VISBREAKER MONITORING FOR MAXIMUM CONVERSION

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Refineries with many crude switches require frequent readjustment of plant processing parameters to bring the units back to high performance. This paper will show a method for improving the visbreaker operation by means of a conversion model. With the help of this model, the unit can be brought to near optimal condition immediately following the feedstock switch.

The Operator's Dilemma

Well-trained operators try to push the visbreaker conversion to the target fuel oil stability constraint. However, no such number representing the "maximum conversion" is available to them. Upon feedstock switch or throughput change, the visbreaker operator is forced to start conservatively and then move slowly towards the target fuel oil stability constraint. Each time he makes a move, he has to wait for the unit to reach steady state, and then call for a fuel oil stability test. Based on the test result he would make a severity adjustment, waits again for steady state and takes another sample. This way of creeping towards maximum conversion can take a day or even more when the feed switches are accompanied by throughput changes.

While the major problem facing the operator is lack of information about how to set the target severity, there is the additional problem of how to measure the actual conversion and compare it against the target.

We arbitrarily define conversion as the yield of material boiling below 165°C. This definition roughly equates conversion to the observed yield of naphtha and offgas when maintaining a naphtha cutpoint of about 165°C. However, a different naphtha cutpoint or changes in LPG absorption rates in naphtha renders a direct measurement of conversion imprecise, and it may lead to an erroneous conclusion.

Proposed Solution

The authors have developed an operating tool containing three parts as shown in Figure 1.

(a) A correlation between measurable feedstock qualities and maximum conversion will be displayed to the operator continuously.

(b) A short cut simulation for correcting the measured yield of naphtha and off-gas to 165° C -minus conversion. The operator will then be able to compare the desired versus actual conversion and make a decision as to whether to increase or decrease the visbreaking severity.

(c) A control program for holding the conversion constant at its target in the face of changing reaction conditions or throughput.

Feed characterization

From the outset we decided to rely only on feed qualities that can be measured by on-stream analyzers. We realized of course that the asphaltene content of the feed is one of the main attributes affecting maximum conversion, however onstream analyzers cannot measure asphaltenes. Our hypothesis was that the asphaltene content is related to the aromaticity and other qualities of the feedstock and we have developed a correlation to that extent.

The ability of our model to predict the asphaltene content of the feedstock is demonstrated by Figure 2. The range of this correlation represents feeds with asphaltene content of 2 to 8% and gravity of 0.98 – 1.04.

Maximum conversion

The maximum conversion for a visbreaker can be correlated from the asphaltene content and the aromaticity. It is noted that the asphaltene content is derived from the aromaticity and feed properties, while the maximum conversion is derived from the aromaticity and the asphaltene content.

This may be regarded as somewhat superficial, however separating these properties has the advantage of being able to compare them against lab data and maintaining the basic perception of the maximum conversion being primarily a function of the asphaltene content and the aromaticity.

Figure 3 shows the ability of our model to predict the maximum conversion constraint. The maximum conversion in the figure was obtained by taking unit data and normalizing the conversion to correspond to our fuel oil stability criterion.

The normalization process involves a measurement of conversion and fuel oil stability, and scaling the conversion to what it would be if we were precisely at the stability limit. It can be seen that the correlation is quite good, and all deviations are within the unit data normalization error.

Actual conversion

It has been stated that we define conversion as the yield of visbroken products boiling below 165° C. To give the operator a consistent indication of actual conversion we employ a short cut simulation model covering the top of the column plus condenser and overhead drum. From flow, temperature and pressure measurements, the model finds out what the actual naphtha cut is and how much LPG is absorbed; and then it corrects the yield to our standard cut of 165° C.

The simulation itself is straight forward, but in order to complete it and make the yield correction, one has to have an idea of what the visbroken product TBP curve is, in the range of say up to 200° C. After a series of tests we concluded that the TBP curve of visbroken light material is neither a function of feedstock nor of severity. The shape of the TBP curve consistently turned out as per figure 4.

This was a very interesting and helpful conclusion. It permitted us to easily determine pseudo components and improve the simulation precision.

