Introducing Fekete’s Regulatory Applications Group

Fekete has provided regulatory advice and services to the oil and gas industry since 1973. Fekete’s Regulatory Applications Group evolved as demand in regulatory matters grew. The group consists of 13 technical and support staff who provide advice on the application required and then prepare, advertise and submit the application to the appropriate jurisdiction. The Group receives approvals on hundreds of applications in a year. This volume of applications and familiarity with the regulations has contributed to our success.

Our work consists of applications for increasing well density, commingling production, disposal, enhanced recovery, oilsands primary recovery, common carrier/processor/purchaser, rateable, compulsory, pooling new well base allowable, concurrent production, and the elimination of oil production restrictions via good production practice. In addition, we also prepare and submit gas metering waivers, water to gas ratio and efficient correction factor exemptions, and gas density measurement frequency waivers to the AERUB. Though these applications do not increase your production, they can result in significant reductions in operating expenses, which ultimately have a positive effect on overall revenues. We also prepare RI, Release Rate Calculations, Otherwise Flared Solution Gas, and Continuations. Any applications can be prepared in conjunction with Fekete’s Geology Department, if necessary, which will minimize your involvement and allow you to concentrate on your core responsibilities.

Fekete Engineering Software Users Conference

THANK YOU!
Over a hundred valued customers and industry leading representatives attended the “first ever” Fekete Engineering Software Users Conference in Kananaskis, Alberta from July 10th to 12th.

Day one began with an opening address by industry veteran Dr. Ram Agarwal who presented his topic, “Perspectives on Rate and Pressure Analysis – A 50-year look back”*. Attendees then received a long term outlook on Fekete’s F.A.S.T.™ software development plans. “The Hit and Myth of Deconvolution” was presented by Fekete’s Karel Zaoui during the noon hour luncheon. Day two began with a presentation by Garth Stotts entitled, “Evaluating and Developing Tight Gas Reserves.” The rest of the day was filled with interactive breakout sessions focused on each F.A.S.T.™ tool. The high point of the second day was a luncheon keynote address by Dr. Tom Blasingame. Excellent feedback was received from all in attendance.

Based on attendees’ comments, it is clear that we are on the right track in continuing to add technically advanced features that have the most practical applications. Some of the feedback we received will lead us in some exciting new directions. Feedback received from the conference will be incorporated into our development plans and we will take new steps to ensure regular communications are established to meet our clients’ expectations. As voiced by vice president Ed Ferguson, “We’ve marked a milestone in software development at Fekete by making this level of commitment to our clients’ needs.”

Fekete is very grateful to all clients who contributed by presenting case studies and who supported us in other ways with this event. Without your input this event would not have been such a huge success.

AND IT WASN’T ALL WORK
The conference included a good dose of Western Canadian hospitality and Calgary Stampede fun, with horseback trail rides, horse drawn hay rides and plenty of games and activities for the kids. Most of us will not forget the shootout at Boundary Ranch where Louis Mattar was “ruffed up” and barely escaped the hangman’s noose. There was also the opening reception with live entertainment and a daytrip to Banff for the spouses and children. Overall the conference was enjoyable and memorable for everyone involved.

SEE US @ THE SHOW »

We want to see you! Please come visit us at the SPE Annual Technical Conference in Anaheim, November 11–14, 2007. We are located at booth #1561, in Hall B across from the outdoor seating and concession area.

To receive an electronic copy of Fekete’s newsletter, please contact us at fast@fekete.com
One of the current issues faced by reserve evaluators is whether or not coalbed methane (CBM) decline performance should be evaluated using traditional decline analysis techniques. Prior to investigating CBM decline performance, conventional gas well decline performance was studied. We reviewed the relevant literature, performed reservoir simulations and evaluated the applicability of traditional decline analysis presented by Arps.

**Review of Decline Analysis**

The Arps decline equation is an empirical relation, valid only when the well is flowing at a constant backpressure (i.e. flowing pressure) and is in boundary-dominated flow. Decline analysis is a procedure for curve-fitting historical production data, and generating a forecast of future production. An initial decline rate, D, and decline exponent, b, are determined based on the curve fit of historical data and are used to define the shape of the forecasted production profile. The decline exponent (b) describes the change in the decline rate (D) with time. The generally accepted limits on the decline exponent (b) are 0 and 1. There are three specialized forms of the decline equation: exponential, hyperbolic and harmonic. Exponential decline is defined by a b value of 0, and a constant decline rate (D). It corresponds to the theoretical (Darcy’s law) rate-time solution for a single phase liquid in a vertically depleted reservoir, at constant flowing wellbore pressure. Hyperbolic decline is defined by a b value between 0 and 1 and is often used to model gas decline, because unlike single phase liquids, gas properties (mainly compressibility) change during depletion, which results in b values greater than 0. Harmonic decline is when b = 1. During both hyperbolic and harmonic behavior, the decline rate (D), decreases with time. Accordingly, the choice of b value not only influences the estimate of reserves, but it also affects how long and at what rates the well will produce, which directly affects the economics of the project. Any factor that increases the drawdown will result in b values approaching 0.5.

