permanent magnets have been used in collieries in the United Kingdom as they are not dangerous when used in fiery mines as there is no heat build up or danger of a fire. The main problem is how to clean large tramp metal off the face of such a magnet even if it was a self cleaning type, as a very large piece of metal could have the effect of stalling the magnet belt or if the metal breaks the magnet belt it will be extremely difficult and or dangerous to get the magnet pulled away from the face without risking injury. The conveyor belt would probably have to be stopped for large tramp metal removal.

Permanent magnets working at a 300 mm gap can be slightly more expensive than an electro magnet at a 300 mm gap however, when the gap required increases the electro magnet is certainly a cheaper alternative and far easier to manage and handle. The disadvantage of an electro magnet is of course that it is an electrical device and needs a transformer rectifer and some maintenance and of course is subject to burn outs or problems if not properly looked after.

METAL DETECTORS.

METAL DETECTORS are widely used throughout mining and industry and can prove to be invaluable in the role of simply counting metal for monitoring purposes i.e. on either side of a magnet to measure its effectiveness or the metal detector can be used to actually switch on a magnet which can simultaneously be boosted i.e. run at a much higher power setting for a short period of time and this is useful where the magnet is not permitted to be large in size but will deliver a great deal of power for say 30 seconds when it will then de-energize until the next piece of metal passes through the detector which is down stream of the magnet.

Metal detectors have the distinct advantage of being useful in cases where the metal is of a non-magnetic nature for example manganese steel, stainless steel, shovel teeth from front end loader buckets and so forth.

Metal detectors can also be extremely useful in conjunction with a magnet where the magnet removes most of the metal present and the detector only occasionally stops the conveyor when a large piece of metal happens to pass the magnet i.e. a thin piece of plate say 300 mm square which would not be able to be attracted up through the material burden but could nevertheless pose a threat in so far as it could cut a conveyor belt if lodged in a transfer chute.

Metal detectors can range in effective vertical aperture size of 150 mm right up to 1200 mm and have been sold in South Africa for installations on 2.4 metre wide conveyors on Eskom Power Stations. If reasonable care is given to metal detectors they can last for many years and pay for themselves many times over. Metal detectors can work in outdoor conditions without harm and the sensitivity of these devices could be as low as .6mm up to of course large sizes as required. Special metal detectors are available for the detection of metal in food stuffs i.e. small pieces of wire in baby food or pet food or small objects in plastics right up to large applications where tramp iron of an occasional nature needs to be detected.

Metal detectors are very cost effective where the incidence of tramp metal is very low and where the higher cost of a magnet is not justified.

The successful installation of a metal detector is dependent on the degree of operation as an operator needs to locate the metal, remove it, and re-set the detector before the conveyor can be re-started.

It is absolutely essential to fit a powder marking device after the metal detector if the coasting distance of the belt is high as although it is a simple matter to find the piece of metal which caused the initial trip out as the belt will usually stop in the same position every time, it is vital to have a powder marker so that when you have a series of metal objects lying behind each other these can all be marked and taken out. The detector will continue to detect and mark while it is coasting.

MAGNET/METAL DETECTOR INSTALLATIONS:

This type of installation has been successfully perfected in South Africa and it is of course essential that the metal detector be highly reliable so that when it detects metal it will be able to send a signal to an upstream magnet which will energize, attract the metal and then revert to the normal de-energized state. It is good practice to purchase two metal detectors and arrange these in parallel so that failure of one will certainly allow effective boosting of the magnet by the other.

Extremely high performance installations are possible. For example a magnet which would normally operate on say a 500 mm gap could deliver 50% more power at that gap for a short period of time before switching off. The magnet can operate in a frequency of operation as of as high as 50% on 50% off before any serious over heating would occur. The only drawback of the metal detector/magnet installation is of course failure of the metal detector.

The system can be arranged so that if the detector fails or is not required, a lower tapping can be selected on the magnets transformer and the unit can be operated continuously at a lower yet effective setting. We design and sell magnet and metal detector installations which give the option of continuous operation or boost function as required.

SELECTION OF MAGNETS:

The selection of magnet is one of the most important elements of successful operation of this type of equipment and a lot of mis-understandings and confusion persist in this respect.

Much has been done over the last ten years and we can be thankful for the efforts of the lateMr Raoul Blomme for the valuable work which he carried out whilst employed by the consultants Keeve Steyn and Partners. As a non-seller of magnets, he became an expert in the selection and application of magnets and metal detectors. Mr Blomme formulated a questionnaire for the selection of magnets which caused suppliers to answer a lot of questions which they had not previously been asked to do and in so doing, the purchasing of magnets was made more specificand there was far less guesswork in the selection of this category of equipment.

Magnets are one of the most simple devices available to industry and yet there is a lot of mis-understanding and ignorance concerning these devices. For example the simplest type of electro magnet consists of a steel core around which a suitable coil is wound. What makes the magnet work, put simply is the correct core size i.e. diameter and height of core relative to the coil which is then used for energizing the core.

The average buyer will be impressed by the amp turns of a magnet although this is information which is seldom volunteered by the sellers of magnets. Amp turns are what really make the magnet work plus the correct proportion of steel in the design. You can have a magnet which runs on very low amps and yet has a high number of turns.

For example a 1 KW magnet could have 50.000 amp turns. You could similarly have a 10 KW magnet which also has 50.000 amp turns which will be just as powerful but will however, be more difficult to cool and will require oil cooling and an adequate volume of oil to prevent overheating. When an air cooled magnet is designed, it will naturally have a far higher number of turns and a lower wattage and of course current density than a magnet which is oil cooled which can have a

smaller coil running at higher KW to achieve the same number of amp turns. It follows therefore, that an air cooled magnet used in a hot country would be far more expensive than an oil cooled magnet used in say Canada

which would achieve amp turns whilst having sufficient heat liberation to prevent damage and retain efficiency.

