

Self adaptive real-time optimization of reforming unit at a Shandong refinery

A 250,000-ton/annual reforming self adaptive real time optimization system at a Shandong petrochemical company has been operational since June 2011.

Optimization objective:

- Maximum octane yield of C5+ stabilized gasoline
- Maximum octane yield of C7+ heavy fraction gasoline
- Maximum yield of C5+ stabilized gasoline
- Maximize the overall economic benefits of the reforming unit

Optimization variables:

- First-stage reactor temperature
 - Second-stage reactor temperature
 - Third-stage reactor temperature
 - Fourth-stage reactor temperature
- Online octane number measurement: Online Raman spectrometer

Online Raman spectrometer

- This system can measure the aromatics, alkane, and cycloalkane content of the feedstock online.
- It can detect online the research octane number (RON), motor octane number (MON), benzene, toluene content, total aromatics, C8 aromatics, and PX content of the reforming reaction liquid.

The system was commissioned in early 2014 and has been operating stably since then, requiring no maintenance.

Technical assessment results of C5 octane yield optimization scheme:

	Manual operation (four days)	Optimization (four days)	Increment of optimization
Feed flow rate (t/h)	29.00	29.56	0.56
Hydrogen yield (%)	5.24	5.36	0.11
Dry gas yield (%)	3.98	4.04	0.06
Liquid hydrocarbon yield (%)	4.06	3.16	-0.90
C ₅ + Stabilized gasoline (%)	86.72	87.45	0.72
C ₇ +Heavy distillate gasoline (%)	53.15	55.08	1.93
C ₅ distillate yield (%)	7.86	7.09	-0.77
Non-aromatic yield (%)	22.12	21.00	-1.12
Benzene yield (%)	3.91	3.77	-0.14
C ₅ + octane number yield (%)	76.33	76.98	0.658

Technical assessment results of the unit's of economic benefit optimization scheme:

	Manual operation	Optimization	Increment of optimization
Feed flow rate (t/h)	30.01	29.99	-0.01
Hydrogen yield (%)	5.22	5.29	0.07
Dry gas yield (%)	5.69	5.74	0.05
Liquid hydrocarbon yield (%)	2.09	1.31	-0.78
C ₅ + Stabilized gasoline (%)	86.99	87.65	0.66
C ₇ +Heavy distillate gasoline (%)	56.89	59.29	2.39
C ₅ distillate yield (%)	6.23	6.22	-0.01
Non-aromatic yield (%)	21.49	19.75	-1.74
Benzene yield (%)	2.90	2.95	0.06
C ₅ + octane number yield (%)	55.22	57.40	2.18
Fuel gas consumption rate	7.20	7.34	0.14
Economic benefit (RMB/t)	799.55	819.18	19.63 (about 2.76\$/ton raw)

In this optimization system, a highly reliable online Raman spectroscopy octane number and aromatics analyzer was developed to directly measure the composition of the reforming reaction feed solution, guiding optimization and achieving excellent results, which is worthy of replication.

The project passed factory acceptance in September 2015.

Long-term operation statistics:

Overall operational rate of the optimized system from January to July 2017: 93.16%

Comparison of manual operation and optimization periods of long-term operation from January to July 2017:

	Manual operation	Optimization	Increment
Raw material N+A (%)	44.86	44.74	-0.12
Hydrogen gas (%)	5.15	5.03	-0.12
Dry gas (%)	1.09	1.24	0.15
Liquid hydrocarbon (%)	2.50	2.01	-0.49
Stable gasoline yield (%)	91.25	91.71	0.46
Heavy distillate gasoline (%)	57.63	59.80	2.17
C ₅ fraction yield (%)	8.15	7.38	-0.77
Non-aromatic yield (%)	21.71	21.08	-0.63
Benzene yield (%)	2.46	2.37	-0.09
C ₅ + octane number yield (%)	78.34	79.14	0.80