The effects of these three factors on conventional gas decline are illustrated in Figure 1. The base case in this figure was simulated assuming that the productivity of the reservoir, matrix shrinkage and layered reservoirs were found to significantly affect the b value. The following observations were made in regards to CBM decline performance:

- As the Langmuir pressure decreases, the isotheerm becomes more non-linear and the b value increases.
- Increasing permeability caused by matrix shrinkage tends to reduce the b value.
- Multi-layer CBM reservoirs exhibit b values greater than 0.5 when there is a significant contrast between layer properties.

**Decline Performance of Conventional Gas Wells**

Numerous simulations of gas production from conventional gas reservoirs have been performed, and could be matched with b values between 0 and 0.5. Exponential decline (i.e. b value of 0) implies that the fluid properties (compressibility and viscosity) are relatively constant during depletion, whereas a b value of 0.5 implies that there is a significant change in the fluid properties. Because the change in fluid properties becomes more significant at lower pressures, the value of b changes with reservoir depletion. Factors such as the flowing wellbore pressure and turbulence, affect the drawdown in the reservoir, and have a strong effect on the b value. For example, a high backpressure does not reduce the reservoir pressure as significantly as a low backpressure, which results in less fluid property change, and therefore a value of b closer to 0. Similarly, the turbulence near the wellbore reduces the drawdown within the reservoir and therefore reduces the value of b.

In practice, many gas wells (e.g. tight gas wells) are produced at the highest possible drawdown. For these cases, b values approaching 0.5 are anticipated. On the other hand, high deliverability wells may be produced at high backpressures in order to restrict gas production, thereby decreasing the reservoir drawdown and the b value.

According to Fetkovich, b values as high as 1 (i.e. harmonic decline) can be used to match the behavior of layered gas reservoirs. He observed that if one layer depletes quicker than another due to higher permeability or less skin damage, the b value increases.

The results of our simulations for conventional gas well decline are:

- Low drawdowns result in b values approaching zero, while high drawdowns result in b values approaching 0.5.
- Turbulence around the wellbore (high rate wells) decreases the value of b.
- Multi-layer reservoirs can exhibit b values as high as 1 when there is a significant contrast between the layer properties.

The Arps decline equation is an empirical relation, valid only when the well is flowing at a constant drawdown pressure (i.e. flowing pressure) and is in boundary-dominated flow. Decline analysis is a procedure for curve-fitting historical production data, and generating a forecast of future production. An initial decline rate, D, and decline exponent, b, are determined based on the curve fit of historical data and are used to define the shape of the forecasted production profile. The decline exponent (b) describes the change in the decline rate (D) with time. The generally accepted limits on the decline exponent (b) are 0 and 1. There are three specialized forms of the decline equation: exponential, hyperbolic and harmonic. Exponential decline is defined by a b value of 0, and a constant decline rate (D). It corresponds to the theoretical (Darcy’s law) rate-time solution for a single phase liquid in a vertically depleted reservoir, at constant flowing wellbore pressure. Hyperbolic decline is defined by a b value between 0 and 1 and is often used to model gas decline, because unlike single phase liquids, gas properties (mainly compressibility) change during depletion, which results in b values greater than 0. Harmonic decline is when b = 1. During both hyperbolic and harmonic behavior, the decline rate (D), decreases with time. Accordingly, the choice of b value not only influences the estimate of reserves, but it also affects how long and at what rates the well will produce, which directly affects the economics of the project. Any factor that increases the drawdown will result in b values approaching 0.5.

The effects of these three factors on conventional gas decline are illustrated in Figure 1. The base case in this figure was simulated assuming that the productivity of the reservoir, matrix shrinkage and layered reservoirs were found to significantly affect the b value. The following observations were made in regards to CBM decline performance:

- As the Langmuir pressure decreases, the isotheerm becomes more non-linear and the b value increases.
- Increasing permeability caused by matrix shrinkage tends to reduce the b value.
- Multi-layer CBM reservoirs exhibit b values greater than 0.5 when there is a significant contrast between layer properties.

