

煤层冲击倾向性试验研究

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摘 要:采用 MTS 对山东某矿 3_下 煤进行了煤层冲击倾向性试验研究,通过对冲击能量指数、弹性能量指数和动态破坏时间 3 个煤层冲击能量指标的试验和分析,得出煤层具有较弱的冲击倾向;结合实际采矿条件,应加强冲击地压的预测预报,以保证矿井的安全生产。

关键词:煤层;冲击倾向性试验;冲击能量指数;弹性能量指数;动态破坏时间

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冲击地压是煤矿经常发生的主要灾害之一。煤层冲击倾向性研究是冲击地压机理研究的重要组成部分,是冲击地压预测预报及防范治理的基础。世界上有关国家提出了各种鉴别冲击倾向的指标,其中具有代表性的有弹性能量指数、弹性变形指数、最大塑性变形速度、含水量指数、脆性系数、脆性破坏系数有效冲击能指数、极限能比、极限刚度比、破坏速度指数、应力应变时间特性指数及波兰岩石弹性能指数等^[1]。我国煤炭行业标准中规定采用试验测得的冲击能量指数 K_E 、弹性能量指数 W_{ET} 、动态破坏时间 DT 作为煤层冲击倾向性的分类指标^[2]。

山东某矿主采煤层为 3_下 煤,厚度 3.70~8.35 m,平均厚 7.14 m,开采深度 700 m。在回采巷道掘进及工作面回采过程中出现了煤炮等冲击地压现象,但其强度和频次尚未对生产有较大影响。随着采深不断增加,矿井开采范围的扩大,发生冲击地压的危险必然增大。为保证安全生产,对主采煤层进行冲击倾向性试验研究是很有必要的。

1 试验条件

朝阳煤矿 3_下 煤现采区为三一采区,为使冲击倾向性试验研究更有代表性,分别在 3105 工作面切眼、3107 工作面材料道、3107 工作面胶带道、3109 工作面材料道、3109 工作面胶带道共 5 个地点取样。放炮崩落大块煤后立即现场封蜡,以保证与现场有相同的湿度和含水率,然后运抵实验室,在实验室内

经过切、磨,加工成直径 50 mm 的圆柱体标准岩石试件。

试验在 MTS 岩石电液伺服试验机上进行,试验机的精度、刚度都符合煤炭行业冲击倾向性试验要求。根据行业标准和多年的试验经验,采用不同的加载方式和加载速率以测定煤层的冲击性指标。每个取样地点的试件均分作 3 组,每组 3 个试件,分别进行冲击性能指标试验。

2 煤层冲击倾向性试验

2.1 单轴抗压强度及冲击能量指数试验

煤岩试件的单轴抗压强度和冲击能量指数试验可以同时进行。根据经验在 MTS 上以 0.006 7 mm/s 的位移控制速度对试件进行准静态加载,可以测得试件的单轴抗压强度和单轴压缩下的全应力应变曲线,并进行煤的冲击能量指数计算。试验测得的煤岩单轴压缩典型全应力应变曲线如图 1 所示。

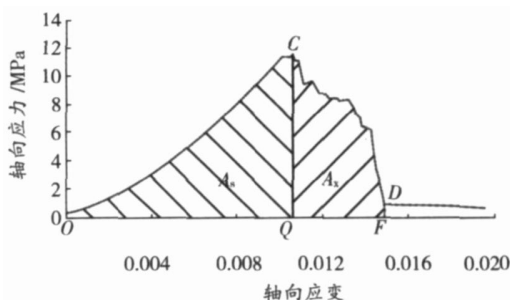


图 1 3109 胶带巷试件单轴压缩冲击能量指数计算图

煤岩的冲击能量指数计算公式如下:

$$K_E = A_s / A_x \quad (1)$$

式中: A_s 为试件峰值前积聚的变形能; A_x 为试件峰

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值后消耗的变形能。

如图 1 所示, C 为峰值强度点, D 为残余强度的初始点; A_s 为 $OCQO$ 的面积, A_x 为 $CD FQC$ 的面积。由计算机自动采集数据, MTS 可以根据采集的曲线上各点数据计算出 A_s, A_x 的值。

