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MAKING MARS'S PHOBOS CONCENTRATING SOLAR THERMAL TURBO GENERATOR TO SOLVE PROBLEMS ON EARTH, MARS, OUR MOON, AND IN ORBITS.

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Phobos, one of the MARTIAN moons, has a number of unique properties that make it an ideal location for profitable industrial development of Mars and indeed the Solar System. These properties include strong evidence of industrially useful liquid or gases, probably water, in the moon, essentially no gravity, and an unusually low but slow orbit around the planet Mars. Presently, no other body in the Solar System is known to share these properties. I will be discussing how to use Phobos to meet the future energy needs of the human race and establish a profitable manufacturing facility in Mars orbit, Earth orbits, asteroids, our moon, and then many other locations throughout our solar system. There are many more reasons, but most of all it can be done cheaper and more reliably than about anywhere else I have been able to find.

I've studied developing asteroids, our moon, Mars, and it's asteroid like moon. As long as we are limited in outer space by the resources launched from Earth using rockets everything there we do there is prohibitively expensive. Once Mars and its moon or asteroids start to get significant mining and simple manufacturing established some amazing potentials develop. Energy is one of the most critical for any project especially in outer space. The availability of it also has great promise. Robert Zubrin [1]proves most solar powered satellites programs don't pay if they are made with resource launched with rockets from the surface of Earth. Even when lunar oxygen is available using rocket from our moon does not improve things enough. If we want to move lots of material to Earth orbits then there are far better ways than rockets. There are far better places to get these and to ship from. There are better places to process the materials than Earth or our moon especially if the projects are large. Many large projects become easier in space because gravity does not limit you. Many others projects can be done there very well but the capacity to mine, manufacture, and ship must be developed first.

The L-5 Society and other O'Neill people did lots of plans mostly using aluminum from our moon. A concentrating thermal solar turbo generator was designed by Boeing Aerospace under contracts with ERDA (Energy Research & Development Administration) and NASA. It basically reflects and concentrates lots of solar heat onto a "boiler". In back of the reflectors is a radiator and between the boiler and radiator is a turbine driving a generator and pump. The very old versions of thermal engines wood or coal to boil water for steam. The early Greeks had something that would spin above a pan of boiling water. They got no useful work out of it. I understand the Boeing design is made mostly of aluminum. No fuel needs to be burned and there is no need for radioactive material. There is nothing that can wear out except the bearings in the turbine and generator and the bushings in the generator. Especially in that gravity free

environment magnetic bearings can even eliminate this wear. The total setup including expanding gas and microwave beam weights ten tons and can produce one mega watt of electricity[ii]. To repeat ten tons of aluminum and gas to produce one mega watt of electricity

10 tons Al = 1 MW e

This all sounds fine except there are real problems producing aluminum. Iron is much more practical in most cases. The production of aluminum takes lots of electricity, lots of pure carbon, and lots of fluorine all at a very high temperatures. The fluorine is not used up but some will work out of the system. Most of the carbon can be recovered from the carbon monoxide that is left, by using lots more electric power. Fluorine is the most reactive element known. It can be difficult to mine and work with. All together it takes more than ten times the resources to process aluminum than iron.

Now let's look at making on a moon of Mars or on one of the wetter asteroids a similar concentrating solar turbo generator using carbon dioxide as the fluid in a setup mostly made of iron. The Mars Direct plan puts onto Mars an in sutra fuel production equipment, brought to Mars with the return vehicle. It can pull out of the Martian carbon dioxide atmosphere seven tons of oxygen in twenty days using sixty-kilo watts of electricity[iii]. The carbon monoxide is release. When the ship returns to Earth this equipment and power is left on Mars.
That is: 24 days * 60 KW e = 7 tons O_2

The hydrogen is used to pulls the oxygen out of the carbon dioxide to leave carbon monoxide and water as the products of this step. With nearly the same resource the oxygen can be removed from the iron oxide on Mars or asteroids. The average red dust on Mars has quit a bit of easily mine able iron (rust) mostly in the form: $Fe_2 O_3$. On carbonations asteroid like the Mars moon Phobos the iron is in the form Fe_3O_4. This gives us more iron along with the same amount of oxygen using nearly the same amount of resources. It is a little better for our use than what we find on the surface of Mars. To reduce out the oxygen (reduce is to remove the oxygen from the oxides or rust):