Furnace outlet temperature

Although the above procedures, implemented as an off-line control scheme, would suffice for the purpose of severity control, it is helpful to also guide the operator in setting the furnace outlet temperature to achieve the maximum conversion. This is particularly needed when dealing with simultaneous visbreaker feed rate and quality changes.

The reaction section simulation program incorporates the following features:

- The conversion reaction is assumed to have a first order kinetics, with the reaction rate constant being a function of feed properties.
- An evaporation model calculating the vapor liquid ratio as a function of temperature, pressure and conversion. This information is needed for integrating the temperature/residence time dependent conversion rate.

Test Results and Conclusion

The ability of our reaction simulation to advise a reasonable coil outlet-temperature is demonstrated in Table 1. This table shows, through a period of three months, the actual versus maximum desired conversion, and the actual versus suggested coil outlet temperature. It can be seen that when the conversion is below maximum, the program consistently suggests a temperature that is higher than the current measurement. There were two events of overcracking, on the 25th and 28th of February; and in both cases the program suggested a decrease in the temperature.

Our approach for the prediction of maximum conversion versus actual conversion, and advising the operator on how to move the severity has proven feasible and we plan to next implement it in open loop as an operator guidance tool.

Figure 1: Principal Flow Diagram

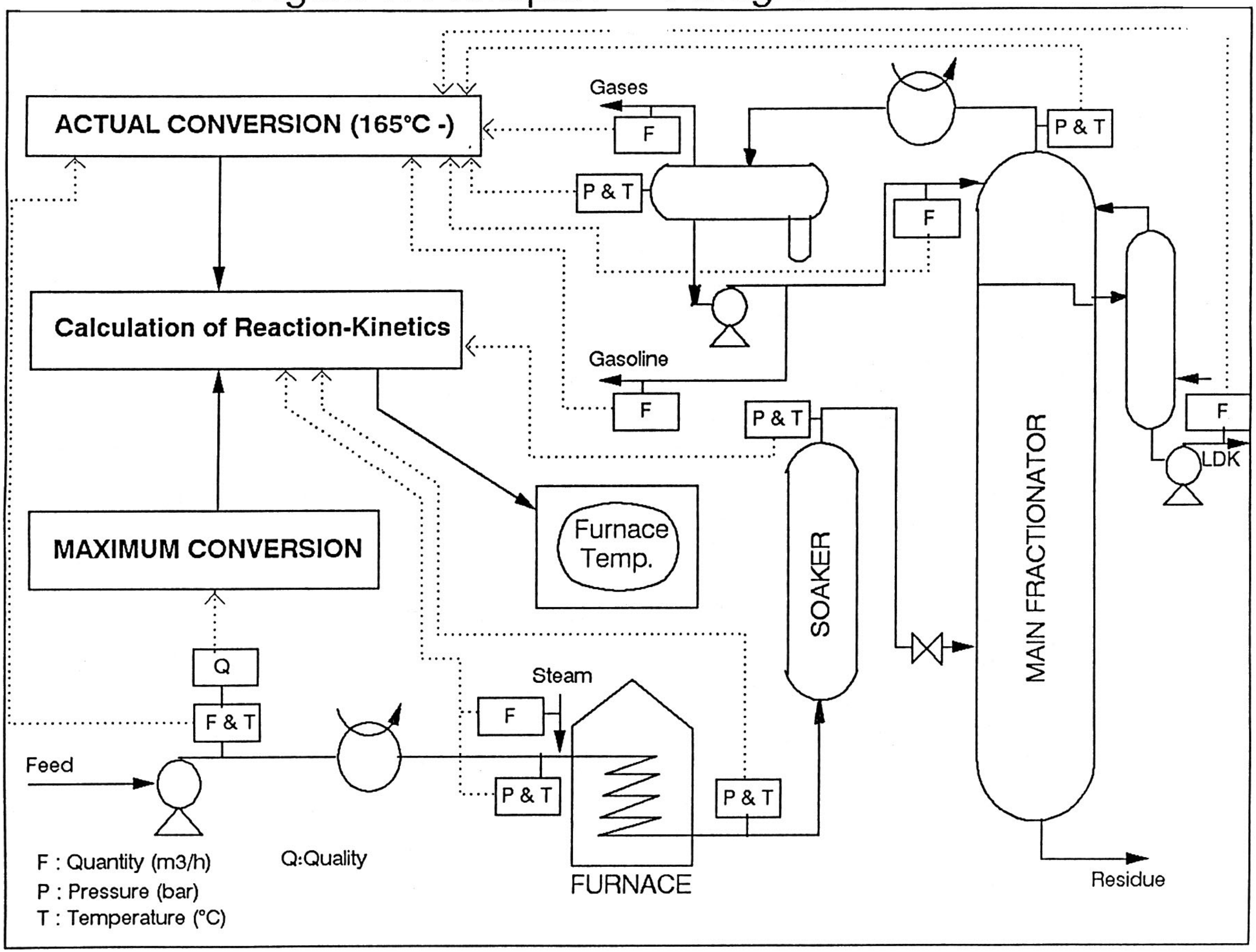

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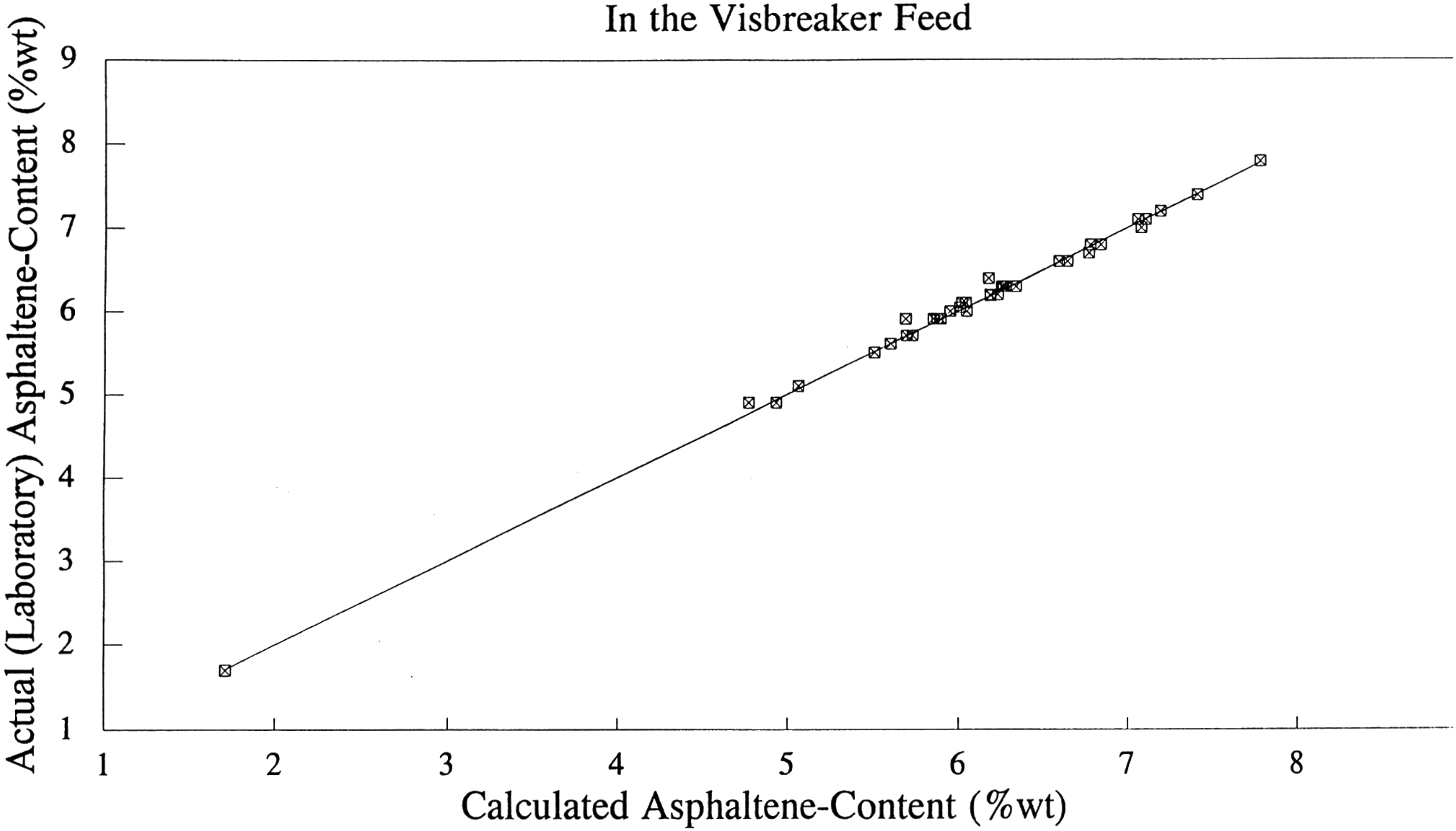
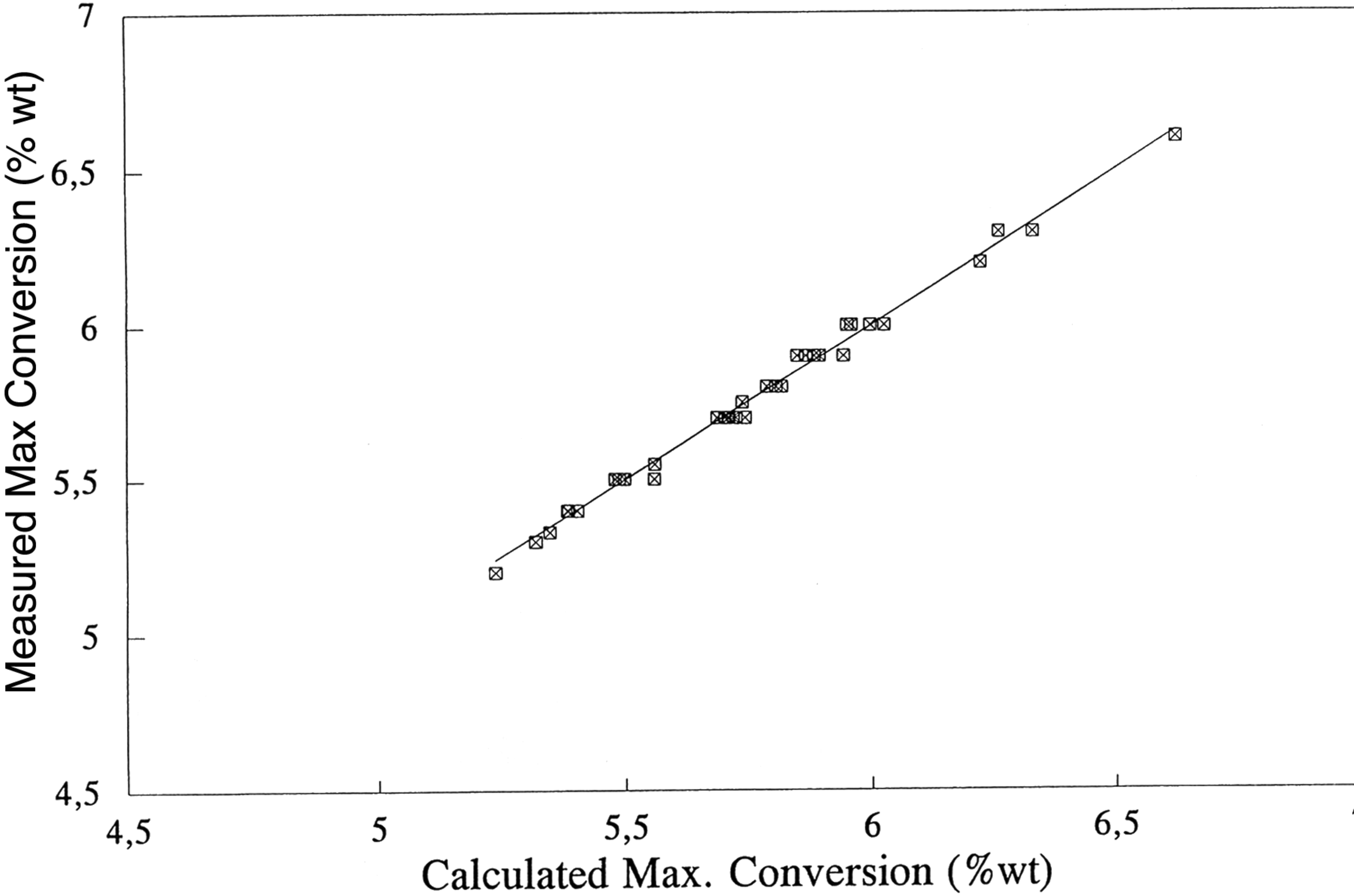
Figure 2. Asphaltene-Content

