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The MiSa 1, A Agricultural Machine with Demining Capabilities

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The MiSa 1, A Agricultural Machine with Demining Capabilities

By Detlef Schulz

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Introduction

The MiSa 1 mobile **plant by the BIGAT** Engineering Office for Processing of Waste Ltd. is a agricultural machine designed to pick up and sift through soil, separate out metal fragments and undergrowth, and replace the cleaned soil. While BIGAT envisions many uses for the MiSa I mobile plant, they are particularly encouraged by its performance as an aid for mine clearance. The MiSa I is capable of clearing specific minefield areas of vegetation that is up to 15 years old, while at the same time sifting through the soil to a depth of 50cm, cleaning the soil of all manner of metal fragments, including ammunition, mines, and other unexploded ordnance (UXO). BIGAT acknowledges that the MiSa I is not appropriate for use on all minefield areas, but is encouraged by the results produced by the machine in tests thus far. The following article sets forth the detailed specifications of the MiSa 1, and examines the ways in which the machine may be used to aid mine clearance operations.

Worldwide, areas contaminated with ammunition, mines, wreckage, and scrap metal pose a significant problem. The clearance of ammunition is necessary in order to make these areas economically viable and usable. This involves a great effort of both personnel and time, and large risk, which results in high clearance costs per surface unit. Many varied prerequisites have to be observed, such as soil and type of topography, as well as type of contamination. A high pollution with metal splinters and waste complicates the search for and recovery of explosive ammunition by traditional means and manual excavations.

In Germany, we have few problems with mines, although 100,000 hectares out of 1 million hectares of areas used by the armed forces are polluted considerably with ammunition (predominantly metal parts). Deposits of waste and vegetation that have increased through the decades complicate the recovery of these areas.

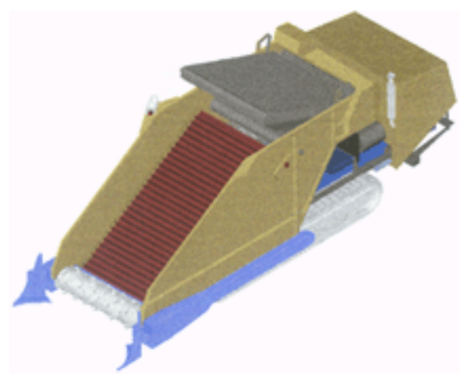
A machine and its accompanying technology for the clearance of ammunition from contaminated areas must:

1. Show a high security standard and meet with legal and technical demands.
2. Secure a guaranteed separation of explosive ammunition, proper operation

provided.

3. Remain unsusceptible to technical trouble and to the changing conditions both of soil and of vegetation.
4. Remain unsusceptible to trouble caused by bulky goods, rock, concrete, waste, wire, and other ground hazards.
5. Carefully handle the soil contaminated with warheads. The soil has to be picked up in such a way that no strong vertical forces are introduced into the soil.
6. Possess a design in which the areas, which are endangered by explosions, are especially protected and sheltered. It is important that the pressure of possible explosions can escape from the plant without risk. Endangered parts of the plant must display sufficient dimensions, or be inexpensive (so-called sacrificed parts), and must be designed to allow for easy maintenance.
7. Demonstrate sufficient maneuverability for cross-country use.
8. Possess a design applicable for different purposes; for instance in agriculture and forestry, in order to increase efficiency, and to pick up and separate waste.
9. Automatically operate the plant and process all parameters.
10. Allow for easy transportation on both rail and on road.

The MiSa 1



The MiSa 1 mobile plant by the **BIGAT** Engineering Office for Processing of Waste Ltd. is a agricultural machine designed to pick up and sift through soil, separate out metal fragments and undergrowth, and replace the cleaned soil. While BIGAT envisions many uses for the MiSa I mobile plant, we are particularly encouraged by its performance as an aid for mine clearance. The MiSa I is capable of clearing specific minefield areas of vegetation that are up to 15 years old, while at the same time sifting through the soil to a depth of 50cm, cleaning the soil of all manner of metal fragments, including ammunition, mines, and other unexploded ordnances (UXO). BIGAT acknowledges that the MiSa 1 is not appropriate for use on all minefield areas, but is encouraged by the results produced by the machine in tests thus far. The following article sets forth the detailed specifications of the MiSa 1, and examines the ways in which the machine may be used to aid mine clearance operations.

The object of the plant is an almost automatic and mechanical separation of soil and metal parts. This is executed with maximum security by means of technical protection. A considerable reduction of costs per surface unit can be reached compared with the costs of traditional methods.