$Fe_3O_4 + 4H_2 \Rightarrow 3\ Fe + 4H_2O$
Or $Fe_3O_4 + 4CO \Rightarrow 3\ Fe + 4H_2O$
$CO_2 + H_2 \Rightarrow CO + H_2O$
$2H_2O + \text{energy} \Rightarrow 2H_2 + O_2$

We can calculate by just examining the oxygen to determine energy uses and the ration of oxygen to iron to get the comparable mass of iron. The iron to oxygen atomic is ratio is 3 to 4. The atomic mass of Fe is 55.845 the atomic weight of oxygen is 15.9994. This reaction is exothermic and requires little equipment and no extra power. The mass of the iron that this can produce is:

Mass Fe = mass O_2*ration Fe*it's atomic mass/(ration O_2*it's atomic mass)
= 7 tons * (3 * 55.845)/(4 *15.9994)
= 18.3 tons Fe for Phobos and carbonaceous asteroids.
= 14 tons Fe for the surface of Mars

The seven tons oxygen also means eighteen point three tons of iron is also reduces and processed. This is collected at the same time with nearly the same resources as the seven tons of oxygen collected from the atmosphere. Either way most of the energy is used to electrolyze water, to recover the hydrogen so little hydrogen is lost.

This power station is using iron instead of the aluminum it was originally designed with so it is appropriate to compare the two metals. Aluminum has about half the mass of iron, is a much better conductor of heat and electricity. Iron is much stronger and a much higher temperature metal. The turbo generator power satellite power paper said if you use higher temperature metals then more power could be generated. Mars is farther from the sun than is Earth, but the reflectors are a minute part of the total. Doubling that up to Earth levels does not cause a significant impact on production. Some aluminum is needed in the electromagnetic part of the generator. The small production of aluminum also does not have a significant impact on the result. It looks like we need about twice as much iron as we would need in aluminum, but lets use a five to one conversion factor until we do a better study of the design and know more about the relative thermal generator.
So:
(24 days*60 K W e)/18 tons Fe)*(10 tons Al/1000 K W e)*5(Fe/Al)
= 3.934 days

That is just under four days to recover the energy used. Collecting carbon for carbon dioxide takes almost no resources. It can even produce energy depending on the mining techniques. Collecting lots of water can be done using a small amount of the waste heat. Doing ceramics, glass, and fiberglass with the moons dust and rock also takes little energy. Mostly putting the object to heat in front of the boiler will do it, or in it's own concentrated sunbeam. The production of methane, ethylene, and some other hydrocarbons take hydrogen and carbon dioxide or even better carbon monoxide under pressure. Then the hydrocarbons can be turned into simple plastics with a few drops of a catalyst.

The production workers on carbonaceous asteroids, Phobos, or the surface of Mars will shovel in regolith (dirt without living or dead materials) into a very large pressurized heater. It may be washed it with water, and then vaporizing the water can collects many salts and water-soluble minerals. This can use the waist heat from the power supply system. It only needs to get a little above the boiling point of water. The vapors are brought though a condenser then these are kept in tanks. Different chemicals vaporize and condense at different temperatures and this makes it simple separate them as it is heated up and then as the vapors are cooled. Water can be the most important of these. Then the dried materials are passed though screens. The larger materials are put through a grinder and back to the screens. The very dry dirt is then magnetically separated into very magnetic, slightly magnetic, and none magnetic. The magnetic grains are reduced and with hydrogen and or carbon monoxide and then processed by the Mon's carbonyl method.

Reduction of iron can be done at high temperature, or high pressures. Hydrogen or carbon monoxide is used to pull the oxygen out of the iron oxide. This leaves the iron. This can be then melted to make parts, but has many other metals. Using the Mon's carbonyl processing does not require hard, difficult or high temperature tools. For iron it's at just a few atmospheres at only 100℃ to 210℃. At the lower pressure carbon monoxide is bonded with the iron to make a

liquid. At the higher temperature the carbon monoxide is driven of leaving a 99.97% pure iron. This can be done inside a mold not requiring any further processing. But this must be done very slowly or bubbles can form. The normal way to prevent bubble is to vaporize the metal carbonyl before heating in the mold. Most of the heat for this processing can be waste heat from the generator. Nickel is processed at slightly higher temperatures. Then at somewhat higher pressures and temperatures cobalt can be processed the same way. The cobalt mass is less than one percent of the iron and nickel mix. Most of what is left is classified as platinum group metals. When not producing much initially much of this may not be bothered with. It is very valuable, and can even be worth bringing back to Earth using lots of expensive rocket fuel. In fact this along can more than pay for the cost of developing and producing all the rest. This may be shipped back to Earth this way, or they can be processed on at the same location using similar techniques. Very cheap shipping will be discussed later.[iv]

