Mini Review

Tiab's direct synthesis (*TDS*) technique: a perspective on its maturity and relevance in modern well test interpretation

Abstract

Well test interpretation remains a fundamental discipline within reservoir engineering, providing critical insight into reservoir properties, flow regimes, and well–reservoir interactions. Although several interpretation methodologies are available, many continue to exhibit limitations related to subjectivity, ambiguity, and non-uniqueness of solutions. Tiab's Direct Synthesis (TDS) technique, introduced in the early 1990s, was conceived as an analytical alternative grounded in pressure and pressure derivative diagnostics. Over more than three decades, TDS has evolved into a mature and versatile methodology applicable to fractured wells, horizontal and multifractured systems, naturally fractured reservoirs, unconventional formations, and composite systems. This paper presents a perspective on the conceptual foundations, general aspects, and enduring relevance of the TDS technique, emphasizing its role as a verification-oriented and physics-based approach for modern well test interpretation.

Keywords: TDS technique, well test interpretation, pressure derivative, flow regimes, perspective paper

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Introduction

Pressure transient analysis has been used for decades as a reliable means of characterizing reservoirs and evaluating well performance. The discipline has evolved significantly since its early applications, particularly after the introduction of the pressure derivative, which enhanced diagnostic capabilities and improved identification of flow regimes. Nevertheless, the reliability of well test interpretation depends not only on diagnostic tools but also on the methodology used to extract reservoir parameters.

Conventional straight-line analysis, type-curve matching, and automatic computer modeling matching (ACMM) remain widely applied in engineering practice. However, their limitations are well documented. Straight-line analysis lacks intrinsic verification and is highly sensitive to incorrect flow-regime identification. Type-curve matching relies on subjective trial-and-error procedures and may lead to significant errors when data quality is limited or tests are short. ACMM, although powerful, often yields non-unique solutions due to the inverse nature of the problem and the use of nonlinear regression techniques.

Tiab's Direct Synthesis (TDS) technique was introduced to address these issues by offering a direct analytical framework based on characteristic features observed on pressure and pressure derivative log–log plots.[1] Rather than fitting data to models, TDS derives reservoir parameters directly from governing equations associated with individual flow regimes. Since its introduction, the technique has undergone continuous development and has been extended to a broad range of reservoir and well configurations.[2–4]

This paper is written as a perspective rather than an exhaustive or tutorial review. Its objective is to reflect on the maturity, methodological strengths, and continued relevance of the TDS technique in modern well test interpretation, particularly in the context of increasing reservoir complexity and operational constraints. Detailed mathematical derivations, algorithmic developments, and exhaustive case-by-case applications are therefore intentionally outside the scope of this work and are extensively documented in the existing literature. Readers interested in the formal analytical developments and practical implementations of the technique are referred to the referenced publications, where the theoretical foundations and full mathematical formulations of TDS are presented in depth.

Conceptual foundations of the TDS technique

The TDS technique is fundamentally rooted in analytical solutions of the diffusivity equation. Each flow regime -wellbore storage, radial, linear, bilinear, spherical, or pseudosteady-state-is governed by a specific mathematical expression that manifests as a characteristic signature on the pressure derivative plot.

Unlike conventional methods that often focus on a single straight line or global data matching, TDS isolates individual flow regimes and treats them independently. This allows reservoir parameters such as permeability, skin factor, fracture conductivity, and drainage area to be estimated directly from characteristic points or straight-line segments.[1,3]

A defining aspect of TDS is its reliance on pressure derivative diagnostics. Plateaus, slopes, minima, maxima, and intersection points on the derivative curve are not merely qualitative indicators, but quantitative elements linked to reservoir physics. These features serve as direct inputs to analytical expressions, minimizing interpretation ambiguity.

General aspects and methodological strengths

Use of characteristic points

The use of characteristic points is central to the TDS philosophy. Reservoir parameters are obtained from well-defined features on the pressure derivative plot, such as derivative plateaus during radial flow or intersection points between different flow-regime lines.[1,2] This approach eliminates the need for type curves and significantly reduces reliance on subjective matching procedures.

An important advantage of TDS is its ability to operate even when certain flow regimes are weakly developed or entirely absent. In such situations, missing regimes can be analytically reconstructed, allowing parameter estimation without violating the governing physics of the system.[3] As a result, reliable interpretation remains possible under conditions where conventional methods often fail.