The machine shall be used on open areas and areas grown over with grass, heather, bushes, or small wood (not older than 15 years). The soil can be sand, loam, or clay, but not strongly loaded with stones. The machine can not be used on rocky subsoil, on areas inclined more than 15degrees, on marshy ground, within dense wood, or for the clearance of ruins in towns. A modified version of the machine can be used to redevelop shooting ranges, separating bullets starting with caliber 5,45 nun. Because of the large range of the radio remote control the machine can be used in areas where the user can expect shells filled with poison gas.

The compact plant designed by the BIGAT Engineering Office for Processing of Waste Ltd. does not depend on any supply service and thus can be employed also in areas which are entirely undeveloped (training areas, former war zones, and other). All parts of the plant are driven with a diesel generator.

The plant is mounted on a tracked chassis and is operated completely by radio remote control. It is equipped with a soil mill in order to pick up the soil down to a depth of 50 cm and to dig out and chop up plants. The equipment includes a screen, a metal detector with signalization for the coarse portions (parts > 40 nun), and an automatic metal separation for the portions 6-40 nun (diameter 40 mm, length can be more). Ferrous and non-ferrous metals are caught up separately. All metal particles starting with 6mm diameter are separated with high accuracy and can be sold to a scrap-dealer after examination.

Large field of employment

The machine can be used to redevelop dumps and landfills, to clean areas during the demolition of industrial plants (redevelopment of scrap yards), and for the clearance of mines. It can also be used for the cleaning of bathing beaches, for metal separation out of rubbish, and the clearance of waste, ashes, and other bulky goods from building sites. For any of these purposes, little or no modifications to the plant are necessary.

Improvement of soil

The input conveyor of the wood shredder mounted on the machine can be converted to a bunker with dosage at little expenditure. With this conversion, it is possible to feed the soil with a defined quantity of additional substances (lime, dung, fertilizer, humus, micro- organisms, etc.) The bunker is charged with a wheel loader or a conveyor belt.

Attachment of agricultural machines

The rear the machine is equipped with a traverse with adjustable height, on which agricultural or forestry machines can be hung. It is possible to even out the ground in one working operation, and to sow or to plant young plants. Thus, it is possible to use the machine to clear an area which is contaminated with mines or ammunition, to clear bushes and little woods (up to 15 years old), and to plough, dung, and sow in one step.

In mine free areas, the ground is explored with a relatively insensitive investigation in order to find large objects (for instance bombshells). Suspect objects are investigated by digging them out. The process is as follows:

1. The contaminated upper section of soil is loosened and picked up by the soil mill. During this process the grass together with its roots is reduced to small pieces. The roots of little trees and bushes are also partially chopped up. Above the mill there is a chain conveyor that carries the loose bushes to the left or right side of

the machine. The mill turns in opposite direction to the movement of the plant. This ensures that explosive charges (for example mines with fuses sensitive to pressure) are not actuated while digging them out. Its sensors automatically regulate the milling depth of the plant, or it can also be regulated by the radio remote control. The mill is designed in such a manner that it is widely resistant to the force of explosions.

2. The loosened soil is lifted and carried by a conveyor belt to a vibrating bar-sizer. This is advantageous because parts of plants, especially the roots, can be dumped out, requiring a low charging height. The soil is classified and conveyed by a vibration screen in a careful manner. In order to avoid the activation of fuses the mechanical charge is comparatively very low. (This is the reason why no slice classifier is used at this point!) In case of danger, a signal informs the operator and the whole plant is stopped.
3. The coarse portion of soil, which is handed to the conveyer by 40mm bar-sizer, consists of stones, parts of plants, and some metal parts. The conveyor belt runs through an induction loop sensor, consisting of a special metal detector that detects all metal parts larger than 10 mm. A special feature of this sensor is that a Digital Signal Processor (DSP) filters the signal. The strong magnetic field disturbances generated by the bar-sizer and the eddy current separator are filtered out. With the help of this new technology an even higher sensitivity can be ensured. If any metal is detected, the belt and the conveying bar-sizer will stop immediately and a signal will inform the operator that the plant has stopped. Then an experienced person can safely inspect the ammunition part, and, if necessary, it can be deactivated. It is also possible to detect plastic material by means of an infrared spectrometer or an X-ray spectrometer (for the detection of mines). The construction of the plant is designed in such a manner that either device can be added later, as well as a magnetic drum for iron separation.
4. The fine material that passes the 40mm bar-sizer falls down on another bar-sizer screen with 6mm-bar distance. It is very probable that the fine portion that falls through the bars is free of explosive charges. The 6-40mm portion is slowly conveyed horizontally by short, lifting vibration movements to a belt conveyor. An eddy current separator consisting of a quick rotating magnetic drum with very strong magnets and made of neodymium-boron is built in the head-roll of the belt conveyor. Non-ferrous metal parts are thrown out of the magnetic field into the conveying direction and are caught separately in a bin filled with water. The output is limited by the thickness of the material on the belt conveyor (eddy current separator). It should not exceed 10mm (fine portion).
5. Before the fine portion reaches the eddy current separator, it passes below an over-belt magnet, which separates ferrous metal parts. It also separates compound materials consisting of non-ferrous and ferrous material (for example cartridges with brass shell and steel projectile), because they can be problematic when they pass the eddy current separator.
6. The ferrous parts separated from the material by the over-belt magnet are brought to a bin filled with water and can be sorted at appropriate intervals. Filling the bin with water reduces the forces occurring when the objects fall down from a height of approximately 40cm. The reception bin for non-ferrous metal particles is also filled with water.