The nonmagnetic material can be use to make optically clear glass by doing little more than adding heat to melt it. The Green CELSS people want some of this for developing soil. This none magnetic regolith can also be use to make clays for molds, bricks, glass, fiberglass, and many other things. Except for the initial shoveling, the mold, and finishing the parts all this can be automatic. Some of this can be separated into densities using screens to separate the size of the material. Then it is dropped through a cross breeze. To different slots for different densities. Another way to separate is to use the intense concentrated sunlight to heat all materials to their vapor point. Using controlled temperature heating, and condensation temperatures all materials can be separated into their elements.

These simple tools do not require much electric power, manpower, or special equipment. Even these can be made nearly automatically w/light weight simple computer controlled tools. On the micro gravity of Phobos, Deimos, asteroids and open space greatly increasing the scale does not require much change. Something that would weigh a hundred thousand tons on Earth is something we can handle using just muscle power on these tiny moons or asteroids. A generator setup ten percent built will output about five percent of the power as one fully built. Since all the energy used to make the setup can be recovered in four days in eight days all the materials are collected for a setup ten percent of one twenty times as large can be built. Then every four days more than twice as much power is available, until the full size at seventeen more days is done. This is only twenty-five days to get a power setup twenty times as large. To be conservative we will say every two and a half months one a hundred times as large is completed. The extra time means not as much equipment is needed at any one scale. Some of the extra time and energy can be spent on orbital habitat improvement and development.

If we start with the “CfM” hundred-kilo watt power source then in about a year and half after starting we can theoretically have Peta Watts of power, Peta is ten to the fifteenth power, or one million times one billion. That is just about when the next alignment happens. It is when we can ship back to Earth easiest. One a millionth this much can start to have a major improved result on Earth. One this large will not fit easily on Phobos. Even the ten Tera Watts one will require an enormous reflecting area hundreds of kilometers on a side. That is of much closer to the surface of Mars. Much of this will need to be above Phobos. Tidal and Mars gravitational forces will be large. It may be necessary to move most of the operation to Demos the smaller outer Moon of Mars. But that is easy to do on these moons. By then the settlement on the surface of Mars will

be getting Giga Watts of Power using the older cast off power stations from Phobos. A thirty seven hundred miles long Kevlar cable hanging from Phobos would travel at about twelve hundred miles an hour just above the atmosphere of Mars. Twelve hundred miles per hour rocket plane could catch it. This is only about seven percent of the eighteen thousand miles per hour minimum orbital velocity to reach Lower Earth Orbit, from the surface of Earth. Once the cable is hooked then a winch on Phobos can lift its payload. This can make a very cheap way to move people and supplies between the suface of Mars, and it's orbits, and Phobos.

Within a year and a quarter or so after Phobos start also other things will be built. Very important will be an enormous but very simple linear motor to send every alignment millions of fifty ton packages to Earth orbits for pennies a pound. Only 1.8Kmeters./sec needs to be adddedt to send impart an Earth return orbit. At After skimming Earth's atmosphere Only about 60 meters per second needs to be added after skimming the atmosphere to round out the orbit at LEO(that is only about eight times as fast as I walk). These packages will largly included oxygen, methane, water, ceramics, glass, fiber glass, iron, nickel, soil start, plastics, the platinum group mix, of course some will be in parts for the Earth power Stations, and many other materials. The first year possibly only a twenty thousand tons will be sent ofcourse most of this will Methane and oxygen so that more Earth parts of the Earth return kits and more People can be sent to Mars much cheaper. Then Every alignment much more can be added. These large sections will each need to be send on a slightly different orbit. They each will need to do a few mid course corrections. They may be collected together in transit to decease the minimum size of the packets launched, and decrease the number of Earth return kits needed at Mars. These need to do attitude control, communication, and mid course correction and include modest heat shield, a power supply, communication, and control, a modest quality rockets, attitude rockets, and fuel. The light complicaded sections of the these small modules like electronics will most likely will come from Earth. The iron fuel, the tanks, modest quality heat shields, possibly the rockets, and at least part of the power supply will be made on Phobos. Earth atmospheric braking will be under Earth control. Some will go into LEO, some into a highly elliptical Earth orbit, GEO, possibly L1 and other L5 type locations, even in Lunar orbit. At least part of these kits can be sent back to Mars with more of them using a small part of the methane oxygen fuel.

