$N91-71207$
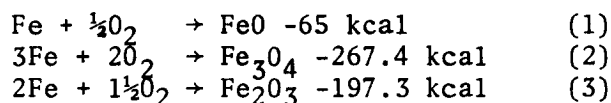
METALLIC IRON AS A POTENTIAL FUEL FOR PRODUCTION OF HEAT ON THE
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Metallic iron alloyed with small but variable amounts of nickel and co-
balt is an abundant constituent in both the highland and mare regolith (1, 2,
3, 4). Some of the iron occurs as either unlocked (liberated) or partly lib-
erated particles which may be separated relatively easily from the silicate
and oxide minerals of the regolith by conventional dry magnetic-concentration
methods. The grade and recovery of this potential particulate iron product
would, of course, depend on the strength of the magnetic field employed and
the degree to which the loose regolith material is divided into size fractions
by screening and dry-elutriation procedures prior to magnetic separation.

It is well known that the oxidation of metallic iron to either FeO, Fe_3O_4,
or Fe_2O_3 is highly exothermic. The corresponding reactions are:

$$Fe + \tfrac{1}{2}O_2 \rightarrow FeO \quad -65 \text{ kcal} \qquad (1)$$
$$3Fe + 2O_2 \rightarrow Fe_3O_4 \quad -267.4 \text{ kcal} \qquad (2)$$
$$2Fe + 1\tfrac{1}{2}O_2 \rightarrow Fe_2O_3 \quad -197.3 \text{ kcal} \qquad (3)$$

Enthalpic values related to these equations are given in Table 1. For compar-
ison, the heat of combustion of carbon in oxygen is -94 kcal per mole of CO_2,
per mole of carbon, or per mole of oxygen. Inasmuch as the supply of iron
from the regolith may be considered to be virtually unlimited, oxygen is the
limiting factor in the combustion of iron on the lunar surface. Consequently,
the most favorable reaction with respect to the evolution of heat is $Fe \rightarrow FeO$
(equation 1). Clearly, the evolution of 65 kcal per mole of product (FeO) or
per mole of iron when iron reacts with oxygen to yield FeO is not as favorable
as the yield of 94 kcal per mole of CO_2 or per mole of carbon from the combus-
tion of carbon. However, if oxygen and not the fuel is the limiting factor,
it is important to note that the reaction $Fe \rightarrow FeO$ results in the evolution of
130 kcal per mole of O_2 whereas the reaction $C \rightarrow CO_2$ results in the evolution
of only 94 kcal per mole of O_2. This argument, of course, is valid only if
reaction rates are sufficiently high at elevated temperature so that the re-
action $Fe \rightarrow FeO$ goes to completion. A hypothetical schematic flowsheet for
the iron combustion process on the lunar surface is shown in Figure 1.

Although there are alternative sources of energy on the moon (e.g. solar
energy), it appears to us that metallic iron in the lunar regolith constitutes
the only easily recoverable mineral that might be utilized as a combustible
fuel.

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Table 1. Heats of Combustion of Metallic Iron (ΔH in kcal) at 25°C, 1 atmosphere (5).

