Table 1 Basic parameters of typical single gas well model

|  |  |  |  |
| --- | --- | --- | --- |
| permeability /mD | 4 | Well control radius /m | 1500 |
| porosity /% | 8 | Primitive formation pressure /MPa | 30 |
| Gas saturation /% | 70 | Production allocation /m3/d | 40000 |
| Reservoir thickness /m | 4.5 | grid step size | 50×50×4.5 |
| Volume coefficient | 0.0042 | Number of grids | 900 |
| Wellhead pressure /MPa | 6.4 | Well-controlled reserves /108m3 | 1.35 |
| Stable production time /a | 5 | Production time | 20 years |

Table 2 Basic Parameters of Single Well Model for Typical Gas Wells

|  |  |  |  |
| --- | --- | --- | --- |
| influence factor | Range of values | influence factor | Range of values |
| reservoir permeability | 0.01、0.05、0.1、0.5、1、4、8×10-3μm2 | Formation pressure | 10、15、20、25、30MPa |
| porosity | 0.05、0.07、0.09、0.11、0.13 | Initial allocation | 2、3、4、6、8×104m3 |
| Reservoir thickness | 1、3、5、7、9m | Well-controlled reserves | 0.1、0.2、0.4、0.8、1、2、4×108m3 |
| Gas saturation | 0.5、0.6、0.7、0.8、0.9 | Wellhead abandonment pressure | 2、3、4、5、6.4MPa |

Table 3 n-value of decline index for different permeability

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| permeability×10-3μm2 | 0.01 | 0.05 | 0.1 | 0.5 | 1 | 4 | 8 |
| *n* | 0.987 | 0.753 | 0.561 | 0.393 | 0.256 | 0.067 | 0.0104 |
| Decline type | hyperbolic | hyperbolic | hyperbolic | hyperbolic | hyperbolic | Near index | Near index |

Table 4 n-value of decline index for different porosity

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Porosity | 0.05 | 0.07 | 0.09 | 0.11 | 0.13 |
| *n* | 0.0145 | 0.0227 | 0.0466 | 0.0585 | 0.0686 |
| Decline type | Near index | Near index | Near index | Near index | Near index |

Table 5 n-value of decline index for Different Gas Saturation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Gas Saturation | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| *n* | 0.0884 | 0.0821 | 0.067 | 0.0498 | 0.0463 |
| Decline type | Near index | Near index | Near index | Near index | Near index |

Table 6 n-value of decline index for Different Thicknesses

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| effective thickness | 1 | 3 | 5 | 7 | 9 |
| *n* | 0.031 | 0.0375 | 0.044 | 0.0682 | 0.0906 |
| Decline type | Near index | Near index | Near index | Near index | Near index |

Table 7 n-value of decline index for different formation pressure

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Formation pressure | 10 | 15 | 20 | 25 | 30 |
| n | 0.0212 | 0.0308 | 0.0485 | 0.0497 | 0.0685 |
| Decline type | Near index | Near index | Near index | Near index | Near index |

Table 8 n-value of decline index for different well-controlled reserves

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Well-controlled reserves /108m3 | 0.1 | 0.2 | 0.4 | 0.8 | 1 | 2 | 4 |
| *n* | 0.01 | 0.012 | 0.02 | 0.0415 | 0.0598 | 0.1731 | 0.2998 |
| Decline type | Near index | Near index | Near index | Near index | Near index | hyperbolic | hyperbolic |

Table 9 n-value of decline index for different constant-gas-production

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Constant-gas-production  /104m3 | 2 | 3 | 4 | 6 | 8 |
| *n* | 0.2039 | 0.1724 | 0.1148 | 0.0772 | 0.0365 |
| Decline type | hyperbolic | hyperbolic | hyperbolic | Near index | Near index |

Table 10 n-value of decline index for different Wellhead Pressure

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Wellhead pressure /MPa | 2 | 3 | 4 | 5 | 6.4 |
| *n* | 0.2705 | 0.1762 | 0.1115 | 0.068 | 0.0468 |
| Decline type | hyperbolic | hyperbolic | hyperbolic | Near index | Near index |

Table 11 Response Surface of 4 Factors and Result of 5 Levels

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factor | permeability /mD | Well-controlled reserves /108m3 | Working system /104m3 | Formation pressure /MPa |
| -α | 0.1 | 0.4 | 2 | 10 |
| -1 | 2.07 | 1.3 | 3.5 | 15 |
| 0 | 4.05 | 2.2 | 5 | 20 |
| 1 | 6.02 | 3.1 | 6.5 | 25 |
| +α | 8 | 4 | 8 | 30 |

Table 12 Response Surface Model Verification Table

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Well number | decline rate of initial annual | Permeability/  mD | Pressure/  MPa | Momentum reserves/  108m3 | production/  104m3 | decline rate of the model for initial annual | absolute error |
| G1 | 11.73% | 0.01 | 17.47 | 1.20 | 4.2 | 10.39% | 1.34% |
| G2 | 4.69% | 0.24 | 17.00 | 1.43 | 1.86 | 4.49% | 0.20% |
| G3 | 2.72% | 0.2212 | 13.53 | 1.33 | 2.09 | 2.85% | 0.13% |
| G4 | 15.57% | 0.1148 | 13.43 | 5.26 | 7.99 | 16.49% | 0.92% |
| G5 | 18.06% | 0.22 | 22.83 | 7.54 | 19.06 | 18.27% | 0.21% |
| G6 | 8.94% | 0.32 | 13.92 | 5.35 | 11.69 | 8.78% | 0.16% |
| G7 | 9.26% | 0.23 | 11.85 | 0.55 | 1.37 | 10.00% | 0.74% |
| G8 | 17.57% | 0.22 | 16.48 | 5.57 | 12.29 | 12.01% | 5.56% |
| G9 | 2.72% | 0.64 | 10.16 | 0.86 | 0.96 | 4.66% | 1.94% |
| G10 | 8.83% | 0.76 | 18.42 | 3.32 | 5.90 | 6.97% | 1.86% |
| G11 | 5.82% | 0.25 | 11.71 | 1.13 | 3.19 | 5.99% | 0.17% |