Mega Watts of power is enough for this much, but it is easier with the extra power, and is not that difficult to get the extra power. The extra power enables more iron, iron parts, methane, oxygen, and similar materials to be prepared and sent.

All this can be done for ten to fourty billion. Almost all the cost is launch costs. If they get cheaper, then all this can be for much less. Five thousand tons of fuel, oxygen, water, and similar materials in Earth orbits are worth more than all investment costs. This is less than point one percent of what can be available in Earth orbits after the second alignment. If NASA has access to these types of outer space resource they can do hundreds of times as much research as they now do with the same money. In fact it would then be practical to raise NASA funds because outer space would be making great profits, and they would be the major taxpayers for space. People are getting frustrated with NASA about the amount of money they spend, and the little we see for all it. Every one is expected to do more for the same money, and this makes this possible and then some.

CONCLUSIONS AND SEEMINGLY WILD PROSPECTS

Some say that the future transportation economy will by hydrogen power. They want to do it with fuel cells. As I understand it the two limiters are the availability of cheap clean electric power, and the fuel cells use platinum. [v]In the processing the Peta Watts Electric stations about seven hundred and fifty thousand tons of the platinum metal can be brought to Earth. Both of these are very limited on Earth, but this nearly unlimited beyond Earth.

Just a few years after starting Phobos inexpensive asteroid type development starter kits and the technology to develop them will be available almost anywhere in the solar system. First these will mostly go to NEAR objects. The bulky simple parts come from Mars. The small complex comes from Earth at first. Within a decade or two they could be fully automated.

With these manufacturing, power, and other resources in orbit we could truly address the threat to all life on Earth imposed by asteroid and comets. In fact, they become great assets instead of threats when fully understood, and with the ability to move and work them.

There are papers showing our solar system can for billions of years support more than two hundred billion times billion people at a higher level than available to the western world now. Our Earth cannot support the current level for long. Processing outer space resources is the first step in developing this.

With these capacities we could construct many powerful telescopes in orbit, much greater than the Hubble. We could construct an inferometric telescopes greater than one hundred thousand miles on a side able to see details of small planets in distant stars. We could put them in orbits at the Earth sun L4 and L5 positions. If they work together this can make a telescope equivalent to one millions of miles in diameter. We could put a few in orbits beyond Saturn. The sections can be mounted on slides. The exact dimension can be controlled be lasers with lightweight servos to keep then relative positions greater than can be done on any fixed mass. It should be able to see details about small planets about other stars. It should able to see the very first spark of Light in the universe. We will be able to see the first galaxies light. The first stars will likely be immense. There will be nothing heavier than hydrogen. Once the star burns very hot a while then it will likely turn into a back hole. We may be able to tell whether there must be a black hole from the big bang before galaxies, and stars can form. We could solve many problems currently unsolvable.

With millions of tons of fuel, and other resources in Earth orbits many projects become practical all over the solar system and beyond. With Peta Watts of electric power even more is possible. If one quarter of a Peta Watt of power in Earth and Mars orbits is devoted to push a one thousand ton light sail pulling a one thousand ton ship it will accelerate at one G of acceleration then the ship could travel between Earth and Mars in just a few days using no fuel. Trips to our moon could be measured in hours. The same size ship could be sent to Alpha Centaury in about five years on a one way trip if a year is spent accelerating at one G, but some form of breaking would be needed like the Mag. Sail. This could easily be ready in twenty years or less. A fifty-ton probe could be sent to accelerating at twenty G's to other stars pushing the practical relativistic limits in less than a month. If half the probe is robots and automated asteroid processing equipment

then the setup to come back to Earth or go on could be ready before the people get there. Imagine a probe to Alpha Centauri in a few years taking five years for people, and just four years for a probe. This half century there could be people living at a dozen other solar systems. It is likely that not all will have viable planets, but it is believed that all have comets and asteroids.

Hundreds of Tera Watts Electric could be beamed down to the surface of Earth. Just fifty or less could allow the elimination of fossil fuels and nuclear reactors while elevating the life style and energy available to all people of the world to greater than the level available to wealthy western Europe, and the US. This will eliminate or at least greatly decrease the greenhouse problem while decreasing population pressures. There is evidence to prove that once the standard of life is above starvation as the wealth increases population growth decreases. The benefits to Earth are enormous. With the capacity to do orbital processing we can increase or decrease the amount of heat hitting Earth. There are lots of indications the sun is not constant. It can cool off or heat up. Mostly it is slowly heating up. We could adjust for heating up, or cooling down. Cheap fresh water could be available anywhere on the planet. We could afford to do processing of resources that are clean, and productive.