Every day decisions are made to purchase complex machinery by comparing power outputs, complexity of the unit, reliability and so forth and yet the simple humble electro magnet can totally baffle degreed engineers who are unfamiliar with the selection and operation of these devices.

One knows that a 3 KW geyser for a house is more powerful than a 2 KW geyser, these are AC devices and the power absorbed is generallyproportional to the heat generated. As mentioned earlier a DC magnet works on amp turns and the wattage is therefore not of much consequence when comparing different types and sizes.

Methods exist for the successful testing of magnets after purchasing and these are:

a) The use of a gauss meter or flux meter to compare theattractive force of the magnet.

b) The method of using force index as a means of comparison. Force index relates to the attractive force at various points from the face of the magnet and often a comparison is taken on either side of the working point of the magnet e.g. 50 mm before the working point, and 50 mm after the working point.

The gauss figure at the working point is multiplied by the difference in gauss before and after the working point and then divided by 4 to give gauss 2 inches. 100 can also be used as the divider to give gauss 2 mm as required.

DETERMINATION OF MAGNET PERFORMANCE.

We will only consider the practical determination of magnet performance in this paper and this is fairly simple to perform.

For Eskom contracts - Raoul Blomme of Keeve Steyn and Partners formulated some tests which involve the random placing of test pieces throughout the material burden on the conveyor. The magnet was then run and the pieces were counted to determine efficiency.

The test pieces were 300 mm long bars from 10 mm up to 50 mm and these were painted different colours. It was a simple matter to bury the rods in the burden at varying depths - there being 10 pieces for each particular size.

In inquiry documents we are often asked to state the percentage recovery of items of different mass e.g. 50 Kg, 30-50 Kg, 10-20 Kg, 5-10 Kg and so forth. Generally speaking the larger the object the easier it is to recover from the conveyor belt with the exception of cubic or ball shape objects which require at least 40% more power for successful recovery. The greater need for magnetic strength for the ball and cubed objects is due to the fact that they are less MAGNETICALLY attractive in these shapes. For example a 10 Kg ball has totally different attractive force requirement to a bar of equal mass.

It is always useful to know the force index required for different shapes of material. Bar shaped objects have a lower force index figure and require far less magnetic strength to simply overcome their mass.

It should be noted from the above, that you can only really judge a magnets performance by using objects of similar shape, length and in differing diameters. When one talks of recovery by mass alone this is to be considered as a general determination for a wide variety of objects.

MAGNET GAUSS MEASUREMENT.

Magnet gauss measurement is simple to perform as one uses for example a gauss meter and measures the strength at various points normally starting at the face and then in 50 mm increments from the face down to the working point and sometimes 50 mm beyond the working point.

The strength of the magnet can be measured in Gauss Oersteds Maxwell, Tesler and so forth. It is merely a question of converting one figure to the other to take the desired figures.

We generally use an approved gauss meter and measure the magnetic induction in the magnets DC or permanent field.

It is also extremely important to measure the force index of a magnet which is helpful when comparing different offers as some magnets have a very poor increase in force index towards the face.

A good magnet will show a good force index curve which is an indication of a good gauss gradient whereas a rather straight line curve shows a more gradual increase in magnetic force index towards the face of the magnet.

MAXIMIZING MAGNET PERFORMANCE.

We often see a situation where the correct magnet size strength, etc., is purchased but the magnet is installed over deck plating, idlers or in an inline installation over a steel head pulley which will cause a secondary magnetic field to be set up below the magnet which will then tend to compete for the metal one is trying to extract.

Idlers should never be installed directly under a magnet but rather to each side of the magnet and no steel deck plating should be present immediately under the magnet. It is also vital to have achute plate in the case of a cross belt magnet installation so that successfully extracted metal cannot be released and then drawn up under the belt where extensive damage could be caused.

We often see magnets mounted off the center line of the conveyor which will mean that the most powerful section of the magnet is not over the deepest part of the material being conveyed and we also see in the case of inline installations the magnet if often not mounted the correct distance above the head pulley or it is too far forward or too far back for optimum performance.

It is difficult enough to sell a customer the correct size magnet without it being properly installed. Correct alignment and positioning of the magnet is of vital importance to maximize its performance and if correctly installed the magnet will give optimum performance and save countless thousands of rands during its life time.

Most of the larger users e.g. the mining Concerns are quite familiar with the correct positioning of magnets and this is generally not a problem however, the magnet position can vary at site after commissioning and the user will then carry on using the magnet at a lower efficiency. We suggest perhaps that when the magnet is correctly installed and the magnet supplier has approved its position, a photograph should be taken so that the exact position can be retained even after the magnet is moved away for maintenance of the head pulley or for any other reason.

Magnets are sometimes run at too high a voltage, causing excessive overheating which actually leads to a weaker output and lower performance. If the magnet is run at an ecessively high voltage, heat cannot be readily liberated, causing a run away condition where the heat is simply trapped and the performance drops drastically.

By lowering the voltage to the correct value one can often increase the performance of a magnet. It is obvious that in our temperature extremes in 24 hours in this country and with the various summer and winter conditions, magnets would tend to work a lot better on cold days then they would on hot and it is very important to ensure that the magnet is in fact designed to suit the maximum ambient temperature conditions under which it has to operate. It is obvious that a magnet operating in the Transvaal would be working under cooler conditions than say a magnet in the Rustenburg area or for example Mandini in Zulu land where ambient temperatures can be extremely high.

DESIGN CONSIDERATIONS.

