Formation Pressure Dynamics

The pressure distribution in subsurface porous media and its evolution in time (dynamics) in response to various disturbances has been practically tested and in vast majority of cases was proved to honour diffusion equation which describes dynamic property with infinite speed of interaction.

This means that interaction forces behind the pressure diffusion process may be thought as propagating at infinite speed, namely:

Pressure Speed Statement
If one start changing the flowrate in some well then formation pressure away from this well will start responding to this event immediately – no matter the distance from disturbing well.

There are few major disclaimers on the above.

Disclaimer 1

Pressure Speed Statement does not imply that pressure dynamics in the whole field is totally synchronised with pressure variation in disturbing well.

If, for example, one creates a pulse (monotonous growth followed by monotonous decline) in flowrate (and a pressure) in some well and check pressure away from this well then a pressure response will show a fair delay in growth and decline.

This delay maybe interpreted as a pressure pulse propagation with finite velocity (equal to distance over delay time), which has nothing to do with the infinite velocity of density impulse propagation.

This velocity is a phase velocity of isobars (and not density impulse velocity) and showing a phase correlation between the original pressure disturbance and its pressure response which is characterizing the media where the pressure is diffusing.

Disclaimer 2

Pressure Speed Statement is only valid in practical ranges of distances (meters to thousands of meters) and times (minutes and longer).

See other disclaimers for popular cases when Pressure Speed Statement fails.

Disclaimer 3

The fluid flow in porous media only starts above a certain pressure gradient threshold.

This means that even in infinite pressure propagation speed there will be some areas away from disturbing well which will never respond to the disturbance.

In practical terms this effect can only be captured at very high distances between wells or at regular cross-well distances but in low mobility formations (usually low permeability and / or high viscosity oil).

Disclaimer 4

The actual physical process behind pressure diffusion in porous media is density impulse transport which propagates at speed of sound in fluid-filled porous rocks (thousands of m/s).

In practical petroleum applications the time travel of density impulse between wells is so small (seconds or fractions of seconds) that it is never measured by gauges and not worth modelling.

That totally justifies describing the pressure dynamics with diffusion equation.

Disclaimer 5

The actual reservoir where pressure dynamic is studied is not an isolated physical object.

It is connected to wellbore and overlying/underlying rocks which represent inertial forces.

This introduces some delay in pressure response which in practical applications can measure up to minutes, can be recorded by gauges and can carry some useful information on the formation-well system and is worth modelling.

This area of knowledge is developed in non-linear Pressure Rheology Theory and linear Pressure Relaxation Theory.