If there is truth to some of the speculations by some more adventurous physicists are true and controlled worm holes, star gates, hyper space travel, space warps, time travel, or something like that is possible I believe it will only be discovered in very high energy research out far from Earth or other any planet. This kind and some other research probably should not be done on Earth. If someone trying to create a wormhole produce a black hole that is drops it on Earth it would cause a supper tragedy. This kind of research should be done in extra terrestrially.

Phobos can also construct orbital habits. Subsets of what the L-5 and O'Neill people would do. The first craftsmen on Phobos and most comets should first buried their transport habitat, until that iron and other processing equipment being producing well. When enough cabling is available constructed and tied into a net or bag, one is filled with rock from Phobos and used as a counter weight. The other has the Mars transfer type vehicle or whatever habitat they traveled in with at least five feet of Phobos rock and stuff as shielding. This is put into Phobos orbit just high enough so that the spinning habitat and counter weight do not hit the moon.. A cable will tie the two together. Then spun to create a reasonable gravity. Should this be Earth level gravity, or more like Mars surface? Also a ladder and a safety line are needed to get between the habitat and the center of mass. The first habitat at Phobos orbit can be in orbit a just a few hundred feet up. I believe people can get from Phobos to that orbit by running and jumping. If they miss they will be able to maneuver and land with the oxygen backpack. The backpack mostly holding air will be able to make many velocity changes if they miss. Orbiting Phobos is extremely slow. More likely to be used is a cable or ladder hanging down from center of the orbiting habitat to near the Equator of Phobos would be going at very slow walking speeds. In fact even most one hundred year old could grab the ladder and climb up while wearing a heavy space suite. A much more health person will be needed to climb between the habitat and that center of gravity if the gravity level is close to Earth, or even Mars level. This may be the first subsonic type skyhook.

A simple iron tube could be extruded using the carbonyl discusded above above. It could have some sections of glass windows. All this could extent the habitable area orbiting Phobos. Sheets of the carbonyl iron nickel can be made as wide and long as needed flat or even compound

curved sheets. In fact a nearly seamless wheel like toris could be made nealy automatically. The tubes could be a hundred meters, with a wheel diameter of kilometers. When there is time for ceramic and glass then some mold can be made that help habitat construction. Large notched bricks with gasket material between then to hold air in then we wrap it all with tight cabling going a few different directions. Extra cabling is needed in the direction of spin. The inside is sealed. Inside are wall, dirt, and most things needed to finish and be something some people wants to call home. It should have room for trees, bushes, and crop growing areas, a stream and lake. After spinning up then add water. A cable wrapped ceramic and glass brick habitat could be the most practical where not much acceleration is needed and where shielding is needed. Of course insulation is needed on the outside of the seal. The cable could be fiber glass or steal.

The parts for a few habitats like this can be sent to Earth orbits, and another can cycle between Earth and Mars. A crew returning to Earth could assemble the cycler habitat. This one can be the Mars Earth cycling habitat. As it passes the planet the people will enter something somewhat like a large Apollo type capsule to land on the planet. Then more people will dock and transfer using a similar capsule and move in living and grow their food for the long time it takes to travel there. They don't need to bring much food, fuel, any living space, air, or heat. These needs are taken care of on the cycling habitat. Possibly a simple sphere or tube in a spinning toris could available very early to lower the cost to Mars.