2.2 弹性能量指数试验

为研究煤层的弹性能量指数, 对煤岩试件进行了加卸载试验。根据煤炭行业标准, 以 0.15 kN/s 即 0.076 MPa/s 的速度加载到同采样点试件平均单轴抗压强度的 75 % ~ 85 % 后, 以相同速度卸载, 卸载到单轴抗压强度的 1 % ~ 5 %; 然后重新以 0.006 7 mm/s 的位移控制速度对试件进行加载直至试件破坏。可以获得各试件的加卸载应力应变曲线, 以此进行煤的弹性能量指数计算。试验测得煤岩典型加卸载应力应变曲线, 由此可以计算煤样的弹性能量指数, 如图 2 所示。

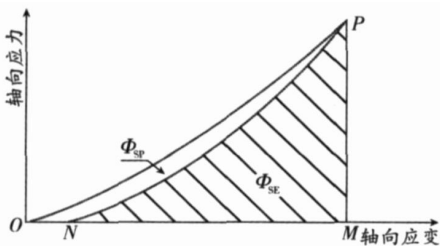


图 2 3107 材料道试件弹性能量指数计算图

煤岩的弹性能量指数计算公式如下:

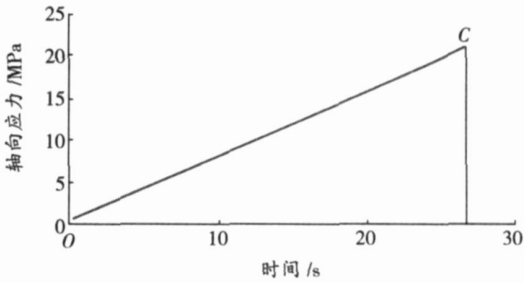
$$W_{ET} = \frac{SE}{SP} = \frac{SE}{C - SE} \tag{2}$$

式中: c 为总应变能, $OPMNO$ 的面积; SE 为弹性应变能, $PMNP$ 的面积; SP 为塑性应变能, $OPNO$ 的面积。

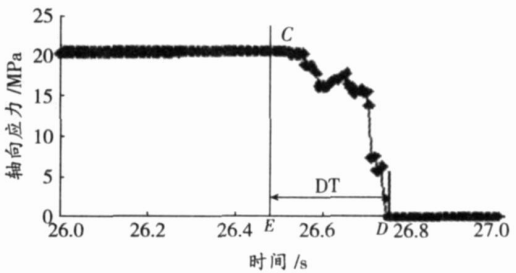
2.3 动态破坏时间试验

为研究该矿 3_下 煤的动态破坏时间, 按照煤炭行业标准以 1.5 kN/s 即 0.76 MPa/s 的速度对煤岩试件进行应力加载。为测得破坏瞬间的动态破坏时间, 在试件即将破坏时改用高速方法采集数据, 采样频率为 5 ms。试验测得的煤岩典型动态破坏时间曲线如图 3 所示。

动态破坏时间是指试件由峰值强度到完全破坏所经历的时间。图 3 中, C 点为峰值强度点, D 点为试件完全破坏点, OC 为加载过程, CD 为破坏过程, DT 为破坏时间。



(a)



(b)

图 3 3105 切眼试件应力时间曲线

3 试验结果分析

该矿煤层冲击性能试验结果如表 1 所示。

表 1 煤样冲击倾向性试验结果

取样地点	单轴抗压强度/MPa	K_E	类别	W_{ET}	类别	DT/ms	类别
3105 切眼	14.162	1.818 02	弱	2.065 5	弱	251.23	弱
3107 材料道	15.745 5	2.060 18	弱	3.229 75	弱	206.645	弱
3107 胶带道	14.439	1.412 7	无	2.688 77	弱	237.396	弱
3109 材料道	10.565	2.261 248 7	弱	2.716 475	弱	124.124	弱
3109 胶带道	10.629 5	1.516 56	弱	2.369 85	弱	260.26	弱

进行试验的煤样采自煤层的不同地点, 因此试验结果可以代表该矿 3_下 煤的冲击性能。可以看出, 不同取样地点的试件单轴抗压强度具有一定的离散性, 并且单轴抗压强度不高, 平均只有 13.108 MPa。生产实践与试验研究均表明: 煤的强度越高, 引发冲击地压所要求的应力越小; 煤的强度越小, 要引发冲击地压就需要高得多的应力^[3]。从单轴抗压强度考虑, 该矿 3_下 煤较难发生冲击地压。

根据国家煤炭行业标准, 从冲击能量指数看出: 4 个取样地点试件 $1.5 < K_E < 5$, 即煤样具有弱冲击倾向性; 只有 3107 胶带巷试件 K_E 小于 1.5, 不具备冲击倾向性。煤样弹性能量指数 $2 < W_{ET} < 5$, 动态破坏时间 $50 < DT < 500$, 各地点煤样均具有弱冲击倾向性。

