Investigation on a mobile fire extinguishing approach using liquid carbon dioxide as inert medium for underground mine

Data set

Injecting the inert gas into the fire zone is the most effective mean used to control the disaster, there are various types of injection equipment for mining inert media, and the comparison is shown in Table 1.

**Table 1.** **Comparison of injection equipment for mining inert media.**

| **Equipment name** | **Production mechanism** | **Gas production**  **（m3/h）** | **Equipment unit price**  **（RMB）** | **Gas production cost**  **（RMB/m3）** | **Technical performance** |
| --- | --- | --- | --- | --- | --- |
| Fuel inert gas fire extinguishing device | Generate inert gas by burning kerosene. | 1 000 | 1.20 million | 3.00 | Gas contains a small amount of oxygen and carbon monoxide, resulting in poor safety，which has been eliminated. |
| Nitrogen generator | Gas production by air separation method. | 1 000 | 2.00 million | 2.00 | High outlet temperature and high maintenance frequency; The maximum oxygen content in membrane separation gas production is 5%. |
| Carbon-dioxide generator | Gas production from the reaction of concentrated sulfuric acid and sodium bicarbonate. | 1 000 | 0.85 million | 8.00 | Chemical reaction production has low safety, low gas production, and a purity of 98%. |
| Liquid carbon dioxide gasification and injection system | Chemical reaction production has Low safety, low gas production, and a purity of 98%. | 1 170 | 0.80 million | 1.80 | Direct injection of liquid can suffocate, cool down, dilute gas, suppress explosion, and Prevent reignition in fire areas; Chemical plants produce liquids with a purity of nearly 100%, providing strong resource guarantee. |
| Liquid carbon dioxide direct injection device | 5 850 | 1.00 million |

The characteristic quantities of degree of fit for each measuring point are shown in Table 2.

**Table 2.** **Characteristic quantities of degree of fit for each measuring point.**

| **Measuring point** | **1** | **2** | **3** | **4** | **5** | **6** |
| --- | --- | --- | --- | --- | --- | --- |
| Maximum deviation *ΔTH*/℃ | 0.6859 | 0.9204 | 0.8097 | 0.4551 | 0.6063 | 0.6272 |
| Minimum deviation *ΔTL*/℃ | 0.0043 | 0.0009 | 0.0004 | 0.0080 | 0.0461 | 0.0158 |
| Average deviation *ΔTA*/℃ | 0.1079 | 0.1797 | 0.1733 | 0.2203 | 0.2473 | 0.2896 |
| Decisive coefficient *R*2 | 0.9894 | 0.9899 | 0.9930 | 0.9927 | 0.9919 | 0.9897 |

The above mentioned characteristic quantities of temperature change in 200 s on the liquid gasification jet path are shown in Table 3.

**Table 3.** **Characteristic quantities of temperature change in 200 s on liquid gasification jet path.**

| **Measuring point** | **1** | **2** | **3** | **4** | **5** | **6** |
| --- | --- | --- | --- | --- | --- | --- |
| Highest temperature *TH*/℃ | 23.3 | 24.1 | 24.4 | 24.3 | 24.3 | 24.5 |
| Lowest temperature *TL*/℃ | 17.4 | 15.8 | 15.6 | 15.4 | 15.2 | 14.9 |
| Temperature change range *TΔ*/℃ | 5.9 | 8.3 | 8.8 | 8.9 | 9.1 | 9.6 |
| Maximum temperature change rate *rM*/℃/s | -0.17 | -0.23 | -0.21 | -0.12 | -0.13 | -0.20 |
| Average temperature drop rate *rA*/℃/s | -0.06 | -0.08 | -0.07 | -0.05 | -0.05 | -0.05 |
| Moment of temperature dropping firstly *tD*/s | 110 | 110 | 90 | 30 | 20 | 30 |
| Moment of maximum temperature change rate *tM*/s | 140 | 140 | 140 | 150 | 150 | 160 |