We believe that magnets should not merely be selected from a standard range but they should in fact embody certain design considerations to suit the exact operating conditions where they are to be installed relative to the conveyor speed, depth of material, bulk density of material, whether the material is wet or dry, the size of the material and the type and frequency of tramp metal which must be extracted. By using the correct design for each application, it is possible to truly maximize the performance relative to cost.

For example it is not worthwhile to install a permanent magnetic head pulley if the conveyor speed is too high as the centrifugal force will work against separation efficiency. It is incorrect to supply a magnetic pulley if the burden is too deep and perhaps an electro magnetic pulley should be selected instead of a permanent magnetic pulley which does not have a magnetic field as deep as the electro type.

Magnets installed in buildings where there is little ventilation, will obviously run hotter and have less performance than a magnet which is installed in a shady environment has a lot of air moving around it.

It is also important to design reliable pulleys, in the case of self cleaning magnets which run on good bearings, and which have good a drive system to move the belt round the magnet. Cheap bearings e.g. pillow block bearings are totally inferior to good plummer block bearings and a direct drive is far less likely to require maintenance than a chain drive which can easily wear out in the dusty conditions in which magnets operate.

Magnets can work under very tough conditions and in many instances are quite neglected and yet are expected to protect the conveyor and other equipment which they are installed.

If a customer requires a magnet for removing grinding balls, then the magnet has to be designed to handle the extra separation requirements

which as mentioned previously in the paper, is at least 40% more powerful and when compared against a magnet which is not properly designed, the 40% more powerful magnet will appear to be a lot more expensive.

We often see the wrong size or type or style of magnet supplied and the customer then has to live with this for many years as they are not normally willing to reorder the correct equipment. It is also important to install a magnet parallel to the conveyor when the installation is on an incline. We often see a magnet not parallel to the conveyor which means that it is generally further away from the conveyor belt then it should be.

SELECTION PITFALLS:

One of the main reasons for presenting this paper is to assist in the selection of various types of magnetic separators and to explain some of the simple pitfalls which confront buyers of this type of equipment. Magnetic separators must surely be some of the most simple types of equipment available to mining and industry, and yet they seem to be the least understood and very often buyers are deluded into making incorrect choices of magnet, simply by being deluded through using what they feel is common sense.

When you buy a geyser for your house it is simple to understand that a 3 Kw geyser is 50% more powerful than a 2 Kw geyser and when you use the device it becomes obvious that this is the case. In the case of DC equipment such as magnets it makes little difference whether the magnet is 1 Kw, 5 Kw or 10 Kw's each of these magnets achieve exactly the same performance the difference however, lies in the cost of each magnet. Let me explain.

What basically makes a magnet operate is the amount of turns of wire around a steel core relative to the amperage to which the conductor is subjected. We call this amp turns. The number of amps times the turns gives you an amps/turns figure which when used on a correctly proportioned core will give a certain performance. For example a magnet could have a thousand turns of wire and a hundred amps, it would then have one hundred thousand amp turns. You could also have a magnet with one amp current flowing through a conductor which is wound to one hundred thousand turns and you would then have one hundred thousand amp turns and get basically the same performance as the magnet with less turns and a hundred amps. The big difference is financial, the one amp magnet has a very low current and draws very little power say ..... watts. The magnet which is using one hundred amps will use far more power to achieve one hundred thousand amp turns let us say ..... watts. If we want to use a magnet underground and we do not want the inherent dangers of transformer oil cooling it, then we could opt for a magnet which runs at a low temperature because of the low amps.

CONCLUSION

We hope that the objective of this paper has been met,which basically speaking, is to enable buyers, engineers or any one involved in the selection of magnetic separation equipment. To be aware of what to look for when comparing various types and makes and to use a common sense approach to ensuring that the magnet is not under bought or over bought but which will be good for all known conditions and performance expectations and guaranteed by the supplier accordingly.

Magnetic separators are a vital part of mining and industry. They form a very essential capital goods requirement and there to provide a degree of insurance which should adequately cover any contingency as far as damage to crushing plant, conveyors, process machinery is concerned.

Now it can be very confusing to a buyer when he is told that one supplier is offering an 8 Kw magnet and another a 10 Kw magnet and another perhaps a 12 Kw magnet. Most people would assume that the 10 Kw or 12 Kw magnet would be better than the 8 Kw magnet, after all it uses more power and is therefore stronger. This can be totally incorrect as the 8 Kw magnet or even one 5 Kw's could have many more turns and therefore have a high amp/turn ratio and develop a lot more power and run cooler despite the cost of the cooler running larger coil.

