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Survey of Applications of Fusion Power
and Technology to the Chemical and
Materials Processing Industries

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Survey of Applications of Fusion Power Technology to the Chemical and Materials Processing Industries

Current efforts are directed toward processes and markets which can utilize the energy forms from fusion reactors. Table I outlines various products and processes which are energy-intensive, and lists them by energy form. The thermal reactions may utilize energy directly or indirectly. Directly indicates that the process gas is introduced into the blanket to obtain the required energy. Indirectly indicates that the process gas is heated by heat exchange with blanket coolant gas. The heat exchange may be accomplished by regenerative pebble-bed heaters, in which alternate beds are heated by reactor coolant gas (e.g., helium). By appropriate valving, the hot bed then gives up its stored heat to the process gas while the other bed is heated.

Table II is a listing of chemicals and products which are basic to the economy, are produced in very large quantities, and can employ energy from fusion reactors for their production. Some of the products listed require thermal energy, some require electrical energy, and many employ both. Present production figures are provided (1970-1973 time frame), and projected estimates for the year 2000 are also furnished. Most of the projections are by the Department of the Interior, and some are estimated in this study. The thermal requirement for CTR's to generate the energy required to meet the year 2000 estimate is outlined. This thermal requirement includes that needed to generate electricity when required in the process. Of course,

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one recognizes that not all the processes will employ CTR energy in the future, and perhaps some will employ energy from alternate sources. The tabulation, however, does provide a measure of the magnitude of the energy requirements necessary in the future; it appears that fossil fuels will not be available, as at present, to meet these needs. This has been taken into account in the analysis. As an example, the projected ammonia energy requirement is based on hydrogen production via electrolysis and thermal energy for the secondary reformer, both derived from CTR's, as opposed to the present practice of employing natural gas for both steps in the process. Future progress reports will delineate the process steps and requirements for each product in terms of a CTR economy.

Table III outlines the processes which employ electrical energy or a combination of electrical and thermal energy. The projected electrical requirements are also outlined. Note that the thermal energy needed to produce the electricity has already been included in Table II, assuming a 40% thermal to electrical conversion efficiency.

It should also be noted that some of the projections are quite conservative. The hydrogen estimates assume that hydrogen may be used by the year 2000 for coal liquefaction processes and iron reduction. However, if ultimately hydrogen replaces natural gas as a power plant fuel or for direct home heating, the demand will be even greater. Similarly, we have projected the methanol growth rate as typical of a high-volume organic chemical. With the increased interest of late in using methanol in the power and transportation area as a liquid fuel and a gasoline supplement or substitute, the requirement would increase enormously.

For example, the U.S. fossil fuel requirement for transportation alone in the year 2000, has been projected as 38×10^{15} BTU. If 50% of this needed is fulfilled by methanol, 2×10^9 tons would be required. This is two orders of magnitude higher than the projected value of Table II.

Table I

POTENTIAL PROCESSES FOR APPLICATION OF FUSION ENERGY

- I. Thermal Reactions
 - A. Wisconsin process for NO_2 - 2200°C
 - B. Acetylene from methane - 1500°C
 - C. Decomposition of CO_2 to $\text{CO} + \text{O}_2$ - 2200°C
 - D. Decomposition of water
 - E. Coal gasification
 - F. Shale retorting
 - G. Lime
 - H. Cement
 - I. Gypsum
 - J. Iron ore reduction
 - K. Ammonia
 - L. Titanium dioxide
 - M. Sodium silicate
- II. Electrical Processes
 - A. Electrochemical
 - 1. Hydrogen and synthetic fuels
 - 2. Oxygen
 - 3. Caustic-chlorine
 - 4. Metal refining - Al, Mg, Cu
 - B. High voltage Electrical
 - 1. Phosphorous - Phosphoric Acid
 - 2. Birkland-Eyde, NO_2
 - 3. Acetylene via arc process
 - 4. H_2O_2
 - 5. Ozone
- III. High Energy Radiation
 - A. H_2O decomposition
 - B. N_2 fixation
 - C. CO_2 decomposition
 - D. Ozone Synthesis

Table II

CHEMICAL PROCESSES
THERMAL ENERGY REQUIREMENTS FROM CTR⁽²⁾

<u>Chemical</u>	Production, 10 ⁶ tons ⁽¹⁾		Fusion Energy ⁽³⁾
	<u>Present</u>	<u>2000</u>	<u>Consumption, MW(t), 2000</u>
Cement	80.0	320	120,000
H-Iron	8.5	130-174	182,000-244,000
Chlorine	10.3	26-44	50,000-85,000
Oxygen	16	39-75	6,000-11,700
Ammonia (Anh.)	16.2	28-51	80,000-150,000
Hydrogen	5.2	40-135	500,000-1,690,000
TiO ₂	0.8	1.8-3.9	-
Phosphoric Acid	6.8	24	35,000
Acetylene	0.5	0.5	2,000
Sodium Silicate	0.7	2.8	600
Lime	19.7	80	18,000
NaOH	10.6	31	see chlorine
Gypsum	8.6	21-31	500-1700
Methanol	3.5	14	33,000
Aluminum	5.0	22-44	110,000-220,000
TOTAL			1.5-2.5x10 ⁶ MW(t)

1) U.S. Department of the Interior projection, Minerals Yearbook, 1970.

2) Excludes potential use for fuel.

3) Taken at 75% energy recovery for thermal reactions, 40% conversion for electrical use, 0.8 plant factor.

Table III

CHEMICAL PROCESSES
ELECTRICAL ENERGY REQUIREMENTS FROM CTR

<u>Chemical Product</u>	<u>Ma(e), 2000</u>
H-Iron	45,000-61,000
Chlorine	10,000-17,000
Oxygen	2,400-4,700
Ammonia	28,000-51,000
Hydrogen	200,000-675,000
Phosphoric Acid	14,000
Acetylene	800
Sodium Hydroxide	see chlorine
Methanol	13,000
Aluminum	44,000-88,000
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TOTAL	357,000-924,500