镨钕金属化学分析方法

碳、铁、钼、铝、硅和镨含量的测定

火花放电原子发射光谱法

实验报告

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二零二四年一月十八日

标样准备

共收到起草单位的20块实验用样品，其中19块用于曲线绘制。

如表1所示；

表1 用于绘制工作曲线的样品

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 名称 | C | Fe | Mo | Al  | Si  | Pr |
| 9# | 0.011  | 0.090  | / | 0.021  | 0.018  | 16.890  |
| 27 | 0.064  | 0.323 | 0.016  | 0.022  | 0.049  | 18.721  |
| 538 | 0.038  | 0.467  | 0.010  | 0.037  | 0.043  | 19.082  |
| 3-55 | 0.107  | 0.180  | / | 0.007  | 0.020  | 19.430  |
| 2-1 | 0.159  | 1.083  | / | 0.008  | 0.029  | 19.712  |
| 4-187 | 0.010  | 0.017  | / | 0.004  | / | 20.715  |
| 11-201 | 0.037  | 0.214  | / | 0.041  | 0.105  | 22.882  |
| 20-193 | 0.012  | 0.034  | / | 0.008  | 0.011  | 23.127  |
| 503 | 0.016  | 0.204  | 0.006  | 0.067  | 0.075  | 23.485  |
| 22-114 | 0.023  | 0.049  | / | 0.006  | 0.009  | 23.690  |
| PNMo-8 | 0.021  | 0.146  | 0.061  | 0.015  | 0.018  | 23.725  |
| PNMo-7 | 0.038  | 0.414  | 0.054  | 0.013  | 0.033  | 23.917  |
| PNMo-9 | 0.023  | 0.288  | 0.064  | 0.030  | 0.032  | 24.114  |
| 9-201 | 0.080  | 0.168  | / | 0.006  | 0.011  | 24.682  |
| 19# | 0.034  | 0.325  | / | 0.177  | 0.138  | 25.725  |
| NCS203036 | 0.090 | 1.480 | 0.0078 | 0.0087 | 0.045 | 30.82 |
| 9-200 | 0.473  | 1.261  | 0.0009  | 0.026  | 0.036  | 33.203  |
| NCS203035 | 0.046 | 0.56 | 0.032 | 0.019 | 0.023 | 20.85 |
| 539 | 0.086  | 0.275  | 0.026  | 0.060  | （0.080） | 18.798  |
| **曲线范围** | **0.010-0.473** | **0.017-1.480** | **0.0009-0.064** | **0.004-0.177** | **0.009-0.138** | **16.890-33.203** |
| **产品标准** | **<=0.05** | **<=0.3** | **<=0.1** | **<=0.1** | **<=0.05** | **18.0-32.0** |

1. 仪器设备
2. 钢研纳克HSRE 1000型稀土金属快速分析仪
3. 仪器主要工作条件：实验采用一次积分，充气、预燃、积分各阶段具体参数见表2。静止流量0.07L/min，分析流量9L/min。实验过程中选用的分析线对见表3. 分析线对选择主要考虑谱线干扰、曲线线性和测试结果精密度几个因素，选择干扰较少，拟合曲线相关系数接近于1且测试结果相对标准偏差较小的分析线对。。

表2实验条件选择

|  |  |  |  |
| --- | --- | --- | --- |
| 实验阶段 | 时间/s | 频率/Hz | 电压/V |
| 吹扫 | 10 | / | / |
| 预燃 | 10 | 500 | 380 |
| 燃烧 | 8 | 500 | 190 |

表3 实验选用的分析线对

|  |  |  |
| --- | --- | --- |
| 元素 | 分析谱线/nm | Nd参比谱线/nm |
| C | 193.09 | 193.5 |
| Fe | 239.4 | 242.9 |
| Mo | 281.6 | 275.8 |
| Al | 396.2 | 395.4 |
| Si | 288.1 | 289.2 |
| Pr | 405.6 | 406.0 |