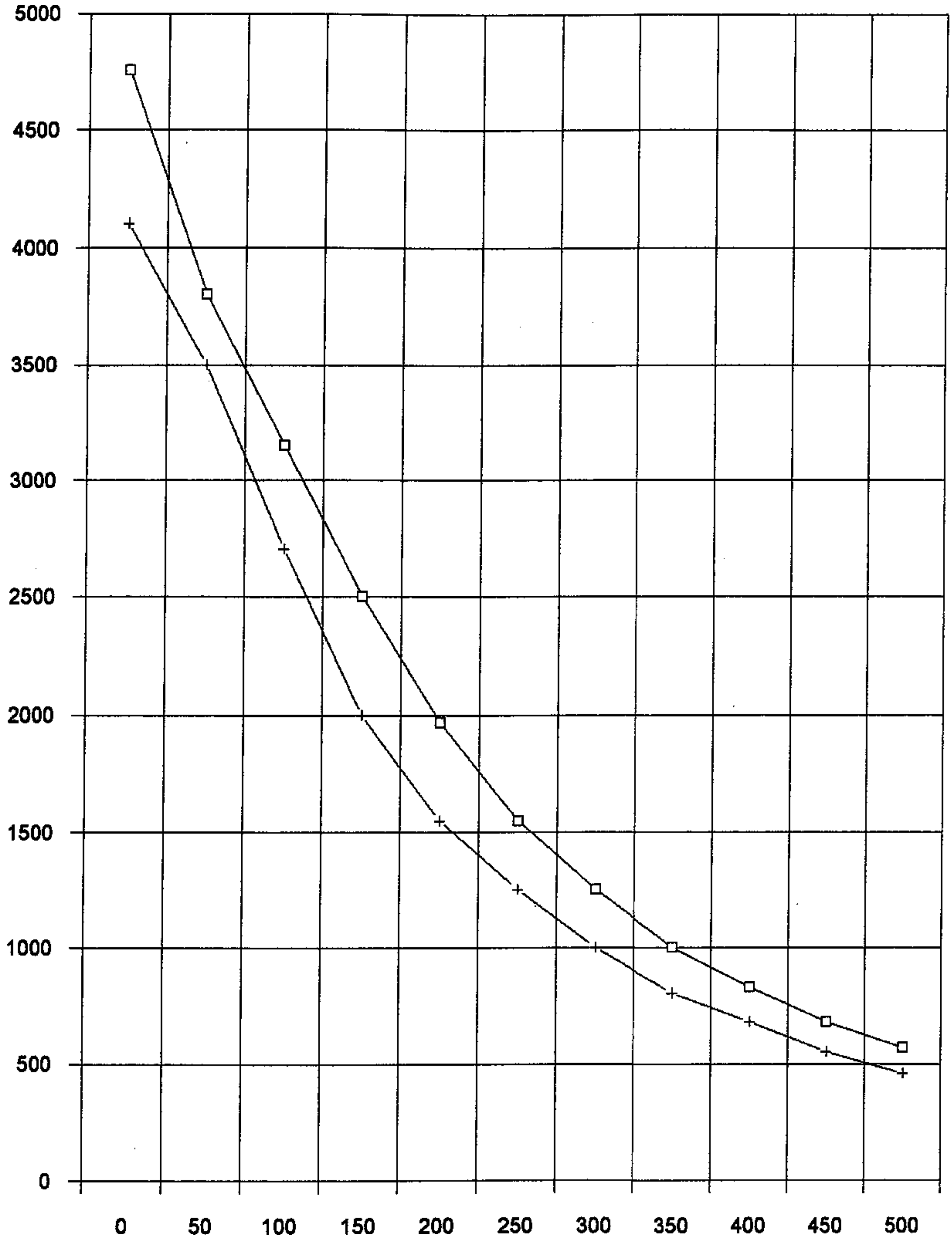
Now one thinks that it must all be about amp/turns when one determines the performance of a magnet. Amp/turns are very important, but you could have a magnet with a very small diameter core which has a lot of wire on it by way of a lot of turns, and therefore has a very high amp turn figure, but yet performs poorly because of the small core which cannot become sufficiently induced to give a good magnetic path. On the other hand you could have a very large diameter core with a relatively small amount of wire that has amp/turns on it, and this will not be very well magnetized either and