The Application Of A Matrix Algorithm In Aspen Hysys Modelling Guides Refineries Crude Oils Selection

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Abstract: *The study was initiated to conduct an in-depth systematic search from available crude oils to match existing design and test run conditions of four refineries.Three of the refineries studied are designed to process only naphthenic crudes while the other one, paraffinic crudes. Stage-wise technical evaluation and simulation of the refineries using ASPEN HYSYS enabled the selection of crude oils other than designed for these refineries.Paraffinicity and naphthenicity[1], as well as other process and products requirements were taken into consideration in the study*

Keywords: *Refinery, distillation, matrix, blends, model, match*

I. REFINERIES CONFIGURATION

The generalized configuration of one of the refineries studied (R_1) is shown here in Figure 1. R_1 has 2 plants as described: plant 1 refines naphthenic crudes, while plant 2, paraffinic. The other 3 refineries, (R_2-R_4) configurations are given in the context of R_1: R_2 and R_3 have HF Alkylation units, R_3 in addition has Dimersol and Butamer units, and R_4 has only CDU and CRU.

In every refinery, the CDU produces the various feeds for downstream processing and therefore contributes to the overall success of the entire production chain. This necessitated the concentration of this effort at the CDUs of each of these refineries (R_1-R_4). R_1 has 2 CDUs and R_2-R_4 each has 1 CDU. All the CDUs have 3 pump arounds (PAs) and 3 side strippers (SSs) with the exception of R_4CDU which has 2 PAs and 4 SSs. Overall, the process conditions, sizes, number of trays, specific feeds and draw-off points and heat loads for each CDU were appropriately taken into consideration during the modeling.