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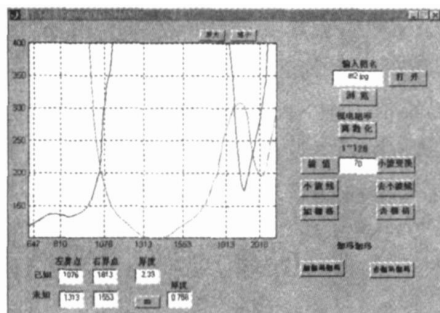


图 4 构造煤厚度计算

3 结论

构造煤厚度自动分层软件实现了钻孔测井曲线中构造煤判识和厚度计算功能,为煤与瓦斯突出预测预报提供可靠依据。本软件具有界面友好,操作简单、实用性强,计算速度快,精度高,可靠性好的特点。不仅可以自动判识构造煤厚度,改进后也可用于测井曲线地层的自动划分。

构造煤分层和定厚依赖于测井曲线资料的准确程度。数字测井技术的发展可为构造煤判识提供更佳的技术保障。因此,该软件具有广阔的应用前景。

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综合分析试验结果,该矿 3_下 煤具有弱冲击倾向。

由于该矿开采深度已达 700 m,在开采过程中出现了煤炮等现象;随着开采深度的进一步增加和开采范围的进一步扩大,煤层重力场和构造应力场将会增大,发生冲击地压的危险性必将增加。因此在开采过程中尤其在构造应力集中区有必要加强冲击矿压灾害的预测预报工作。

4 主要结论

1) 采用 MTS 伺服试验系统可以较好地进行煤岩冲击倾向性能的测试。位移和应力控制可以测取冲击能量指数和弹性能量指数,高速数据采集系统可以准确测量试件的动态破坏时间。

2) 不同地点的煤样试验表明,该矿 3_下 煤具有较

弱的冲击倾向性。5 个取样地点的 3 个冲击性能指标中只有 3107 胶带巷的冲击能量指数显示煤层无冲击倾向,其余试验结果均表明该矿 3_下 煤具有弱冲击倾向。

3) 随着开采深度增大,在开采过程中尤其在构造应力集中区有必要加强冲击地压灾害的预测预报工作,以保障矿井的安全生产。

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English Abstracts of This Issue

Theoretic Study and Experimental Analysis of Propagation Law of Mine Gas Explosion Flame Wave and Shock Wave (1)

— Gas explosion propagation law is the basis for analyzing explosion execution and developing explosion-suppression equipments and measures. Based on a great number of typical experiments and theoretic analysis, this paper analyzed the propagation law of gas explosion flame wave and shock wave, which presents similar attenuation laws, i.e. after the flame wave and shock wave underwent the phase of speedup, they began slowing down, finally, the flame wave propagated at the velocity of normal laminar flow combustion and the shock wave weakened into sound wave. In addition, the quantity of gas that took part in the actual reaction is an important factor for understanding the propagation law of gas explosion.

COSFLOW Simulation Prediction of Coal Face Gas Emission and Gob Gas Drainage (4) — In this paper, the basic method for COSFLOW simulation prediction was described, the simulation and prediction were conducted on the gas emission in Face 1242 (1) and 13118 and gas drainage from gob by surface boreholes in Hanqiao Coal Mine with the build COSFLOW model, and the predicted results tallied with the actually measured results at the site, this indicated that it is feasible to use COSFLOW model for the prediction of gas emission in coal face and gas drainage from gob.

Field Survey Study on Surface Subsidence and Deformation Law of Longer Fully-Mechanized Coal Face with Sublevel Caving (7) — An observation station was set up above 4326 longer fully mechanized caving face in Xinglongzhuang Coal Mine in order to study the surface subsidence and deformation law of a longer fully mechanized caving face under mining condition and direct mine production. Through analysis and study on the observation data, the surface subsidence and deformation law and relevant parameters of the longer fully mechanized caving face in this district during coal mining were obtained, a correction equation for the estimated results with the probabilistic integration method above the coal pillar was given and comparison and analysis were made with the rock displacement parameters in an ordinary fully mechanized caving face.

Experimental Study on Burst Tendency of Coal Seam (10) — Experimental study on burst tendency of coal seam was conducted in a coal mine in Shandong Province with MTS. Through the experiment and analysis of the impact energy index, elastic energy index and dynamic destruction time of three coal seams, it was concluded that the coal seam has weaker burst tendency so it is necessary to strengthen the prediction of rock burst in the light of the actual mining conditions so as to guarantee safe production of the mine.