**Decline Performance of CBM Wells**

Production of gas from coal differs from that of conventional reservoirs because of the manner in which the gas is stored. In conventional reservoirs, the gas is compressed in the pore volume of the reservoir, while in CBM reservoirs the majority of the gas is adsorbed onto the surface of the coal in a liquid-like state. Gas adsoption in coals is typically modeled using a Langmuir isotherm. The following observations were made in regards to CBM decline performance:

- Low drawdowns result in b values approaching zero. However, because most CBM wells are produced at the highest drawdown possible, b values approaching 0.5 are expected.
- As the Langmuir pressure decreases, the isotheerm becomes more non-linear and the b value increases.
- Increasing permeability caused by matrix shrinkage tends to reduce the b value.
- Multi-layer CBM reservoirs exhibit b values greater than 0.5 when there is a significant contrast between layer properties.

**SUMMARY**

Any factor that lowers the drawdown in the reservoir will cause the decline to approach exponential behavior. Any factor that increases the drawdown will result in b values approaching 0.5.

The difference between exponential and hyperbolic decline may not become evident until late in the life of a well. Determining the appropriate value of b can be difficult as there are few CBM analogue available at the present time. Therefore, an evaluator may have to rely on theoretical principles in order to estimate a suitable value of b.

In spite of the more complex production mechanisms, CBM decline behavior is similar to that of conventional gas wells.
One of the current issues faced by reserve evaluators is whether or not to calculate CBM decline performance. The decline performance should be evaluated using this method. Prior to investigating CBM decline performance, conventional gas well decline performance was studied. We reviewed the relevant literature, performed reservoir simulations and evaluated the applicability of conventional decline analysis presented by Arps.

**Review of Decline Analysis**

Arps’ decline equation is an empirical relation, valid only when the well is flowing at a constant backpressure (i.e., flowing pressure) and is in boundary-dominated flow. Decline analysis is a procedure for curve-fitting historical production data, and generating a forecast of future production. An initial decline rate, D_i, and decline exponent, b, are determined based on the curve fit of historical data and are used to define the shape of the forecasted production profile. The decline exponent (b) describes the change in the decline rate (D) with time. The generally accepted limits on the decline exponent (b) are 0-1. There are three specialized forms of the decline equation: exponential, hyperbolic, and harmonic. Exponential decline is defined by a b value of 0, and a constant decline rate (D_i). It corresponds to the theoretical (Darci’s law) rate-time solution for a single phase liquid undergoing volumetric depletion at constant flowing wellbore pressure. Hyperbolic decline is defined by a b value between 0 and 1 and is often used to model gas decline, because unlike single phase liquids, gas properties (mainly compressibility) change during depletion, which results in b values greater than 0. Harmonic decline is when b = 1. During both hyperbolic and harmonic behavior, the decline rate (D_i), decreases with time. According, the choice of b value not only influences the estimate of reserves, but it also affects how long and at what rates the well will produce, which directly affects the economic feasibility of the project. The b value is difficult to distinguish between exponential and hyperbolic decline without having a considerable amount of production data, so it is up to the judgment of the evaluator to use an appropriate b value. This article discusses b values for both conventional and CBM wells.

**Decline Performance of Conventional Gas Wells**

Numerous simulations of gas production from conventional gas reservoirs were performed, and could be matched with b values between 0 and 0.5. Exponential decline (i.e., b value of 0) implies that the fluid properties (compressibility and viscosity) are relatively constant during depletion, whereas a b value of 0.5 implies that there is a significant change in the fluid properties. Because the change in fluid properties becomes more significant at lower pressures, the value of b changes with reservoir depletion. Factors such as the flowing wellbore pressure and turbulence, affect the drawdown in the reservoir, and have a strong effect on the b value. For example, a high backpressure does not reduce the reservoir pressure as significantly as a low backpressure, which results in less fluid property change, and therefore a value of b closer to 0. Similarly, turbulence near the wellbore reduces the drawdown within the reservoir and therefore reduces the value of b.

In practice, many gas wells (e.g., tight gas wells) are produced at the highest possible drawdown. For these cases, b values approaching 0.5 are anticipated. On the other hand, high deliverability wells may be produced at high backpressures in order to restrict gas production, thereby decreasing the reservoir drawdown and the b value.

