

TE process which is widely used benchmark simulation was developed by Downs and Vogel¹. It contains five major unit operations: a reactor, a product condenser, a vapor-liquid separator, a recycle compressor and a product stripper. The control system for TE process which is second structure described by Lyman and Georgakis² is presented in Fig. 1 and the simulation code for open loop is downloaded from <http://brahms.scs.uiuc.edu>. There are 41 measured variables and 12 manipulated variables presented in Table 1. in the process and all the measurements contain Gaussian noise. 21 different faults are generated for further analysis, listed in Table 2.

Table 1. Process monitoring variables in the TE process

No.	Process measurements	No.	Process measurements
1	A feed (stream 1)	28	Composition F
2	D feed(stream 2)	29	Composition A
3	E feed(stream 3)	30	Composition B
4	total feed	31	Composition C
5	Recycle flow(stream 8)	32	Composition D
6	Reactor feed rate(stream 6)	33	Composition E
7	Reactor pressure	34	Composition F
8	Reactor level	35	Composition G
9	Reactor temperature	36	Composition H
10	Purge rate(stream 9)	37	Composition D
11	Product separator temperature	38	Composition E
12	Product separator level	39	Composition F
13	Product separator pressure	40	Composition G
14	Product separator underflow(stream10)	41	Composition H
15	Stripper level	42	D feed flow (stream 2)
16	Stripper pressure	43	E feed flow (stream 3)
17	Stripper underflow(stream 11)	44	A feed flow (stream 1)
18	Stripper temperature	45	Total feed flow valve (stream4)
19	Stripper steam flow	46	Compressor recycle valve

20	Compressor work	47	Purge valve (stream 9)
21	Reactor cooling water outlet temperature	48	Separator pot liquid flow valve (stream10)
22	Separator cooling water outlet temperature	49	Stripper liquid product flow valve (stream 11)
23	Composition A	50	Stripper steam valve
24	Composition B	51	Reactor cooling water flow
25	Composition C	52	Condenser cooling water flow
26	Composition D	53	Stirring rate
27	Composition E		

Table 2. process faults for the TE process

Fault number	process variable	Type
1	A/C feed ratio, B composition constant (stream 4)	step
2	B composition, A/C ratio constant (stream 4)	step
3	D feed temperature (stream 2)	step
4	reactor cooling water inlet temperature	step
5	condenser cooling water inlet temperature	step
6	A feed loss (stream 1)	step
7	C header pressure loss-reduced availability (stream 4)	step
8	A, B, C feed composition (stream 4)	random variation
9	D feed temperature (stream 2)	random variation
10	C feed temperature (stream 4)	random variation
11	reactor cooling water inlet temperature	random variation
12	condenser cooling water inlet temperature	random variation
13	reaction kinetics	slow drift
14	reactor cooling water valve	sticking
15	condenser cooling water valve	Sticking
16	unknown	unknown
17	unknown	unknown
18	unknown	unknown

19	unknown	unknown
20	unknown	unknown
21	valve position constant (stream 4)	constant position

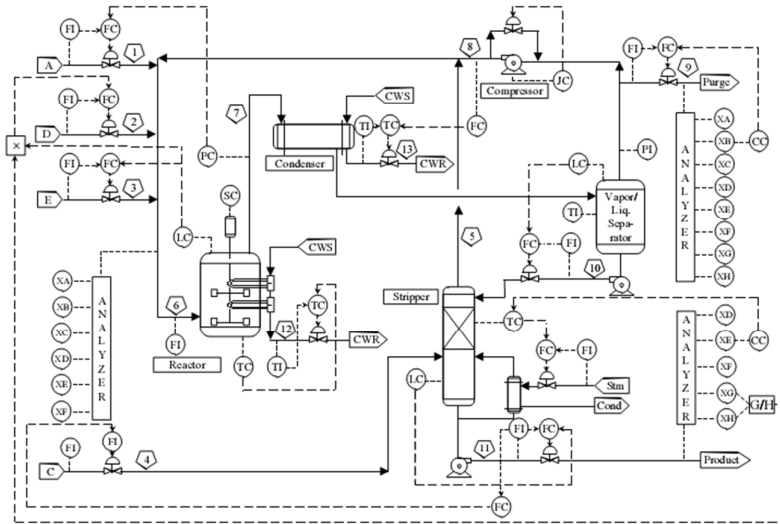


Fig. 1. control system for TE process

(1) Downs, J. J.; Vogel, E. F.: A plant-wide industrial process control problem. *Com. Chem. Eng.* **1993**, *17*, 245-255.

(2) Lyman, P. R.; Georgakis, C.: Plant-wide control of the Tennessee Eastman problem. *Com. Chem. Eng.* **1995**, *19*, 321-331.