Maneuverability on the ground

The machine is designed to clear areas of even ground, and also makes its way through bushes and little wood (up to an age of 15 years). The tolerated slope amounts to 15 % in a moving direction and approximately 10 % laterally. They can be increased up to 25 % by constructive measures. During the milling process only wide turning radii are executable, similar to a bulldozer. With the mill in its upper position the machine can turn on the spot. It does not operate on rocky ground or directly in wood, but it works on forest paths. The machine can be operated together with a small, maneuverable wheel loader in order to take soil out of the wood and put it on the machine while the latter is standing on a forest path.

Security

A micro-controller (SPS) and a radio remote control with wireless video supervision control the plant. There are also two cameras, one to supervise the soil mill (input area), and one to supervise the output of the coarse material. All security controls are implemented according to German laws and regulations. The plant can be immediately switched off from several places without danger. The security concept can be extended without problems.

The mechanical charge of the excavated soil is very low to avoid the detonation of the fuses of activated ammunition. The design of the plant limits the use of materials, which could cause sparks. The conveyer belts are rubberized. The soil mill, and the fork rows of the bar-sizers consist of a special steel alloy. In case of danger the plant can be stopped from several places and an emergency signal informs the operator. Because there are no workstations within the plant, there is no chance that personnel will be endangered. For additional safety, the plant is equipped with a splinter-proof cover.

Places within the plant where there is a high risk of detonating the fuses of ammunition are the soil mill and the bar-sizer. Small ammunition detonated during the mechanical processes of conveying and separating will not endanger the operation, personnel or any material assets. The coarse-fraction conveyor, as well as the input conveyor is equipped with video supervision cameras, so that explosive charges and other things can be seen without danger and the plant can be stopped at once. The operator only has to stay behind the plant when it is working. The plant has the option of being equipped with a gas detector, which supervises changes in the composition of the air (poison-gas), and signals the danger to the operator via radio remote control.

Securing Quality

In the past, there were incidents during the takeover of areas after mine clearance (for example clearance of mines in East Africa) that explosive ammunition was still found. Afterwards, it was never proven whether malevolent persons laid out the ammunition, or if there was a functioning fault of the clearance machine, or a fault in the operation of the machine. The machine developed by BIGAT ensures that all metal parts larger than 6mm are separated as long as no damage of the screens occurs.

When the machine is operated so that the thickness of the layer of the soil on the belt-conveyor of the eddy current separator is bigger than 10mm (fine portion) then the degree of the separation of lead bullets initially decreases. The quality and safety of the separation of ferrous particles is higher. The control of the machine (Personal Computer) can process all data and parameters registered by the sensors (milling depth, driving speed, etc.), a strong impulse noise level, and all operating commands in exact time. Even a GPS support would be imaginable if a spot signal is available.

Performance and Price

The plant has a minimum throughput of 150 m^3/h on even areas and non-binding ground except when there are stops caused by the saving of certain objects. When the ground is strongly overgrown, rocky, or with binding soil, the performance decreases slightly. The machine consumes 15-20ls of diesel fuel per hour, and is operated by only one person from a distance of up to 400m. The machine is driven by a Diesel aggregate with two 10 kW power suppliers and also has a high throughput. When the working depth is 20cm the machine clears a strip 2.5m wide and 300m long per hour. The costs for the clearance of an area amount to approximately 0.20 DM/m^2 (20 cm working depth, including personnel and capital costs).