would operate poorly. I am not trying to confuse you at all, I am merely trying to explain how the selection of a magnet regularly confuses people who are quite knowledgeable, and certainly not unintelligent in terms of buying capabilities.

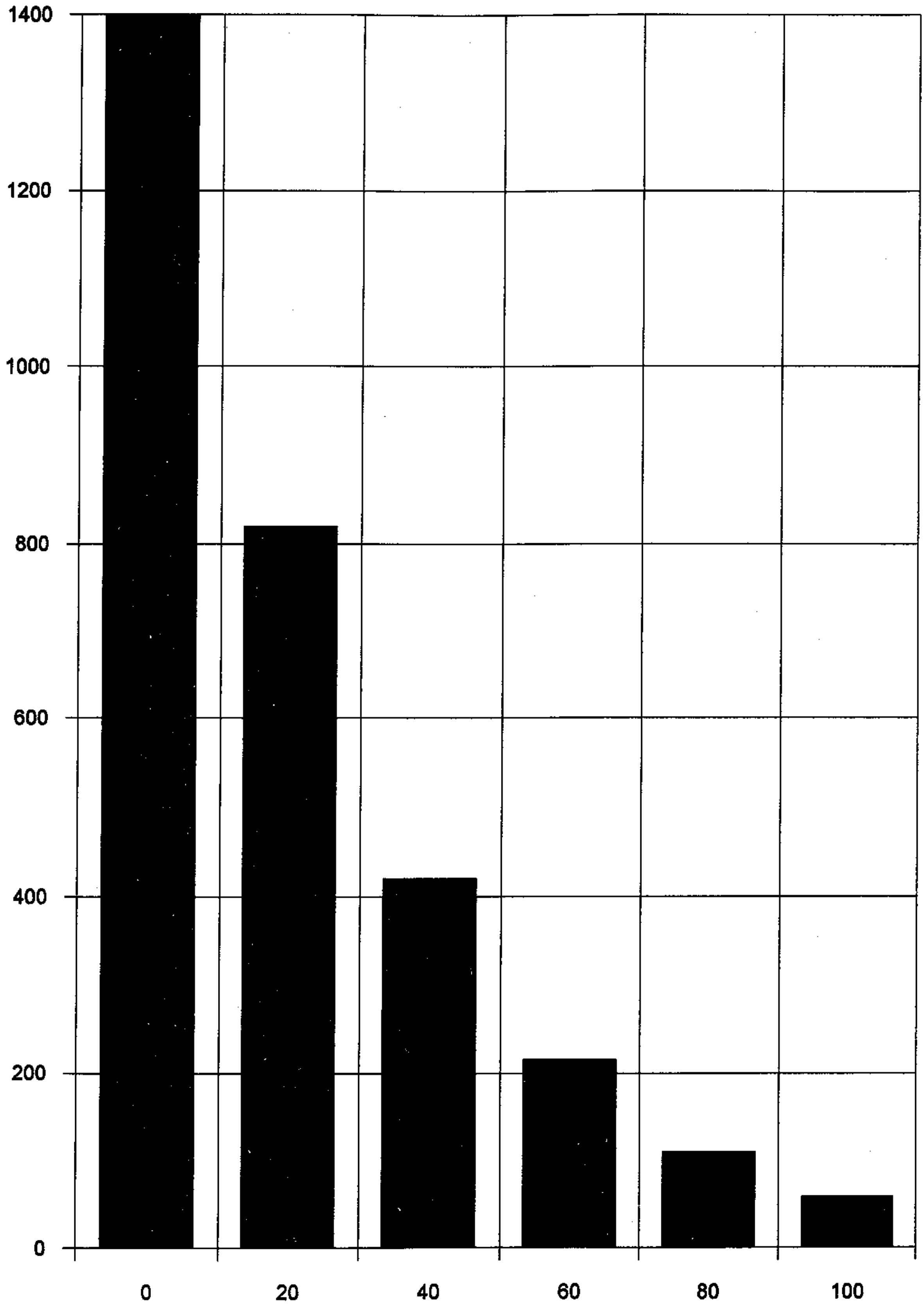
The real answer to good magnet performance and selection lies in asking the correct questions of a supplier. One assumes that the supplier knows what he is doing and that the core size he has selected and the amount of wire which has been put around it will be sufficient to give a good performance relative to cost, mass, heat generation and so forth.