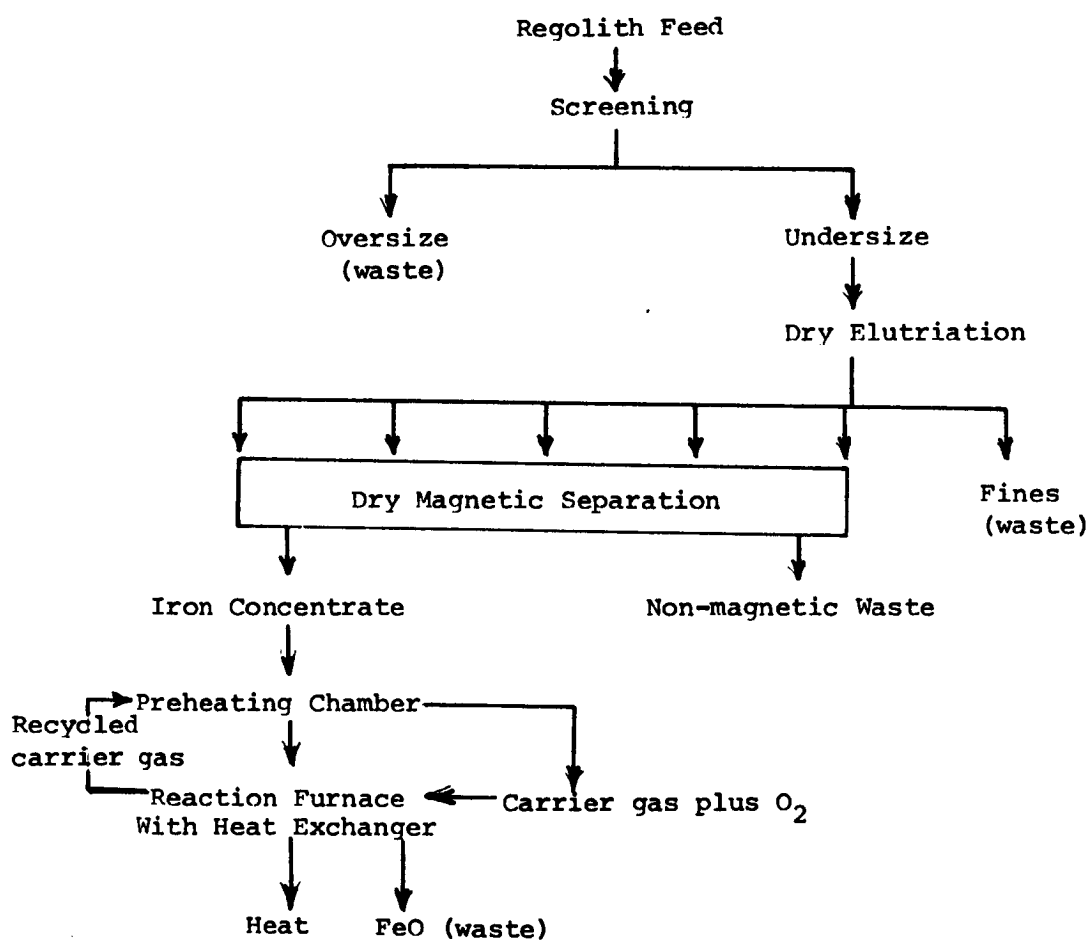| Reaction	kcal/mole of product	kcal/mole of Fe	kcal/mole of O_2	Mole of O_2 Required per Mole of Fe
Fe → FeO	-65	-65	-130	0.5
Fe → Fe_3O_4	-267.4	-89	-133.7	0.66
Fe → Fe_2O_3	-197.3	-98.7	-131.5	0.75

Figure 1. Hypothetical Flowsheet for Iron Combustion Process on Lunar Surface.

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DISCUSSION - (Sclar and Bauer)

SPEAKER 1:   In magnetic separation, do you end up with anything besides iron?

SCLAR: No, not if you control the magnetic field strength properly so as to reject all materials with a magnetic susceptibility lower than that of iron, which should be the most magnetic material on the lunar surface.

SPEAKER 1:   In our looking at the Moon as a place to do work, one of the big problems is sunlight being available part of the time. This (iron) would form an ideal battery where you wouldn't have to take the mass of the battery from the Earth. You could process the oxygen and the iron from the lunar material, separate them, and use them as battery during lunar night.

SCLAR: Okay, I accept all contributions of oxygen to this scheme. I just thought myself, and my colleague I think agrees, that if this ever came to pass, the first attempt would be with oxygen brought to the Moon. But, if there are alternative sources of oxygen, that would be even better.

SPEAKER 2:   I just can't resist remarking that all of that waste that you had indicated there looked very good to me. You know, one man's waste is another man's resource, I guess.

SCLAR: You can look at the FeO as an iron ore but, then you're going to have to reduce it back to iron. It seems sort of silly to have to do that. Might as well keep some of the iron and process it directly.

SPEAKER 2:   If you want the nitrogen and things of that kind, we're going to want to select for fines, and that was one of the things that you were throwing away. There may be a lot of compatible operations that could be involved.

SCLAR: Reaction kinetics are obviously the key here and obviously this is something that would have to be checked out on a laboratory scale initially.