During the development of machines, BIGAT considers not only actual projects for the redevelopment of contaminated areas in Germany (areas formerly used by the armed forces and are contaminated with ammunition), but also actual requirements in Bosnia, Cambodia, and Africa. In these areas land mines are an essential problem. A central concern is to use the machine to clear mines on areas that are now grown over with plants and trees.

For this reason the input device is designed in such a manner that it is largely resistant to explosions. A soil tiller is used to reduce grass and roots to pieces. The actual level of technology available yielded a choice of street mills with tools of special hardened alloys, cutting mills used in forestry, and screw mills with directed conveying movement, as well as hammer-chain crushers. In our machine a cutting mill with hardened tools is used in a comparatively inexpensive constructive design (without a welding seam).

Milling tools shaped into segmented rings are fastened with screws onto a heavy, polished steel shaft. These rings are sized in such a way that they remain largely undamaged when an explosive charge with up to approximately 500g TNT-equivalent is detonated. Anti-tank mines and hollow charged grenades could cause damage to the plant. The ring segments and fastening bolts can be destroyed on defined spots without damage to the shaft. There are some particularities concerning the combination of materials, but it is possible to repair the ring segments with little expense.

The milling device is arranged in such a way that the other parts of the machine are hardly struck in case of an explosion (a detonation in front of the mill is the most probable case). The main force of the detonation can escape upwards without hindrance. As a rule the mill will not be damaged by rocks, concrete, bulky refuse, waste, and thick roots during normal operation. The cutting tools are made of hard metal and can be turned and angled for optimal efficiency. In its present design the mill is patent pending for BIGAT.

The mill is hydraulically driven to charge the separation equipment with the soil that has to be conveyed upwards. The operator can choose between separating and non-separating conveyors. Screen classification is the next step in the process. Just conveying screens could be used if the separating conveyors are chosen. If the material is difficult to sift (possibly moist loamy soil and clay with roots and large, bulky disturbing objects), worm and swing conveyor, as well as drum screens, trieures, and rotating cell classifiers are not practicable for vertical conveying. Permeable belt or chain conveyors are not practical, as they represent a potential source of trouble in a down side area. A textured trough belt or bucket sieve would be a possible solution. Such a model is shown in the annex.

It is a disadvantage that the collected coarse, good soil has to be thrown off at regular intervals. This is not practical on especially rocky soil with dense vegetation, and when land mines are to be cleared. Theoretically, it would also be possible to install a vertical or inclined flex-screen, which would convey the material upwards by directed throwing movements, but the same limitation also apply to this principle in areas of dense vegetation (bushes) or land mines. For these reasons, a stabile non-separating plate-belt chain conveyor is used in order to enable a steady charge of the following screen aggregate.

A central point is the separation of bushes and small trees. In the present design there are two design opportunities. First, a horizontal chain conveyor can be mounted parallel behind the mill. This conveyor transports loose bushes to the side of the machine (on a strip already cleared). A better, but a slightly more expensive variation is the installation of a wood shredder on the machine, combined with an input device for the bushes. The chopped wood is equally worked into the soil. Such a model can also be used on areas without trees. Only a little modification is necessary and it can be used to add dung, lime compost, and other substances to the soil. With this feature the machine fulfils high- quality tasks in agriculture and forestry, and the efficiency of the machine is increased considerably.

The soil, which is freed from bushes, is now classified with a screen. Technologies that are available for difficult-to-strain bulks include flex-screens, star and harp sieves, and brush belts. The magnetic separating devices have been proved in praxis since 1996 but require a pre-separation of the disturbing fraction with a size of more than 40-50mm to ensure that the plant runs safe and without trouble. The careful sizing of the expensive magnet technology (conveying width) is imperative to reach a high throughput. A great portion of the conveyed material should be separated beforehand in order to reach a higher total throughput with an acceptable relation between price and performance (fine portions < 6 mm which are free of explosives). The use of an air separator seems to be ineffective because of the pasty texture of the loam. Drum sieves, star and slice separators, cell separators, and trieures can cause higher pressure and forces on the material particles. For this reason, they represent an increased security risk.

When there are many roots in the soil separators do not reach a sufficient separation rate for fine material. When the machine is used on loamy soil, the bucket sieves, cell separators, and brush belts frequently paste up. Flex screens are reliable with granular and adhesive bulky goods, but grass roots, sharp-edged bulky refuse and concrete pieces with pointed ferrous parts cause considerable problems here. With the help of harp sieves a high throughput can be reached for the fine fraction, but problems arise with roots at the lower attachment ledge, which have to be cleaned from this spot regularly (which can be done mechanically, too). On principle, harp sieves are well suited for the fine separation at 6mm, but they require a higher expenditure for maintenance. For these reasons our choice was a double vibrating bar-sizer in a special design, since an undefined fine portion under 6nun in the middle fraction which is to be separated from metal parts makes no essential difference.