When the magnet is tested in the works the onus lies on the buyer or the inspector to sensibly evaluate the temperature when cold, the temperature when hot, the flux generated cold and the flux generated hot relative to temperature rise and so forth. Not many of our customers will actually come to our works to access the factors in a magnet they have purchased, they simply trust us to design the magnet correctly.

This paper does not make purchasing a cut and dried simple procedure.

400 OCB 1100 COC J2952-3




1400
1200
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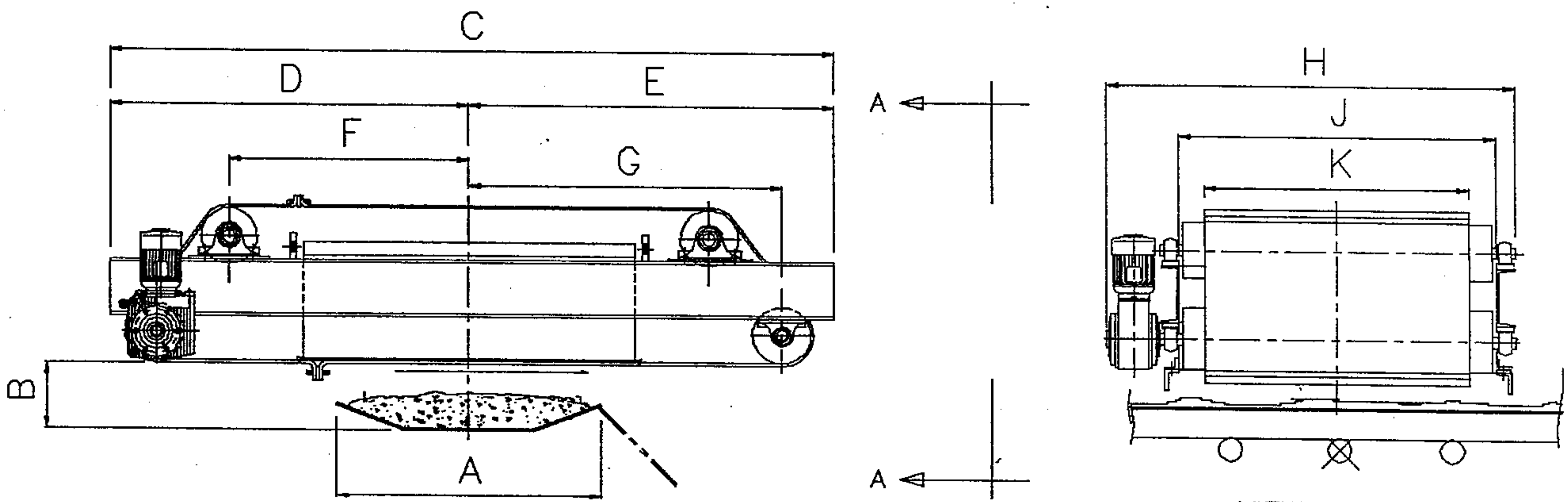
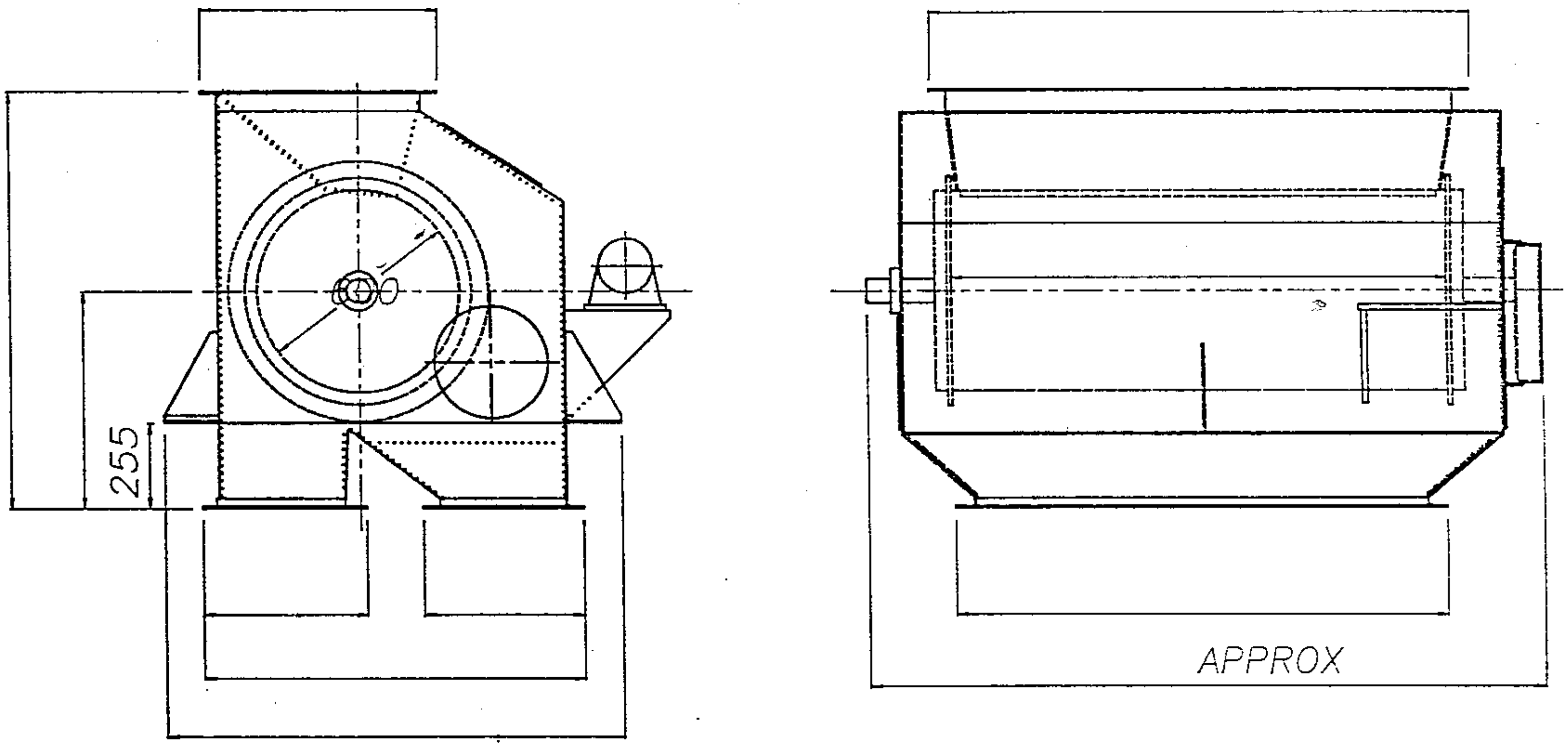
TYPICAL PERMANENT SELF-CLEANING MAGNET.