1. 绘制工作曲线

用BD4800砂带机和40目砂带制样，将样品一个面打磨至表面平整且有方向一致的清晰纹路。磨好的表面不要用手触摸或用其他物品擦拭，直接放在激发台上激发。在选定的实验条件下激发表2所列样品，每个样品激发4个点，以各元素分析线强度与参比线强度比值（相对强度）为横坐标，以各元素含量与Nd基体含量比值（相对含量）为纵坐标，绘制各元素校准曲线。由于火花发射光谱法为持久曲线法，为便于后期使用绘制的曲线分析样品，为每个元素选取接近于曲线上限和曲线下限附近的样品作为强度校正样品。本方法选取9-200、PNMo-8、503、9#等4块样品作为各元素的标准化样品（高低标），其参考含量见表4。

表4 各元素标准化样品（高低标参考含量）

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 名称 | C | Fe | Mo | Al  | Si  | Pr |
| 9# | 0.011  | 0.090  | / | 0.021  | 0.018  | 16.890  |
| 503 | 0.016  | 0.204  | 0.006  | 0.067  | 0.075  | 23.485  |
| PNMo-8 | 0.021  | 0.146  | 0.061  | 0.015  | 0.018  | 23.725  |
| 9-200 | 0.473  | 1.261  | 0.0009  | 0.026  | 0.036  | 33.203  |

1. 制样方法条件实验

分别考察了砂带机磨样和铣床制样两种制样方式对测试结果精密度的影响。

1. 砂带机磨样

采用BD4800型砂带机制样，将样品一个面打磨至表面平整且有方向一致的清晰纹路。磨好的表面不要用手触摸或用其他物品擦拭，直接放在激发台上激发。选取均匀度较好的PNMo-8和NCS203036两块样品，每个样品分别用40目、60目、80目砂带打磨样品，然后用绘制好的曲线对同一样品激发11次（两次激发之间刷电极和更换样品激发位置）。为减少偶然因素影响，每块样品用不同粒度砂纸打磨后各保留2组数据（每组10个激发点），取各元素两组数据相对标准偏差（RSD）的平均值作为衡量标准。2块样品测试数据原始值列于附录1（附表1.1-1.12）中。统计不同砂纸粒度下，RSD平均值最小值出现最多次的砂带粒度作为后续实验所用，表5、6为测试结果统计值，表中用灰色底纹标注了各元素RSD最小的数据。从表5、6可以看出，40目、60目、80目砂带制样时RSD相差不大，可见砂带粒度在40-80目之间，测试结果无显著差异，因此推荐采用40-80目砂带制样。

表5砂带制样测得的PNMo-8样品结果统计值

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 砂带粒度 | 统计结果 | C | Fe | Mo | Al | Si | Pr |
| 含量参考值 | 0.021 | 0.146 | 0.061 | 0.015 | 0.018 | 23.725 |
| 40# | 第一次RSD% | 3.449 | 3.557 | 3.766 | 2.934 | 2.452 | 0.326 |
| 第二次RSD% | 2.824 | 2.839 | 2.388 | 2.934 | 2.703 | 0.242 |
| **RSD%平均值** | 3.1365 | 3.198 | 3.077 | 2.934 | 2.5775 | 0.284 |
| 60# | 第一次RSD% | 3.865 | 1.198 | 2.556 | 1.767 | 2.452 | 0.166 |
| 第二次RSD% | 2.983 | 2.381 | 4.92 | 1.767 | 2.129 | 0.266 |
| **RSD%平均值** | 3.424 | 1.7895 | 3.738 | 1.767 | 2.2905 | 0.216 |
| 80# | 第一次RSD% | 6.086 | 2.782 | 3.314 | 4.536 | 2.452 | 0.143 |
| 第二次RSD% | 2.503 | 1.574 | 4.202 | 5.184 | 2.635 | 0.2 |
| **RSD%平均值** | 4.2945 | 2.178 | 3.758 | 4.86 | 2.5435 | 0.1715 |

表6砂带制样测得的NCS203036样品结果统计值

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 砂带粒度 | 统计结果 | C | Fe | Mo | Al | Si | Pr |
| 含量参考值 | 0.09 | 1.48 | 0.0078 | 0.0087 | 0.045 | 30.82 |
| 40# | 第一次RSD% | 3.567 | 2.674 | 6.723 | 3.31 | 1.142 | 0.16 |
| 第二次RSD% | 3.048 | 1.04 | 5.019 | 1.989 | 0.999 | 0.253 |
| **RSD%平均值** | 3.3075 | 1.857 | 5.871 | 2.6495 | 1.0705 | 0.2065 |
| 60# | 第一次RSD% | 3.444 | 1.673 | 4.872 | 7.713 | 0.755 | 0.151 |
| 第二次RSD% | 3.101 | 3.185 | 8.571 | 1.964 | 1.355 | 0.302 |
| **RSD%平均值** | 3.2725 | 2.429 | 6.7215 | 4.8385 | 1.055 | 0.2265 |
| 80# | 第一次RSD% | 3.265 | 1.561 | 4.514 | 0 | 1.122 | 0.223 |
| 第二次RSD% | 3.082 | 1.201 | 4.514 | 0 | 0.751 | 0.27 |
| **RSD%平均值** | 3.1735 | 1.381 | 4.514 | 0 | 0.9365 | 0.2465 |