Verification-oriented framework

Verification is one of the most distinctive strengths of the TDS technique. Reservoir parameters estimated from one flow regime can be independently confirmed using another regime or an alternative characteristic point. This internal consistency provides a level of confidence that is rarely available in conventional straight-line analysis and is often obscured in ACMM workflows.

This verification-oriented approach reflects traditional engineering practice, where confidence in results is built through multiple independent analytical arguments rather than reliance on a single numerical solution. Consequently, TDS promotes disciplined engineering judgment grounded in physical consistency.

Applicability to complex reservoir systems

Over the past three decades, the TDS technique has been successfully extended to a wide range of reservoir scenarios. These include hydraulically fractured vertical and horizontal wells, naturally fractured reservoirs, composite and multilayer systems, shale reservoirs exhibiting trilinear flow behavior, and systems involving non-Newtonian fluids.[3–8]

In addition, TDS has been applied to interference and pulse testing, as well as to the determination of average reservoir pressure under various test conditions.[6–8] This versatility makes the technique particularly relevant in modern reservoir engineering practice, where increasing reservoir complexity and limited test duration are common challenges.

Practical relevance in modern engineering practice

One of the most practical advantages of the TDS technique is its reduced subjectivity. Because parameter estimation is based on explicit analytical expressions rather than trial-and-error procedures, results are more reproducible and less dependent on interpreter experience.

TDS is particularly effective for short-duration tests, where fully developed radial flow may not be observed. In such cases, early-time and transition flow regimes can provide sufficient information for reliable interpretation using TDS, whereas conventional methods may fail or yield unreliable results.[3,5] Furthermore, TDS complements numerical and simulation-based approaches. Parameters obtained through TDS can be used as physically meaningful initial guesses in ACMM, reducing solution non-uniqueness and improving convergence toward realistic reservoir descriptions.[2]

From an educational and professional standpoint, TDS preserves the analytical tradition of well test interpretation by explicitly linking observed data to governing equations. This transparency is especially valuable in an era increasingly dominated by automated and black-box interpretation tools.

In contemporary field practice, the added value of the TDS technique becomes particularly evident in scenarios where conventional straight-line analysis is either inapplicable or yields unreliable results. For example, in short-duration tests conducted in unconventional or tight formations, flow regimes such as spherical or transient linear flow may dominate the response, preventing the establishment of a stabilized radial-flow straight line. Under such conditions, conventional methods provide little guidance and lack internal verification. By contrast, TDS allows reservoir and well parameters to be estimated and cross-verified using characteristic features of the pressure derivative, even in the absence of classical radial-flow behavior. Similar advantages arise in tests involving non-Newtonian fluids or complex well configurations, where many commercial software packages do not explicitly include the corresponding analytical models. In these situations, TDS supports engineering decision-making by preserving physical consistency and offering parameter verification that conventional approaches cannot provide.

Perspective on the maturity of the TDS technique

After more than thirty years of development and application, the TDS technique can be regarded as a mature methodology. Its continued evolution has not altered its foundational principles but has expanded its applicability and reinforced its robustness.

Rather than competing with numerical or automated methods, TDS provides a solid analytical foundation upon which such tools can be reliably built. In this sense, TDS functions not merely as an interpretation technique but as a methodological framework that promotes physical understanding, verification, and disciplined engineering judgment.

The sustained body of literature on TDS applications reflects its adaptability and confirms its relevance in addressing contemporary reservoir engineering challenges.[3–10]

Conclusion

1) Tiab's Direct Synthesis (TDS) technique represents a mature, robust, and physics-based methodology for well test interpretation. Its reliance on analytical solutions, pressure derivative diagnostics, and internal verification distinguishes it from conventional interpretation approaches.
2) The versatility of TDS across a wide range of reservoir and well configurations, combined with its suitability for short and complex tests, underscores its continued relevance in modern petrochemical and reservoir engineering practice. As a complement to numerical and automated methods, TDS preserves analytical rigor while enhancing interpretation reliability.
3) In the future, the TDS technique is expected to serve as a robust analytical backbone for hybrid and data-assisted interpretation workflows, providing physical validation and engineering discipline to numerical, automated, and data-driven well test analysis.

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Conflicts of interest

The author declare that there are no conflicts of interest.

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