PLASMA ARC PROCESS FOR PRODUCING DISPERSE OXIDE MATERIALS FROM VOLATILE FLUORIDES.

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ABSTRACT

Technological route for plasma conversion of volatile fluorides to disperse oxides and hydrogen fluoride has been developed. Primary it was applied to conversion of depleted UF_6; then the process was modified for conversion of low grade enriched UF_6 and later has been used for conversion of related compound - SiF_4.

INTRODUCTION

Fluorides of many elements are volatile under usual conditions and are used as a raw materials for obtaining metals or ceramics by plasma decomposition or conversion. At processing such raw materials there is a need to regenerate fluorine in any suitable form such as F_2 or HF.

We consider development of this technology for two such fluorides -uranium hexafluoride (UF_6)and silicon tetrafluoride (SiF_4). Both compounds are characterised with high thermal stability; direct thermal decomposition is very difficult and expensive enterprise [1-2]. Therefore, we worked out alternative plasma-distillation process for processing UF_6, SiF_4 concluding conversion in (H-OH)-plasma at stoichiometric or close to it mole ratios of reactants.

PRINCIPLES OF THE PROCESS

The general scheme of a plasma - distillation process is shown in Fig.1. The process consists of generation of steam plasma, mixing the plasma with volatile fluoride. As a rule, two products are obtained: disperse oxides and concentrated HF. Using distillation one can obtain anhydrous HF and azeotrope $HF-H_2O$. Anhydrous HF is used for electrolitic producing F_2, azeotrope is returned to a reactor.

CONVERSION OF DEPLETED UF_6 IN STEAM PLASMA.

Conversion of UF_6 is described by the qross- equation:

$$UF_6+3(H\text{-}OH)\text{-plasma} \dashrightarrow 1/3U_3O_8 +6HF +1/6O_2, AH \simeq 68 \text{ kJ}. \quad (1)$$

The scheme of the pilot plant for conversion of depleted UF_6 is shown in Fig.2. Depleted UF_6 from the containers 1 is directed by the compressor 2 to the plasma reactor 7 where UF_6 is mixed with steam plasma generated by plasmatron 6. Products of conversion - U_3O_8 and HF are separted at the combined system of separation consisting of metal-cloth 10 and metal-ceramic 11 filters. The U -oxides are discharged into a transport container 14, HF-acid is condensed at the condenser 12 and collected in the container 13. Distillation column was placed separately of the pilot plant.

The main parameters of the process are as follows: power of the plasmatron is of 300 kW; capacity of the apparatus is ~ 150 kg UF_6/h; initial temperature of the (H-OH) -

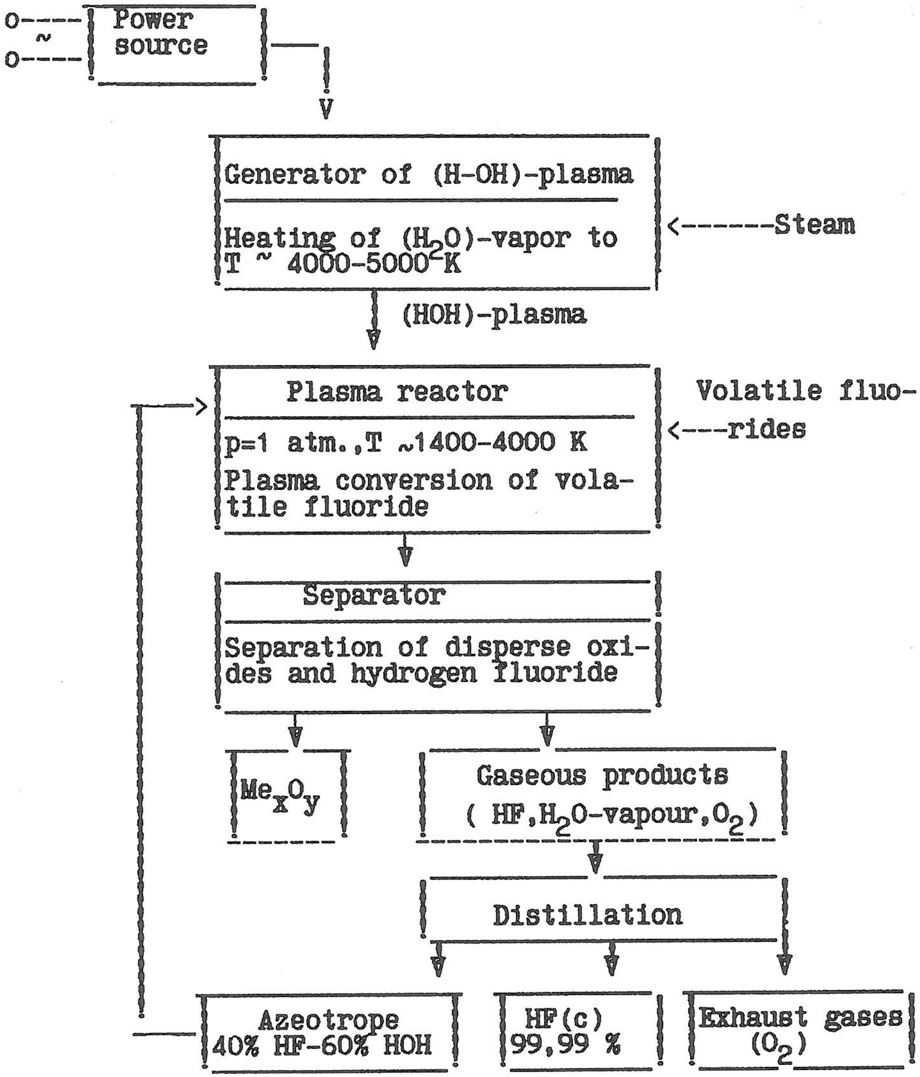

Fig.1. Flow sheet of plasma conversion of volatile fluorides

plasma stream is of 3200-3500 K.