1. 铣床制样

采用小型铣床制样，将样品一个面加工至表面平整且有方向一致的清晰纹路。制好的表面不要用手触摸或用其他物品擦拭，直接放在激发台上激发。选取均匀度较好的PNMo-8和NCS203036两个样品，固定铣刀进给速度为60mm/min，对比转速分别为90r/min、187r/min、270r/min时样品测试结果精密度差异，2块样品测试数据原始值列于附录1（附表1.13-1.24）中。统计不同转速下，RSD平均值最小值出现最多次的铣刀转速作为后续实验所用，表7、8为测试结果统计值，表中用灰色底纹标注了各元素RSD最小的数据。从表7、8可以看出，铣床转速90、187、270时RSD最低的元素分别有5个、2个和5个，可见在进给速度保持不变情况下，提高铣床转速有利于提高测试结果精密度，因此推荐采用的铣床制样参数为：进给速度60 mm/min，铣床转速270r/min。

表7 不同铣床转速制样测得的PNMo-8样品结果统计值

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 铣床转速r/min | 统计结果 | C | Fe | Mo | Al | Si | Pr |
| 含量参考值 | 0.021 | 0.146 | 0.061 | 0.015 | 0.018 | 23.725 |
| 90 | 第一次RSD% | 4.53 | 2.158 | 6.171 | 4.72 | 2.729 | 0.26 |
| 第二次RSD% | 8.57 | 4.415 | 9.234 | 6.659 | 3.813 | 0.753 |
| **RSD%平均值** | 6.55 | 3.2865 | 7.7025 | 5.6895 | 3.271 | 0.5065 |
| 187 | 第一次RSD% | 7.154 | 4.119 | 12.872 | 11.834 | 2.934 | 1.136 |
| 第二次RSD% | 9.528 | 3.395 | 12.662 | 6.659 | 1.767 | 0.644 |
| **RSD%平均值** | 8.341 | 3.757 | 12.767 | 9.2465 | 2.3505 | 0.89 |
| 270 | 第一次RSD% | 11.379 | 3.159 | 11.422 | 7.995 | 2.729 | 0.601 |
| 第二次RSD% | 8.681 | 4.382 | 9.859 | 5.861 | 3.012 | 0.653 |
| **RSD%平均值** | 10.03 | 3.7705 | 10.6405 | 6.928 | 2.8705 | 0.627 |

表8 不同铣床转速制样测得的NCS203036样品结果统计值

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 铣床转速r/min | 统计结果 | C | Fe | Mo | Al | Si | Pr |
| 含量参考值 | 0.09 | 1.48 | 0.0078 | 0.0087 | 0.045 | 30.82 |
| 90 | 第一次RSD% | 5.339 | 2.59 | 7.803 | 3.903 | 1.545 | 0.4 |
| 第二次RSD% | 4.36 | 2.853 | 11.736 | 4.129 | 1.209 | 0.549 |
| **RSD%平均值** | 4.8495 | 2.7215 | 9.7695 | 4.016 | 1.377 | 0.4745 |
| 187 | 第一次RSD% | 4.21 | 3.236 | 9.368 | 4.704 | 1.206 | 0.461 |
| 第二次RSD% | 5.704 | 4.332 | 12.472 | 5.128 | 0.813 | 0.657 |
| **RSD%平均值** | 4.957 | 3.784 | 10.92 | 4.916 | 1.0095 | 0.559 |
| 270 | 第一次RSD% | 3.437 | 1.674 | 9.428 | 3.804 | 1.369 | 0.371 |
| 第二次RSD% | 4.475 | 3.028 | 7.306 | 3.804 | 1.459 | 0.277 |
| **RSD%平均值** | 3.956 | 2.351 | 8.367 | 3.804 | 1.414 | 0.324 |