In order to ensure that the area is free of metal parts after clearance, the operator can easily pass over the area with the bar-sizer (6mm), so that the whole fine portion passes over the magnet. However, doing so considerably reduces the throughput of the plant.

On principle, one can use magnetic separation methods and pick-up methods that are based on sensor-technology to detect particles. The latter is used for the coarse range. When large quantities of goods and undefined forms of particles are detected, the magnetic separation method gives more security. Within the machine an over-belt magnet for iron separation is used. It is mounted before the eddy current separator. Both magnetic systems are special designs, which are characterized by the strongest magnetic fields.

The machine with its new features has been applied for a patent by BIGAT.

In 1996 the first plant for the separation of small ammunition from soil was delivered to BSA Bohrund Sprengtechnik A. Alexander, Potsdam by BIGAT. It works with the same metal separation method. However the throughput is reduced to around 20-25 m^3/h (light soil, only grown with little vegetation) and it is less versatile. The pilot plant proved good in practical use. It is proved and licensed by the authority of the supervision of industrial health and safety regulation and by the Armament Removal Service.

Characteristics

The tiller lifts the contaminated upper section of soil (from 0-500mm), which is highly resistant against explosions. The machine picks it up on a conveyor to a vibrating bar-sizer. Trees and bushes are chopped in a shredder. The soil passing the 40mm bar-sizer is classified and conveyed by a vibration screen in a careful manner. The coarse portion, which is handed over by the 40mm bar-sizer to a conveyor, consists of stones, parts of plants, and some metal parts. The conveyor belt runs through an induction loop sensor with a digital signal processor that consists of a special metal detector that detects all metal parts larger than 3-8mm. An infrared spectroscope sensor for plastic recognition is an available option. The fine material that passes the 4-mm sizer separator falls down on another sizer screen with 6mm-separation distance. It is probable that the fine portion that falls through the separator is free of explosive charges. The portion 6-40mm is slowly conveyed horizontally by short, lifting vibration movements to a belt conveyor. The portion 6-40mm is slowly conveyed horizontally by short, lifting vibration movements to a belt conveyor and magnetic separation units for ferrous and non-ferrous metals.

A micro-controller (SPS) and a radio remote control with wireless video supervision control the plant. There are also two cameras, one to supervise the soil tilled (input area), and one to supervise the output of the coarse material. The number of video channels is expandable. The operational and location parameters will be recorded with and DGPS computer system. All parts > 40mm are laid down in row beside the machine in a strip already cleared. They can be removed manually using the record printouts. The controller of the machine can record all data and parameters registered by the sensors (milling depth, driving speed, etc.), a strong impulse noise level, and all operating commands together with exact time. For a DGPS support a spot signal is required.

Cost of acquisition:

Depending on equipment, from 700,00 DM to 1. 2 Mill DM (e.g. DGPS).

Operational costs:

Approximately 150 DM/h.

Service intervals:

Comparable with the usual agricultural machines.

Limitations:

The MiSa 1 cannot be used on rocky subsoil, on areas inclined more than 10-15°, on marshy ground, within dense wood, and for the clearance of ruins in towns.

Crew Protection:

Due to the remote control in connection with the wireless video system, the operator can be located in a safe distance (up to 400 m).

Completed field tests:

Location: Berlin, Potsdam (removal of ammunition from soil, no landmines tested yet).

Period: In constant use since 08/96.

Report available:

BSA Bohr- und Sprengtechnik A. Alexander GrnbH, Potsdam (Germany)

General information also on the Internet at www.recyclers-info.com/de/bigat.

Lessons learned:

Only the separation unit has been tested. During all weather conditions the soil is rendered free of all explosive particles. Even metal-free soil is possible by closing the bottom sizer. Bad weather conditions and heavy vegetation will cause a drop of throughput. Prototype was constructed to clean light, dry soil. Comparing with MiSa 1 it has no tiller, no caterpillar tracks, no wood shredder, and no DGPS, and the unit is designed smaller (for 20-25m3 of soil per hour) and is not designed for land mine removal.

Mine clearance capabilities of the MiSa1 have been discussed with specialists from the engineering school of the German Army in Munich. All documented mine-types listed on the Internet at www.rnineweb.org by the US-state department can be safely removed or blasted up with the MiSa1. No TNT or detonators are remaining in the soil.