Smoothing of Well Rates in Subsurface Hydrocarbon Reservoir Simulators

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Replace the “rough” flow rate with a smoother function, which retains two properties of the original:

- It remains positive at very instance;
- The integral over the entire time range is preserved.

Different smoothing scenarios are expected to be seen.
First Scenario: Approximation by Splines and Newton-Raphson Method

Replace the data function by smoothing spline with restrictions

\[ f(t) \ S_f \in C^2 : \]

\[ \int_0^T f(t) dt = \int_0^T S_f dt \]

\[ S_f > 0 \ \text{for} \ 0 \leq t \leq T \]

\(\text{OldArea} = 1.316303598725274\)

\(\text{NewArea} = 1.316303598725274, \ \text{Error} \sim 10^{-17}\)
First Scenario: Spline Approximation with Restrictions

Figure: 1
First Scenario: Spline Approximation with Restrictions

Figure: 2

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First Scenario: Spline Approximation with Restrictions

Figure: 3
Second Scenario: Explicit Relationship to the Average Value

\[ f_x = \frac{f_{i-1}(h_{i-1} + h_i) + f_i(h_i + h_{i+1}) + f_{i+1}(h_{i+1} + h_{i+2})}{h_{i-1} + 2(h_i + h_{i+1}) + h_{i+2}} \]

where \( h_i = t_i - t_{i-1}, \ i = 1, N \) procedure for \( i = 1, \ldots, N \) by step 4. It is possible to cut the largest deviations by reiterating. We repeat this

\textit{OldArea} = 1.31630359872527E + 00
\textit{NewArea} = 1.31630359872527E + 00, \ Error \sim 10^{-17}
Second Scenario: Moving average sketch

Figure: 4 Graph sketch of the averaging.
Second Scenario: Moving average sketch

Figure: 5
Piece-wise linear replacement or Spline Approximation with Restrictions

Which scenario to choose? We’ll see on Monday.
Thank you for your attention!