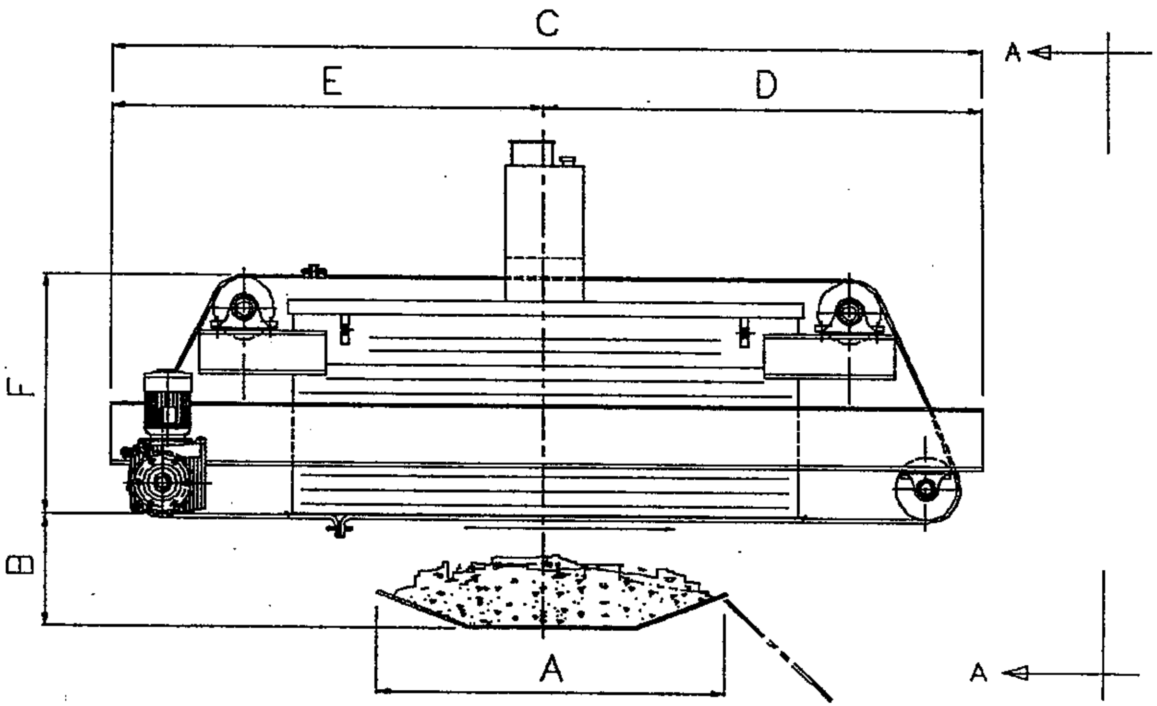


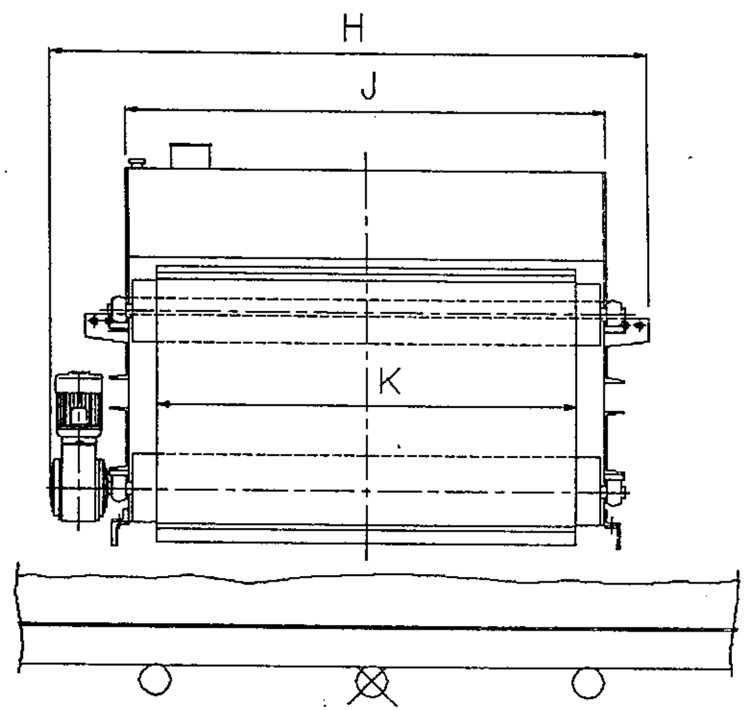
VIEW ON 'A'

TYPICAL ENCLOSED MAGNETIC DRUM SEPARATOR.



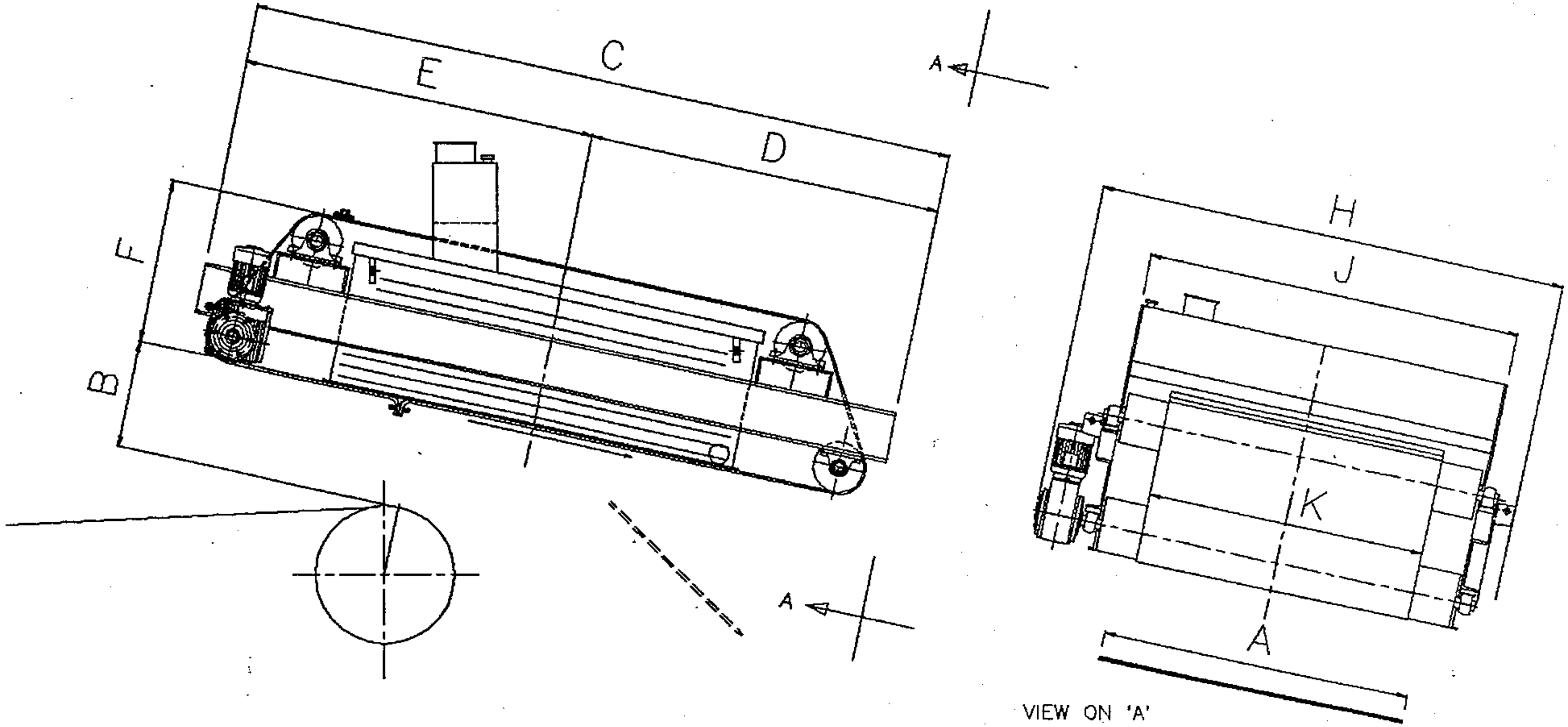
TYPICAL CROSS-BELT MAGNET.





VIEW ON 'A'

TYPICAL IN-LINE ELECTRO MAGNET.



