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**IDMS AND DWPF SRAT OFFGAS FLUX AND PARTICLE
ENTRAINMENT (U)**

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November 11, 1992

INTER-OFFICE MEMORANDUM

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IDMS AND DWPF SRAT OFFGAS FLUX AND PARTICLE ENTRAINMENT (u)

Summary

Bench scale experiments showed that the peak H_2 generation rate increases with an increase in the PHA addition/evaporation rate. A 2,500 gal Slurry Mix Evaporator Condensate Tank (SMECT) was installed in the IDMS to allow performing PHA addition and evaporation both at the same rate and continuously. The SMECT allowed prototypic boil-up rates to be used, which allowed the investigation of hydrogen evolution in a more prototypic fashion and also made it possible to investigate solids entrainment in the offgas.

The prototypic PHA addition/evaporation rate in the IDMS is 1.28 gal/min. In a recent IDMS run, denoted by PX5, the extreme condition of 1.8 to 2.0 gal/min was used to obtain worst case hydrogen evolution data with the nitric acid / late wash flowsheet. This addition/evaporation rate required a steam flow rate of about 1,200 lb/hr. This steam flow rate caused the entrainment of a considerable amount of sludge solids in the offgas. The sludge solids went through the SRAT condenser into the MWWT and then into the SMECT.

A theoretical analysis showed that the maximum particle size that could be entrained in the DWPF SRAT depended on the specific gravity of the particle and ranged from 20 to 43 μm in diameter for specific gravities ranging from 5.0 (Fe_2O_3) to 1.1 (SiO_2). Moreover, these results were essentially independent of the air purge rate as the boil-up rate accounted for 86 % of the flow.

It is recommended that during the initial runs at the DWPF the steam flow rate to the SRAT and SME should be started at 500 lb/hr and increased gradually in 500 lb/hr increments. The SMECT should be sampled for entrained solids.

J. T. Carter

Authorized Derivative Classifier

Discussion

Table 1 lists the IDMS and DWPF SRAT dimensions. The DWPF design freeboard is the same as the actual freeboard used in IDMS PX-5. The DWPF maximum freeboard is greater (66 inches). Note, the condenser riser diameters are the same in each case. These conditions suggest that the DWPF SRAT has the same potential or maybe an even worse potential for entrainment as the IDMS SRAT.

Table 1. IDMS and DWPF SRAT Dimensions

	IDMS	DWPF
diameter (ft)	7	12
liquid surface area (ft ²)	38.5	113
freeboard (in)	41 (PX-5 actual)	42 (Design) 66 (max)
condenser riser dia. (ft)	0.5	0.5
condenser riser area (ft ²)	0.2	0.2
riser height (ft)	6	8

Table 2 lists the air inleakages and air purges for both the IDMS and DWPF SRATs. It also displays the steam flow rates, boil-up rates and corresponding PHA addition rates in both SRATs. The IDMS boil-up rate was based on a steam pressure of 125 psig, and that for DWPF on 85 psig. The required steam rate was determined from information given by Zamecnik (1992). He accounted for heating the PHA from 35 to 100 C and assumed an efficiency of 90%. These numbers are provided here as a basis for the calculations to follow and to compare the cases with and without an air purge present. It was suggested that entrainment could possibly be mitigated by moving the air purge from the SRAT to the top of the condenser.

Table 2. IDMS and DWPF SRAT Flows

	IDMS	DWPF
air purge (lb/hr)	150	1,100
air in-leakage (lb/hr)	20	109
steam flow rate (lb/hr)	1,200	6,400
boil-up rate (lb/hr)	900	3,490
PHA addition rate (gpm)	1.8	7.0

Table 3 gives the flow characteristics of the IDMS and DWPF SRATs, based on the information in Table 1. The flux, velocity and retention time for the SRAT and the riser are listed for both cases, i.e., with and without air purge. Note that the difference in the numbers for the two cases is not great as the air purge in the worst case accounts for only 14% of the flux, but is typically less than 10%. It is also interesting that because the riser in the IDMS and DWPF are the same diameter, the velocity in the DWPF riser is very high, which results in a very short retention time.

The implications of this are that if any particle come near the riser entrance, they will be lifted very easily out of the SRAT.

Table 3. IDMS and DWPF SRAT Flow Characteristics

	IDMS		DWPF	
	w/purge	w/o purge	w/purge	w/o purge
SRAT flux (lb/hr/ft ²)	27.3	23.9	40.6	31.8
riser flux (lb/hr/ft ²)	5,350	4,688	23,389	18,339
SRAT vel. (ft/s)	0.19	0.18	0.27	0.24
riser vel. (ft/s)	37.6	35.1	155.6	136.7
SRAT res. t (s)	21.7	23.3	13	14.7
riser res. t (s)	0.16	0.17	0.05	0.06

Table 4 lists the particle entrainment characteristics for both SRATs. These numbers were obtained from a theoretical analysis given in Foust *et al.* (1980). The theoretical analysis showed that the maximum particle size that could be entrained in the DWPF SRAT depended on the specific gravity of the particle and ranged from 20 to 43 μm in diameter for specific gravities ranging from 5.0 (Fe_2O_3) to 1.1 (SiO_2). Iron and silica particles were chosen for convenience, along with a water particle containing some sludge solids. Moreover, these results were essentially independent of the air purge rate as the boil-up rate accounted for 86 % of the flow. It is emphasized that these results are at best qualitative due to some of the assumptions made. Nevertheless, they do give a good representation of the size of the particle that can be entrained.

Since it is not known what the sizes of the sludge particles actually are, it is assumed that virtually any or all of the sludge components have the potential for being entrained in the offgas. Moreover, recent bench scale experiments have shown that the addition of mercury and/or noble metals and possibly the late wash PHA have all contributed to causing some degree of foaming in the SRAT. As a result, it is recommended that during the initial runs at the DWPF the steam flow rate to the SRAT and SME should be started at 500 lb/hr and increased gradually in 500 lb/hr increments. The SMECT should be sampled for entrained solids.

Table 4. IDMS and DWPF SRAT Particle Entrainment Characteristics

particle sp. g.	spherical particle dia. (μm)			
	IDMS		DWPF	
	w/purge	w/o purge	w/purge	w/o purge
1.1 (H_2O w/ solids)	35.6	33.9	42.9	39.0
2.0 (SiO_2)	26.4	25.1	31.8	28.9
5.0 (Fe_2O_3)	16.7	15.9	20.1	18.3

Conclusions

The theoretical analysis showed that the maximum particle size that could be entrained in the DWPF SRAT depended on the specific gravity of the particle and ranged from 20 to 43 μm in diameter for specific gravities ranging from 5.0 (Fe_2O_3) to 1.1 (SiO_2). Moreover, these results were essentially independent of the air purge rate as the boil-up rate accounted for 86 % of the flow.

It is recommended that during the initial runs at the DWPF the steam flow rate to the SRAT and SME should be started at 500 lb/hr and increased gradually in 500 lb/hr increments. The SMECT should be sampled for entrained solids.

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