REFERENCES

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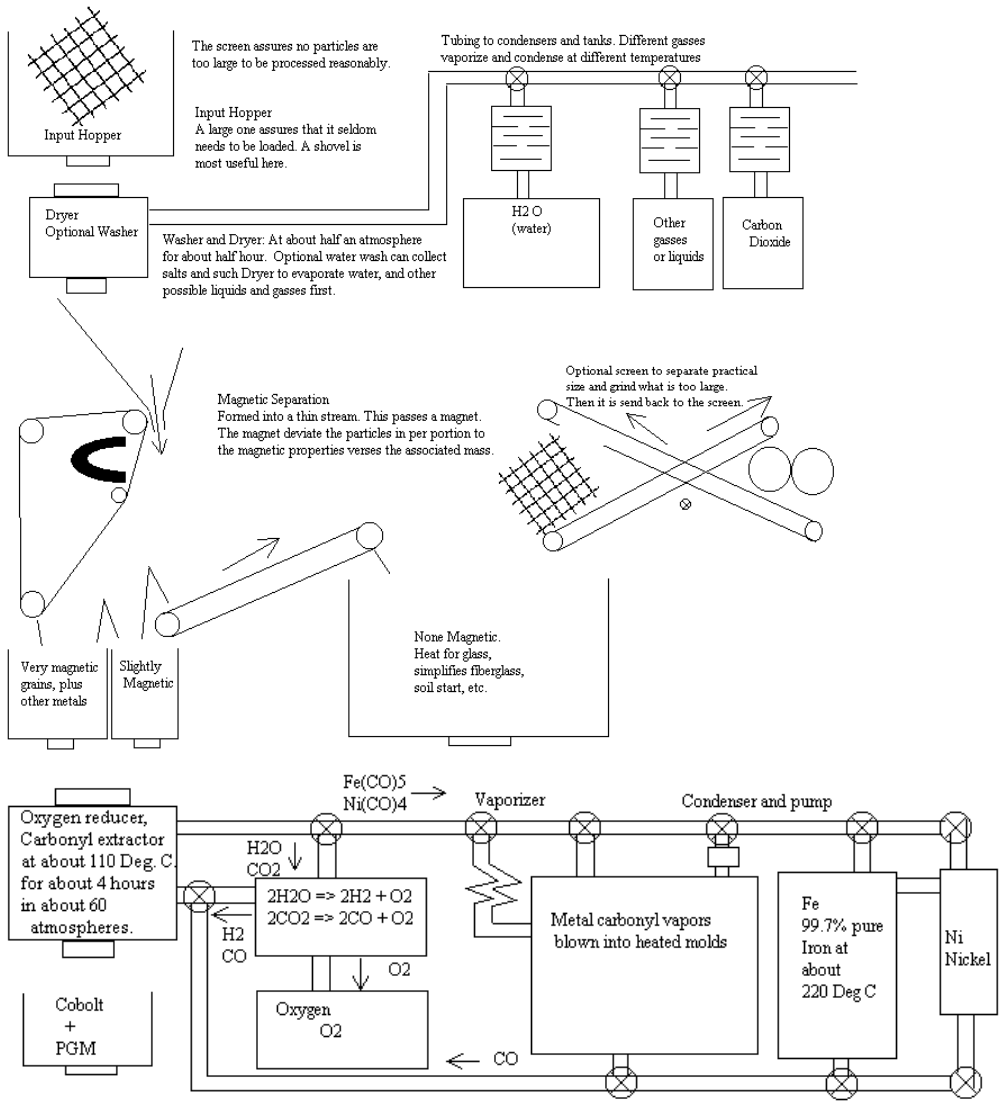
[v] MOONRUSH Improving Life on Earth with the Moon's Resources" by Dennis Wingo


Input Hopper
The screen assures no particles are too large to be processed reasonably.
Input Hopper
A large one assures that it seldom needs to be loaded. A shovel is most useful here.
Tubing to condensers and tanks. Different gasses vaporize and condense at different temperatures
Dryer
Optional Washer
Washer and Dryer: At about half an atmosphere for about half hour. Optional water wash can collect salts and such Dryer to evaporate water, and other possible liquids and gasses first.
H2 O
(water)
Other
gasses
or liquids
Carbon
Dioxide
Magnetic Separation
Formed into a thin stream. This passes a magnet. The magnet deviate the particles in per portion to the magnetic properties verses the associated mass.
Optional screen to separate practical size and grind what is too large. Then it is send back to the screen.
Very magnetic grains, plus other metals
Slightly
Magnetic
None Magnetic.
Heat for glass, simplifies fiberglass, soil start, etc.
Oxygen reducer, Carbonyl extractor at about 110 Deg. C for about 4 hours in about 60 atmospheres.
Fe(CO)5
Ni(CO)4
Vaporizer
Condenser and pump
H2O
CO2
2H2O => 2H2 + O2
2CO2 => 2CO + O2
H2
CO
O2
Oxygen
O2
Metal carbonyl vapors blown into heated molds
Fe
99.7% pure
Iron at
about
220 Deg C
Ni
Nickel
Cobolt
+
PGM
CO

Fiigure 1