1. 精密度实验结果

选取9#，503，PNMo-8，PNMo-9，19#，502，539，2-1，9-200九块样品作为精密度实验样品，依次编号为样品1~样品9。用表4中选取的标准化样品对绘制好的曲线进行全局校正后，用绘制的校准曲线分别对9个样品进行11次独立测定，结果如表9~17所示。测试结果中C、Fe、Mo、Al、Si保留至小数点后4位，Pr保留至小数点后3位，相对标准偏差RSD保留至小数点后2位，数值修约按照GB/T 8170的规定执行。

表9 9# 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0093  | 0.0792  | 0.0005  | 0.0167  | 0.0191  | 17.186  |
| 2 | 0.0096  | 0.0807  | 0.0023  | 0.0171  | 0.0190  | 17.151  |
| 3 | 0.0094  | 0.0800  | 0.0017  | 0.0173  | 0.0189  | 17.209  |
| 4 | 0.0089  | 0.0790  | 0.0018  | 0.0174  | 0.0194  | 17.285  |
| 5 | 0.0103  | 0.0809  | 0.0016  | 0.0173  | 0.0193  | 17.216  |
| 6 | 0.0091  | 0.0778  | 0.0019  | 0.0177  | 0.0191  | 17.250  |
| 7 | 0.0100  | 0.0778  | 0.0015  | 0.0177  | 0.0191  | 17.194  |
| 8 | 0.0098  | 0.0799  | 0.0020  | 0.0177  | 0.0189  | 17.221  |
| 9 | 0.0099  | 0.0807  | 0.0015  | 0.0175  | 0.0193  | 17.227  |
| 10 | 0.0091  | 0.0809  | 0.0010  | 0.0173  | 0.0191  | 17.169  |
| 11 | 0.0091  | 0.0773  | 0.0017  | 0.0173  | 0.0192  | 17.180  |
| 平均值 | 0.0095 | 0.0795 | 0.0016 | 0.0174 | 0.0191 | 17.208 |
| SD | 0.0005 | 0.0013 | 0.0005 | 0.0003 | 0.0002 | 0.0381 |
| RSD | 4.75  | 1.70  | 30.72  | 1.71  | 0.85  | 0.22  |

表10 539 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0878  | 0.2399  | 0.0247  | 0.0511  | 0.0626  | 18.774  |
| 2 | 0.0873  | 0.2390  | 0.0255  | 0.0511  | 0.0633  | 18.750  |
| 3 | 0.0882  | 0.2406  | 0.0250  | 0.0510  | 0.0631  | 18.905  |
| 4 | 0.0879  | 0.2398  | 0.0259  | 0.0516  | 0.0619  | 18.852  |
| 5 | 0.0888  | 0.2396  | 0.0271  | 0.0513  | 0.0634  | 18.843  |
| 6 | 0.0877  | 0.2429  | 0.0255  | 0.0519  | 0.0630  | 18.760  |
| 7 | 0.0887  | 0.2388  | 0.0253  | 0.0515  | 0.0630  | 18.869  |
| 8 | 0.0882  | 0.2315  | 0.0248  | 0.0515  | 0.0616  | 18.885  |
| 9 | 0.0886  | 0.2402  | 0.0264  | 0.0517  | 0.0627  | 18.840  |
| 10 | 0.0895  | 0.2349  | 0.0257  | 0.0513  | 0.0633  | 18.821  |
| 11 | 0.0859  | 0.2428  | 0.0271  | 0.0520  | 0.0630  | 18.808  |
| 平均值 | 0.0880  | 0.2391  | 0.0257  | 0.0514  | 0.0628  | 18.828  |
| SD | 0.0009  | 0.0033  | 0.0008  | 0.0003  | 0.0006  | 0.0507  |
| RSD | 1.07  | 1.38  | 3.25  | 0.64  | 0.92  | 0.27  |