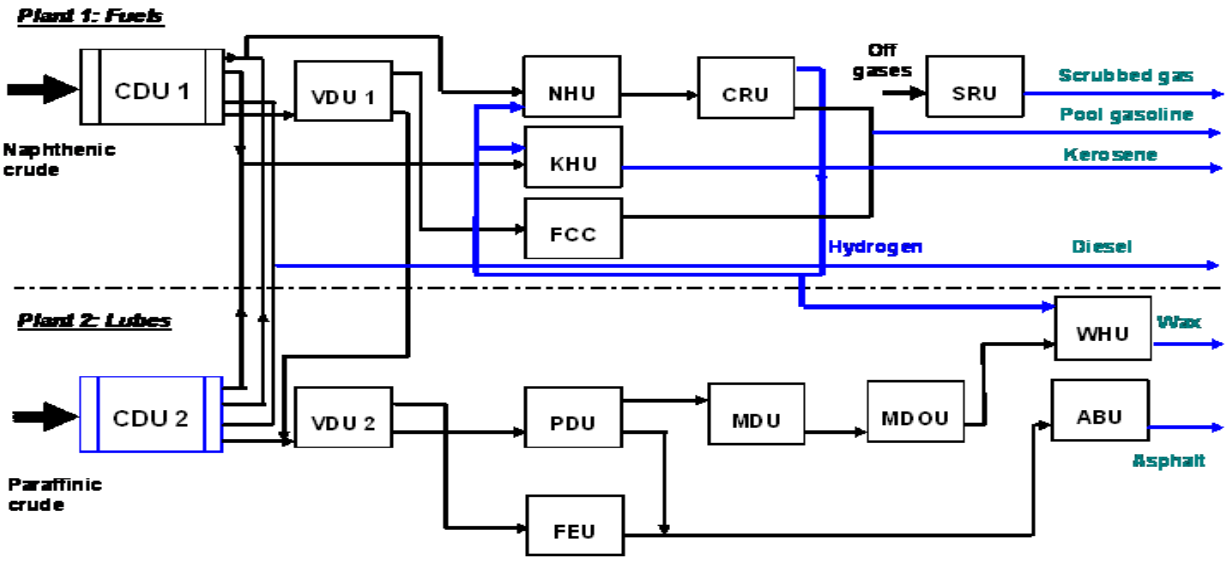

Figure 1: Generalized configuration of R_1

II. MATRIX MODEL

A step by step approach using laboratory assay data was adopted to select the crude oils taking into consideration design requirements determined after an elaborate technical evaluation of the 4 refineries and simulation using ASPEN HYSYS to match the results to design within ±5. Thereafter further advanced simulation using crude blend ratios c_i/c_j from 0/100 to 100/0 volume percent with 10 percent increment as appropriate to match the design/test run data was carried out to produce matrices m_1, m_2 and m_3 for the referenced crudes $c_1,\ldots,c_x$ (where x=20). The matrix elements a_{ij} are either '0' when there is no blend relationship between c_i and c_j or '1' when such relationship exists. The best match in terms of $c_i + c_j$, and process conditions were selected. This approach progressively reduced and repopulated the matrices in the direction: $m_1 \rightarrow m_2 \rightarrow m_3$,as shown below:where:$m_1$ (size x_1*y_1) shows the crudes $c_1,\ldots,c_x$ on both axis of the matrix with elements a_{ij}; $m_2$reduced (size x_2*y_2) based on same concept as m_1,m_3, further reduced matrix (size x_3*y_3) for each refinery R_1-R_4: m_{31}-m_{35} representing the blend for each CDU.

Total blends for each matrix p_1, p_2, p_3 respectively for m_1, m_2, m_3 determined through the ASPEN HYSYS simulations to match with design and test run conditions are described as pi (i=1,3) = $\sum a_{ij}$. Matching from m_1 to $m_3$we derived the matrix population index defined by MPI_i (i=1,3) =p_i/q_i , $q_i=x_i/y_i$. More than 200 simulations were done each fully solved with results analyzed and compared with some production data to confirm technical and operations feasibilities. All the modeling results were evaluated in the context of the objectives of this study.

m_1

	c_1	c_2	c_3	.	.	c_y
c_1	a_{11}	a_{12}	a_{13}	.	.	a_{1y}
c_2	a_{21}	a_{22}	a_{23}	.	.	a_{2y}
c_3	a_{31}	a_{32}	a_{33}	.	.	a_{3y}
.	.	.	.	.	.	
.	.	.	.	.	.	
c_x	a_{x1}	a_{x2}	a_{x3}	.	.	a_{xy}

m_2

	c_1	c_2	.	.	c_y
c_1	a_{11}	a_{12}	.	.	a_{1y}
c_2	a_{21}	a_{22}	.	.	a_{2y}
.	.	.	.	.	
c_x	a_{x1}	a_{x2}	.	.	a_{xy}

m_3

	c_1	.	c_y
c_1	a_{11}	.	a_{1y}
c_2	a_{21}	.	a_{2y}
.	.	.	
c_x	a_{x1}	.	a_{xy}

III. CONCLUSIONS

The study has matched the crudes to the design and process requirements for the refineries as follows, within the existing design process conditions:

Results show in Table I ,consistently blends that match within acceptable limits the design/test run conditions and comprehensive behavior of all the crudes for each stage: Matrix 1 to 3. Matrix 3 showed the 'best' twelve identified crudes when processed and 'matched' with design requirements for the 4 refineries. The matrix approach employed here has guided the modeling to achieve the desired results. The matrix population index MPI (a measure of efficiency of the match) increased from 0.065 for m_1 to 0.208 for m_2 and to 0.667 and 0.750 for m_3. Overall, massive volume of data on crude oils potentials, process and products conditions (comparable to pilot plant blending experiments) became available for each blend for future engineering decisions.

TABLE I: SIMULATION MATCHES

S/N	**Refineries**	***Best Crude blends***		***Next Best Crude Blends***	
		c_i+c_j	***Ratio: (Vol %)*** c_i/c_j	c_i+c_j	***Ratio: (Vol %)*** c_i/c_j
1	R_4	$c_7 + c_{18}$	50/50-0/100	$c_7 + c_{19}$	100/0-60/40
2	R_3	$c_7 + c_{18}$	50/50-0/100	$c_7 + c_{19}$	100/0-60/40
3	$R_1(1)$	$c_9 + c_{19}^{++}$	50/50-0/100	c_5,+ c_9	100/0-60/40
4	R_2	$c_5^{++} + c9$	50/50-0/100	$c_2 + c_{19}^{++}$	50/50-0/100
5	$R_1(2)$	$c_3 + c_{16}^{++}$	50/50-0/100	$c_{16} + c_{17}^{++}$	50/50-0/100

++ Additional crudes of special characteristics, not originally included in the matrix.

REFERENCE

[1] Eric O Okeke. Paraffinicity and Naphthenicity – impact in product yield and process conditions in a crude distillation unit simulation. 7th World Congress of Chemical Engineering, Glasgow, 10-14 July 2005