VIEW ON 'A'

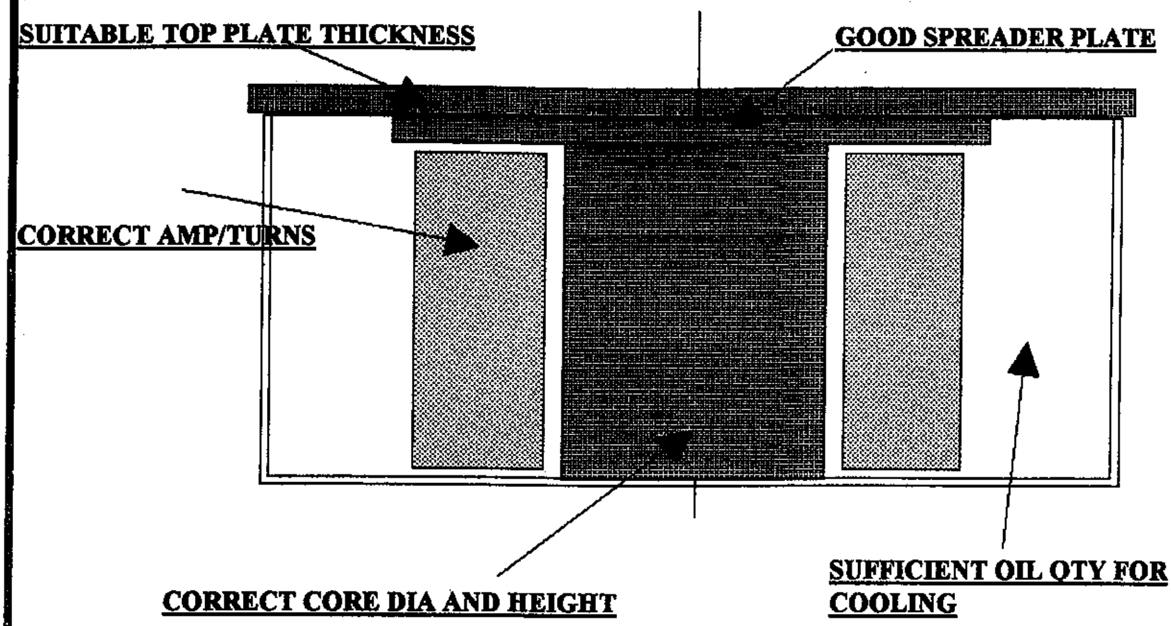
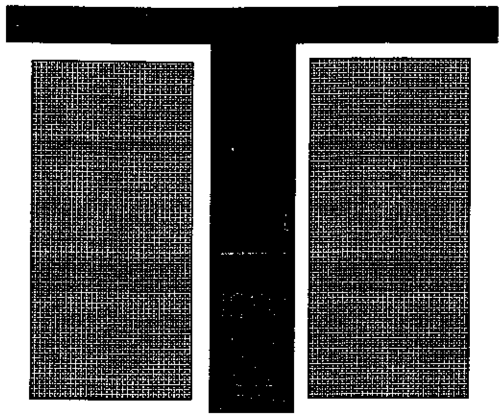


DIAGRAM SHOWS A MAGNET WITH GOOD GENERAL PROPORTIONS
WHICH WILL GIVE MAXIMUM SEPARATION PERFORMANCE
RELATIVE TO COST, MASS ETC. DESIGN WILL ALSO PREVENT OVERHEATING
IN HIGH AMBIENT TEMPERATURE CONDITIONS

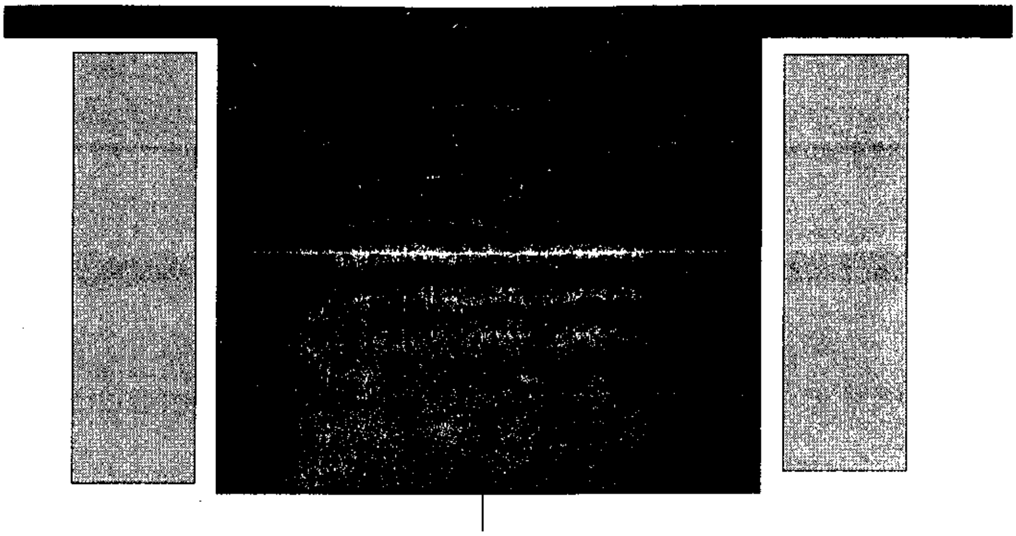
EXAMPLE OF A GOOD GENERAL DESIGN.



MAGNET WITH HIGH COIL SHAPE

POOR RESULTS AS AMP/TURNS GOOD BUT LOW FLUX AS CORE RELUCTANCE FACTOR NOT SUITABLE

EXAMPLE OF POOR MAGNET DESIGN (1)



MAGNET HAVING A LARGE CORE AND SMALL COILS

'POOR PERFORMANCE AS AMP/TURNS LOW

EXAMPLE OF POOR MAGNET DESIGN (2)