表11 2-1 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.1506  | 1.0429  | 0.0023  | 0.0063  | 0.0237  | 20.219  |
| 2 | 0.1516  | 1.0464  | 0.0023  | 0.0062  | 0.0236  | 20.280  |
| 3 | 0.1520  | 1.0352  | 0.0015  | 0.0062  | 0.0235  | 20.290  |
| 4 | 0.1520  | 1.0651  | 0.0023  | 0.0061  | 0.0232  | 20.225  |
| 5 | 0.1511  | 1.0497  | 0.0023  | 0.0062  | 0.0235  | 20.342  |
| 6 | 0.1533  | 1.0538  | 0.0025  | 0.0063  | 0.0238  | 20.336  |
| 7 | 0.1528  | 1.0704  | 0.0021  | 0.0061  | 0.0239  | 20.233  |
| 8 | 0.1516  | 1.0504  | 0.0026  | 0.0064  | 0.0235  | 20.424  |
| 9 | 0.1525  | 1.0637  | 0.0026  | 0.0063  | 0.0234  | 20.136  |
| 10 | 0.1536  | 1.0756  | 0.0019  | 0.0062  | 0.0235  | 20.142  |
| 11 | 0.1513  | 1.0598  | 0.0023  | 0.0056  | 0.0235  | 20.098  |
| 平均值 | 0.1520  | 1.0557  | 0.0023  | 0.0062  | 0.0236  | 20.248  |
| SD | 0.0009  | 0.0123  | 0.0003  | 0.0002  | 0.0002  | 0.0991  |
| RSD | 0.61  | 1.17  | 14.27  | 3.41  | 0.81  | 0.49  |

表12 502 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0335  | 0.3017  | 0.0155  | 0.0384  | 0.0434  | 24.089  |
| 2 | 0.0334  | 0.2975  | 0.0171  | 0.0386  | 0.0445  | 24.040  |
| 3 | 0.0328  | 0.2961  | 0.0166  | 0.0387  | 0.0439  | 24.206  |
| 4 | 0.0327  | 0.3073  | 0.0175  | 0.0389  | 0.0448  | 24.041  |
| 5 | 0.0325  | 0.3091  | 0.0180  | 0.0386  | 0.0444  | 23.762  |
| 6 | 0.0327  | 0.3017  | 0.0164  | 0.0381  | 0.0438  | 23.848  |
| 7 | 0.0326  | 0.3149  | 0.0171  | 0.0390  | 0.0456  | 23.863  |
| 8 | 0.0326  | 0.3067  | 0.0179  | 0.0389  | 0.0450  | 23.905  |
| 9 | 0.0330  | 0.2972  | 0.0169  | 0.0387  | 0.0442  | 23.961  |
| 10 | 0.0339  | 0.3104  | 0.0172  | 0.0388  | 0.0447  | 23.785  |
| 11 | 0.0336  | 0.3162  | 0.0177  | 0.0392  | 0.0452  | 23.979  |
| 平均值 | 0.0330  | 0.3053  | 0.0171  | 0.0387  | 0.0445  | 23.953  |
| SD | 0.0005  | 0.0070  | 0.0007  | 0.0003  | 0.0007  | 0.1360  |
| RSD | 1.47  | 2.30  | 4.27  | 0.77  | 1.46  | 0.57  |

表13 503 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0144  | 0.1729  | 0.0076  | 0.0672  | 0.0771  | 23.718  |
| 2 | 0.0157  | 0.1705  | 0.0076  | 0.0680  | 0.0779  | 23.828  |
| 3 | 0.0154  | 0.1788  | 0.0075  | 0.0689  | 0.0796  | 23.703  |
| 4 | 0.0157  | 0.1784  | 0.0076  | 0.0690  | 0.0792  | 23.816  |
| 5 | 0.0149  | 0.1758  | 0.0078  | 0.0689  | 0.0779  | 23.683  |
| 6 | 0.0156  | 0.1758  | 0.0079  | 0.0699  | 0.0802  | 23.717  |
| 7 | 0.0146  | 0.1762  | 0.0074  | 0.0691  | 0.0786  | 23.796  |
| 8 | 0.0146  | 0.1767  | 0.0073  | 0.0694  | 0.0797  | 23.789  |
| 9 | 0.0149  | 0.1774  | 0.0082  | 0.0691  | 0.0785  | 23.850  |
| 10 | 0.0149  | 0.1761  | 0.0074  | 0.0688  | 0.0773  | 23.794  |
| 11 | 0.0159  | 0.1732  | 0.0092  | 0.0646  | 0.0771  | 24.187  |
| 平均值 | 0.0152  | 0.1756  | 0.0078  | 0.0684  | 0.0785  | 23.807  |
| SD | 0.0005  | 0.0025  | 0.0005  | 0.0015  | 0.0011  | 0.1376  |
| RSD | 3.49  | 1.42  | 6.93  | 2.13  | 1.40  | 0.58  |