In the Visbreaker Feed



Asphaltene-Content = Function (Measured Feed Quality)
(R2 = 0,9950)

Figure 3: Maximum Conversion



Max. Conversion = Function (Measured Feed Quality)
(R2 = 0,9950)

FIGURE 4: PRODUCT TBP CURVE

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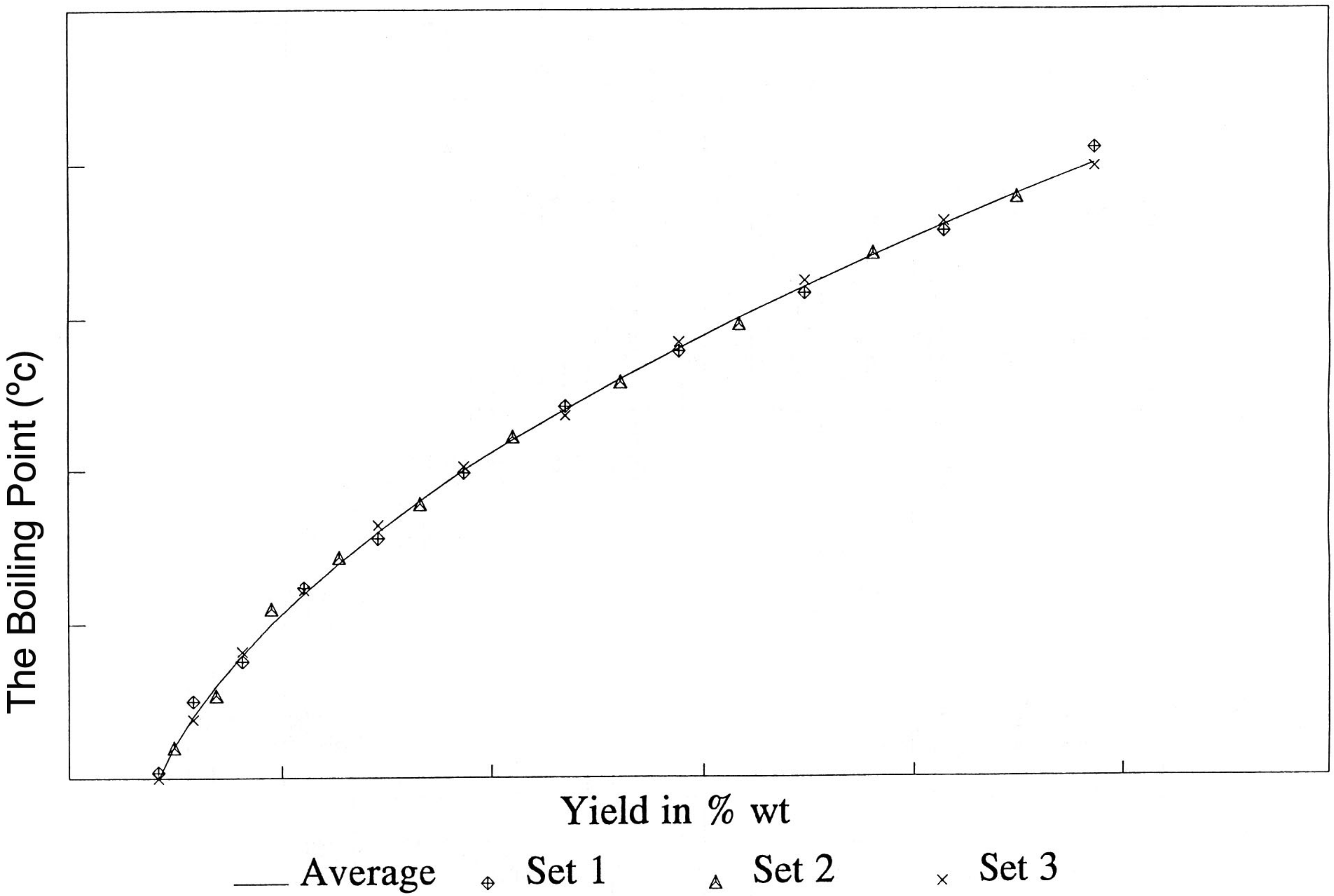

