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TRANSPORT OF POWDERS THROUGH ROTARY KILNS : EXPERIMENTAL STUDY AND MODELLING

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THEME 5 (II.I b) : Transferts de matière et de chaleur (réacteurs polyphasiques, rhéologie, écoulements réactifs…), mécanique des fluides, phénomènes interfaciaux.

keywords : rotary kiln, motion, model, powder, residence time

introduction

During the nuclear fuel cycle, uranium as hexafluoride is enriched by means of gaseous-diffusion process. The depleted UF_6 resulting from the isotope separation stage is converted into U_3O_8 to enable its safe storage (conversion carried out by COGEMA). The $UF_6 \rightarrow UO_2$ conversion is performed in four identical plants : UF_6 is hydrolysed in the gaseous phase through a vertical reactor, then the UO_2F_2 powder formed is pyrohydrolysed into U_3O_8 powder through a lightly inclined rotary kiln.
Modelling of these rotary kilns requires a deep understanding of solid hydrodynamic behaviour, because mass transfer and heat exchange are strongly dependent on the powder motion, especially regarding the quality and the duration of gas/solid contact.

previous works

Many papers about transport of powders through rotary kilns have been published since that of Sullivan (1). Most of them proposed relationships giving the mean residence time as a function of design, material and operating parameters. Most of these works are based on descriptions of particle trajectories. Unfortunately none concerns rotary kilns provided with lifters and baffles.

experimental study of powder transport

Axial bed motion has been experimentaly studied by the mean of Residence Time Distribution measurement. Several experiments were performed for one of the industrial kilns thanks to an isotopic tracer technique : a square signal of more enriched UF_6 was

introduced into the vertical reactor inlet, and gamma radiation was measured at the rotary kiln inlet ① and outlet ② (see **Figure 1**).

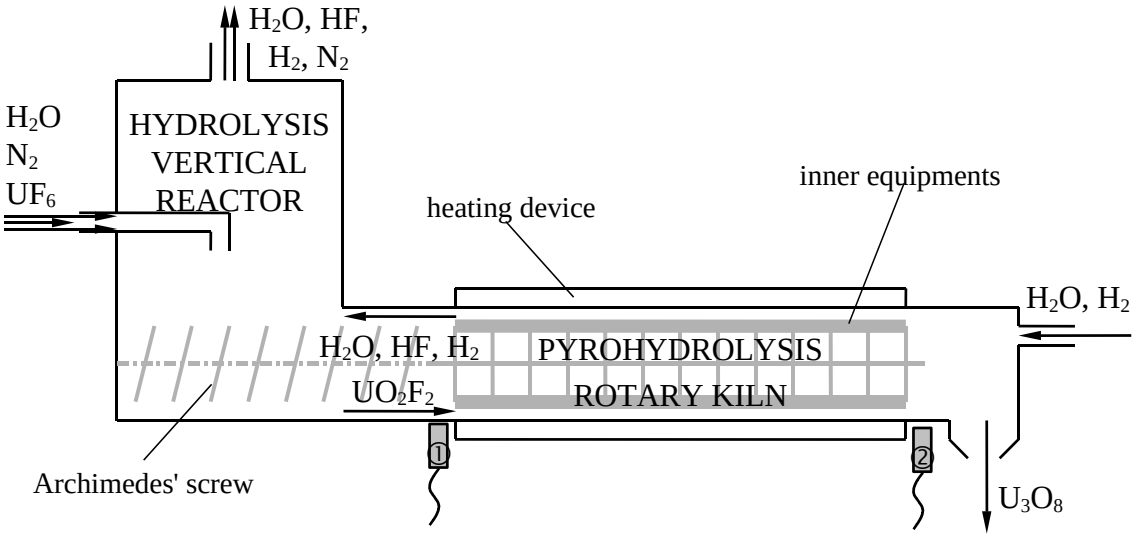

Figure 1 : Schematic view of a conversion reactor
(including location of gamma radiation probes).

The Residence Time Distribution obtained allows us to check that industrial rotary kilns behave as plug flow reactors with low dispersion. Several experiments were performed by varying feed rate and rotational speed of the kiln, in order to establish a correlation between the mean residence time and the operating parameters.

Transverse behaviour of both powders (UO_2F_2 and U_3O_8) has been experimentaly observed in a scale model working at room temperature. It represents a segment of the corresponding industrial kiln, with the same diameter and the same inner equipments. The behaviour of each powder was filmed through the glass end wall of the model for different operating parameters (filling ratio and rotational speed). Viewing of the movies and image analysis allow us to evaluate the proportion of powder lifted and the proportion in contact with the gaseous atmosphere at any time. Powder behaviour has also been observed in a one meter long glass model, in order to observe the influence of baffles on the axial motion of the powders.

conclusion

Using previous approaches and putting all the experimental observations mentioned in this paper together, a comprehensive mathematical model describing powders motion through the rotary kilns can be built up. This description of the solid flow will be then integrated into a global mathematical model of the rotary kilns used for the conversion.

(1) Sullivan, Maier, Ralston, U.S. Bur. of Mines, Technical Papers, **384**, 1-42 (1927)