During commissioning the apparatus the next integral indices have been attained: mole ratio HOH/UF_6 ~3.2-3.3 (stoichiometric mo- le ratio is of 3.0); concentration of HF downstreams of the reactor is of 93-95 %, yield of fluorine to HF up to 99,4 %, specific expenditures of energy ~ 1.4-1.5 kWh/kg UF_6.

By-product of a plasma conversion of UF_6 is gaseous O_2 liberating in a quantity of 10.61 nm^3/1 t UF_6. It is an unique case when a gas exhaust of technological apparatus is useful for environment.

The apparatus for conversion of low grade enriched UF_6 operates on the same principles but in this case one must provide conditions of nuclear security.

PLASMA CONVERSION OF SIF_4TO SILICA AND HYDROFLUORIC ACID.

The technique developed for conversion depleted UF_6 in steam plasma have been used for processing SiF_4 containing in gas exhausts of HF-plants [3]. The scheme of the pilot plant corresponds to the general scheme in Fig. 1. The process is described by the equation

$$SiF_4(g) + 2(H\text{-}OH)\text{-plasma} \dashrightarrow SiO_2(c) + 4\ HF(g) \qquad (2)$$

The pilot plant operated under the following conditions:

-raw material - off-gas of hydrofluoric plant	30-42 nm^3/h
-content of SiF_4 in the off-gas aforesaid	15-30 % vol.
-plasma gas	steam with ~5 % N_2 for protection of cathode
-power of the plasmatron	120-200 kW
-mole ratio of the reactants	6,0-6,5
-specific expenditure of energy	2,0-2,5 $kW.h/nm^3$
-concentration of hydrofluoric acid	50-55 % mass.

The silica obtained had the following properties: particle sizes of 170-1000 Å, bulk density of 0.05-0.12 g/cm^3 before shaking and 0.07-0.22 g/cm^3 after shaking, specific

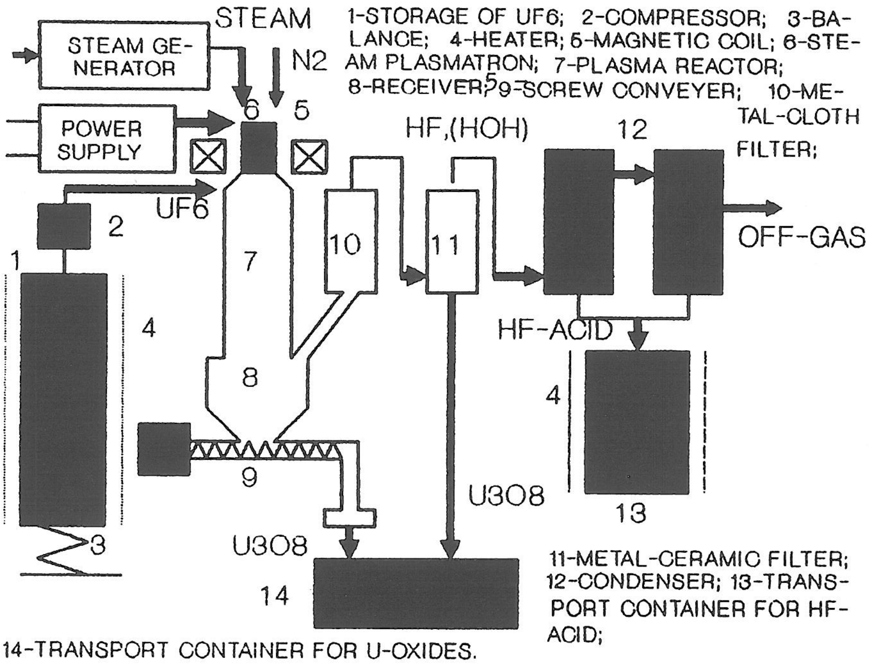

Fig. 2. Pilot plant for plasma conversion of depleted UF_6 to uranium oxides and hydrogen fluoride.

surface area of 100-300 m^2/g; silica can be amorphous or mildy crystallic; heat conductivity of compressed samples is within 0.3-0.5 W/m.K at 100- 450 C, specific resistance is $10^{9.5}$ - 10^7Ohm.m at 100-420 C.

OPERATION PRINCIPLES OF STEAM PLASMATRON

Operation of steam plasmatron is more complicated as compared to other plasmatrons operating on inert or usual gases. There are some basic principles which must be carried out to have operating generator of steam plasma.

1. PRINCIPLE OF HOT WALLS OF A PLASMA TORCH. It means that a wall of such plasma torch must have a temperature high enough to prevent condensation of steam and a negative con-

sequences of this phenomenon.

2. **EQUALLY ELECTROSTABLE CHANNEL MUST BE OF CONTRACTING FORM.** This is necessary to prevent shunting an arc at an initial part of an anode channel.

3. **DIAPHRAGM MUST SEPARATE CATHODE AND ANODE SPACES.**
4. **ALL THE PIPELINES AT THE APPARATUS MUST BE DAMPED.**

Steam plasmatrons operating on these principles have power of 800-1000 kW. More powerful plasmatrons are based on application of new principles of generation of plasma e.g. on using powerful microwave discharge.

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