Design and Development of Auto Identification Software for Tectonic Coal (12) — Auto-identification of tectonic coal is helpful to present outburst regulation of distribution and to determine coal seam range of outburst occurrence. A new method is put out based on wavelet transformation's well log delaminated automatically to identify the thickness of tectonic, which gets over the limitation of the well log' derivation by curve fitting, and gets a good purpose. Depending on the method, for convenient calculation, we work out the software about tectonic coal which based on wavelet transformation's auto-identify through MATLAB6.5 program, and introduce the structure and functions of the software. According to actual validation, the precision is higher.

Optimum Analysis on Coal Dust Suppression by On-line Water Spraying System (15) — Study was conducted on fugitive dust suppression by an on-line water spraying system in the process of coal handling by using a new automatic water spraying device for bulk material fall. The shape and chemical composition of bulk material were investigated by SEM-EDX. Air-water nozzle was used to produce more finer droplets under lower water flow, which has a good suppression effect. Air pressure, spraying position and water flow have influence on dust suppression. the optimal air pressure, spraying position and water flow were found out by experiments. Adding chemical suppression agent to

water can greatly improve dust suppression efficiency. A model of water flow and dust suppression efficiency was thus set up, with which water flow can be calculated. By optimizing water-spraying conditions, spraying water flow can be reduced greatly so that the property of bulk material can't be changed and spraying water cost can be lowered.

Applying Gas Analysis Method to Predict Coal Spontaneous Combustion (21) — Through coal heating and oxidizing experiment, analysis was made on the gas release regularity of coal oxidation with the change of coal temperature and the indicator gases for predicting coal spontaneous combustion were determined. The reliability of the indicator gases in different oxidation phases was analyzed by means of gray correlation analysis. Based on the experimental data and analysis results, a prediction system for spontaneous combustion was designed.

Research on Heavy Metal Pollution and Its Environment Geochemistry in Chenchao Iron Mine (23) — Large amounts of castoffs were produced during mining in Chenchao Iron Mine, Hubei Province, including various kinds of waste water and solid wastes. The discharge of these castoffs may cause the release and migration of heavy metals and pollute the surfacial environments of water bodies, soils and plants. Study indicated that the element which exceeded the environmental criterion of water bodies in this area is Hg and is Cu in the soil, the content variation characteristic of the elements in water bodies is similar to the variation characteristic of background value, but the content of elements in soil is widely discrepant to the background value. The biological absorption coefficients of these elements are different for different plants, according to the absorption of heavy metals in different plants, the fern and sagebrush can be taken as the vegetation of ecological reclamation in this area and the corn can be planted as a heavy metal-resistant crop. In addition, rice and rape contain more heavy metals and have larger absorption coefficients to various elements, so more serious environmental risk exists.

Application of Wavelet Transform in GPR Signal Processing (26) — The key of signal processing of GPR is to remove noise and pick up useful information. As a new method of signal processing, wavelet transform refines different spatial domain signal, setting up variant scale parameters. This paper applies the wavelet transform to GPR signal processing and introduces the basic concepts of wavelet transform. The result of application demonstrates that wavelet transform de-noising effect is satisfied and improved signal-noise-ratio.

Evaluation of Heavy Metal Pollution in Large Opencast Mine (36) — Since opencast mines have large mining intensity, they destroy the environment more seriously, especially when the heavy metals have been transformed from the deep level to the surface. As a result, the heavy metals were redistributed on the surface and can cause serious pollution in parts of an area due to the change of geochemistry conditions for their migration. Through the investigation of the heavy metals contents and their occurrence condition in the overburden formation of No.5 Coal Seam at Shengli Opencast Mine, it was concluded that the content of the heavy metal cadmium (Cd) exceeded its normal content, so it is the main factor of soil pollution by heavy metals in this area.

Estimated Parameter Analysis of Surface Subsidence and Deformation of Non-subsidence Observation Data of an Operating Mine (56) — Through the analysis on the relation between the destruction degree of buildings affected by mining and the surface subsidence and deformation values, the analytic values of surface subsidence and deformation were obtained. On this basis, the surface points where the surface subsidence and deformation values are obtained were estimated by choosing several groups of initially estimated parameter values, the difference square of the estimated value and analyzed value and the minimum group of corresponding estimated parameter were taken as the estimated parameter of the surface subsidence and deformation of the mine. The example proved that this analysis method is correct and also easy to use.