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Table 1. FURNACE OUTLET TEMPERATURES

Day	Actual Conversion % wt	Outlet Temperature °C	Measured Max.-Conv. % wt	Calculated Max.-Conv. °C	Outlet Temperature °C	Conv. Ratio Max/Acutal % wt/wt	Temperature Difference °C
15.12	5.02	436	5.67	5.69	441.5	1.13	5.5
16.12	4.99	437	5.36	5.37	440.1	1.08	3.1
17.12	4.85	440	5.10	5.16	442.5	1.06	2.5
18.12	5.30	439	5.65	5.67	442.1	1.07	3.1
21.12	5.32	439	5.57	5.51	440.6	1.04	1.6
22.12	5.34	440	5.46	5.49	441.2	1.03	1.2
23.12	5.05	439	5.30	5.35	441.4	1.06	2.4
24.12	5.22	440	5.57	5.55	442.7	1.06	2.7
25.12	5.43	440	5.53	5.54	440.9	1.02	0.9
28.12	5.40	439	5.53	5.56	440.3	1.03	1.3
29.12	5.25	437	5.60	5.60	439.9	1.07	2.9
30.12	5.22	438	5.62	5.68	441.8	1.09	3.8
31.12	5.23	437	5.63	5.69	440.8	1.09	3.8
01.01	5.13	436	5.88	5.88	442.1	1.15	6.1
04.01	5.28	436	6.03	6.00	442.0	1.14	6.0
05.01	5.83	436	6.58	6.64	442.7	1.14	6.7
06.01	5.51	437	5.89	5.83	439.6	1.06	2.6
07.01	5.31	437	5.81	5.84	441.3	1.10	4.3
08.01	5.33	439	5.71	5.71	442.1	1.07	3.1
11.01	4.95	438	5.45	5.46	442.2	1.10	4.2
12.01	5.10	439	5.50	5.52	442.4	1.08	3.4
Average	5.24	438	5.64	5.65	441.4	1.08	3.4
24.02	5.52	442	5.52	5.54	442.1	1.00	0.1
25.02	5.80	444	5.55	5.49	441.4	0.95	-2.6
26.02	5.79	443	5.79	5.81	443.1	1.00	0.1
27.02	5.45	442	5.70	5.71	441.1	1.05	2.1
28.02	5.97	444	5.72	5.70	441.8	0.95	-2.2
01.03	5.31	440	5.56	5.56	442.0	1.05	2.0
02.03	5.65	441	5.90	5.87	442.8	1.04	1.8
03.03	5.75	443	5.75	5.76	443.1	1.00	0.1
04.03	5.59	443	5.84	5.85	445.1	1.05	2.1
05.03	5.46	443	5.71	5.69	444.9	1.04	1.9
06.03	5.49	443	5.74	5.75	445.2	1.05	2.2
07.03	5.51	442	5.76	5.78	444.2	1.05	2.2
09.03	5.55	442	5.80	5.79	44.0	1.04	2.0
10.03	6.03	443	6.03	6.05	443.1	1.00	0.1
11.03	6.01	443	6.01	6.03	443.2	1.00	0.2
12.03	5.93	442	5.93	5.95	442.1	1.00	0.1
Average	5.68	443	5.77	5.77	443.3	1.02	0.8