According to Fertikovich, b values as high as 1 (i.e., harmonic decline) can be used to match the behavior of layered gas reservoirs. He observed that if one layer depletes quicker than another due to higher permeability or lower skin damage, the b value increases. The results of our simulations for conventional gas well decline are:

- **Low drawdowns result in b values approaching zero,** while high drawdowns result in b values approaching 0.5.
- **Turbulence around the wellbore (high rate wells)** decreases the value of b.
- **Multi-layer reservoirs can exhibit b values as high as 1 when there is a significant contrast between the layer properties.**

The effects of these three factors on conventional gas decline are illustrated in Figure 1. The base case in this figure was simulated assuming that the well produced from a single layer, CBM reservoir can be estimated using the conventional decline equations (Arps) and can be matched with b values between 0 and 0.5, similar to conventional gas wells. Due to the non-linear shape of the isotherm (see Figure 2), a significant volume of gas will desorb as the reservoir pressure declines (i.e., late-life production), which stabilizes the late time gas rates and increases the b value.

The isotherm becomes more non-linear as the Langmuir pressure decreases (see Figure 2) and for this reason, coals with lower Langmuir pressures desorb more gas at late time and therefore exhibit higher b values. The value of b was not dependent on the Langmuir volume because it does not affect the curvature of the isotherm.

As gas desorbs, the coal matrix may shrink (‘matrix shrinkage’), which increases the permeability of the coal cleat network. Our simulations showed that as the effect of matrix shrinkage increases, the value of b decreases. This is consistent with the observation that any phenomenon that results in a lower reservoir drawdown tends to decrease the b value.

**Decline Performance of CBM Wells**

Production of gas from coal differs from that of conventional reservoirs because of the manner in which the gas is stored. In conventional reservoirs, the gas is adsorbed in the pore volume of the reservoir, while in CBM reservoirs the majority of the gas is adsorbed onto the surface of the coal in a liquid-like state. Gas desorption is a complicated process, which increases the permeability of the coal cleat network. Our simulations showed that as the effect of matrix shrinkage increases, the value of b decreases. This is consistent with the observation that any phenomenon that results in a lower reservoir drawdown tends to decrease the b value.

**SUMMARY**

Any factor that lowers the drawdown in the reservoir will cause the decline to approach exponential behavior.

Any factor that increases the drawdown will result in b values approaching 0.5.

The difference between exponential and hyperbolic decline may not become evident until late in the life of a well. Determining the appropriate value of b can be difficult as there are few CBM analogies available at the present time. Therefore, an evaluator may have to rely on theoretical principles in order to estimate a suitable value of b.

In spite of the more complex production mechanisms, CBM decline behavior is similar to that of conventional gas wells.
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During the past six years there have been extensive changes with the three regulators and Fekete has responded to these changes rapidly and efficiently. Some of the highlights of these changes are the new default well density for various pools in Saskatchewan and the electronic submission formats in Alberta and British Columbia.

Our work consists of applications for increasing well density, commingling production, disposal, enhanced recovery, oilsands primary recovery, common carrier/processor/purchaser, rateable take, compulsory pooling, new well base allowable, concurrent production, and the elimination of oil production restrictions via good production practice. In addition, we also prepare and submit gas metering waivers, water to gas ratio and effluent correction factor exemptions, and gas density measurement frequency waivers to the AERUB. Though these applications do not increase your production, they can result in significant reductions in operating expenses, which ultimately have a positive effect on overall revenues. We also prepare In-Situ Release Rate Calculations, Otherwise Flared Solution Gas, and Completions. Any applications can be prepared in conjunction with Fekete’s Geology Department, if necessary, which will minimize your involvement and allow you to concentrate on your core responsibilities.

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Be sure to stop by and check-out some of our NEW software features:

- New Numerical Models for Horizontal Wells
- New Real-time Test Data Acquisition and Reporting
- New Tools for Tight Gas Testing
- New GIS and On-screen Drawing Tools
- New Rate History Matching Capability in Models

As always, you’re welcome to bring along any data, and our engineers will gladly answer questions on using the software and/or completing an analysis.

We look forward to the opportunity to visit with you in Anaheim.

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Based on attendees’ comments, it is clear that we are on the right track in continuing to add technically advanced features that have the most practical applications. Some of the feedback we received will lead us in some exciting new directions. Feedback received from the conference will be incorporated into our development plans and we will take new steps to ensure regular communications are established to meet our clients’ expectations. As voiced by vice president Ed Ferguson, “We’ve marked a milestone in software development at Fekete by making this level of commitment to our clients’ needs.”

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