表14 PNMo-8 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0212  | 0.1278  | 0.0694  | 0.0162  | 0.0201  | 23.615  |
| 2 | 0.0210  | 0.1230  | 0.0565  | 0.0164  | 0.0197  | 23.680  |
| 3 | 0.0222  | 0.1246  | 0.0569  | 0.0169  | 0.0199  | 23.749  |
| 4 | 0.0220  | 0.1215  | 0.0563  | 0.0169  | 0.0201  | 23.700  |
| 5 | 0.0228  | 0.1235  | 0.0545  | 0.0168  | 0.0198  | 23.614  |
| 6 | 0.0215  | 0.1267  | 0.0576  | 0.0173  | 0.0201  | 23.705  |
| 7 | 0.0213  | 0.1240  | 0.0566  | 0.0170  | 0.0200  | 23.656  |
| 8 | 0.0211  | 0.1217  | 0.0575  | 0.0172  | 0.0197  | 23.633  |
| 9 | 0.0211  | 0.1228  | 0.0552  | 0.0171  | 0.0199  | 23.651  |
| 10 | 0.0213  | 0.1244  | 0.0564  | 0.0172  | 0.0197  | 23.657  |
| 11 | 0.0215  | 0.1233  | 0.0573  | 0.0170  | 0.0202  | 23.660  |
| 平均值 | 0.0215  | 0.1239  | 0.0576  | 0.0169  | 0.0199  | 23.665  |
| SD | 0.0006  | 0.0019  | 0.0040  | 0.0003  | 0.0002  | 0.0407  |
| RSD | 2.60  | 1.55  | 6.95  | 2.00  | 0.93  | 0.17  |

表15 PNMo-9 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0229  | 0.2723  | 0.0609  | 0.0313  | 0.0362  | 24.104  |
| 2 | 0.0227  | 0.2622  | 0.0612  | 0.0312  | 0.0355  | 24.104  |
| 3 | 0.0225  | 0.2609  | 0.0595  | 0.0312  | 0.0346  | 24.117  |
| 4 | 0.0228  | 0.2689  | 0.0824  | 0.0310  | 0.0351  | 24.086  |
| 5 | 0.0220  | 0.2624  | 0.0611  | 0.0313  | 0.0350  | 24.086  |
| 6 | 0.0232  | 0.2789  | 0.0583  | 0.0316  | 0.0362  | 24.153  |
| 7 | 0.0234  | 0.2631  | 0.0580  | 0.0317  | 0.0361  | 24.125  |
| 8 | 0.0236  | 0.2656  | 0.0630  | 0.0316  | 0.0358  | 24.014  |
| 9 | 0.0237  | 0.2698  | 0.0560  | 0.0316  | 0.0356  | 24.162  |
| 10 | 0.0240  | 0.2635  | 0.0607  | 0.0316  | 0.0358  | 24.066  |
| 11 | 0.0230  | 0.2647  | 0.0586  | 0.0316  | 0.0352  | 23.950  |
| 平均值 | 0.0231  | 0.2666  | 0.0618  | 0.0314  | 0.0356  | 24.088  |
| SD | 0.0006  | 0.0054  | 0.0071  | 0.0002  | 0.0005  | 0.061  |
| RSD | 2.52  | 2.04  | 11.50  | 0.74  | 1.49  | 0.25  |

表16 19# 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.0400  | 0.2925  | 0.0019  | 0.1773  | 0.1374  | 25.528  |
| 2 | 0.0416  | 0.2903  | 0.0016  | 0.1797  | 0.1364  | 25.493  |
| 3 | 0.0416  | 0.2930  | 0.0021  | 0.1783  | 0.1376  | 25.549  |
| 4 | 0.0409  | 0.2980  | 0.0025  | 0.1808  | 0.1415  | 25.491  |
| 5 | 0.0404  | 0.3015  | 0.0021  | 0.1803  | 0.1384  | 25.601  |
| 6 | 0.0400  | 0.2981  | 0.0017  | 0.1800  | 0.1379  | 25.532  |
| 7 | 0.0409  | 0.3097  | 0.0013  | 0.1825  | 0.1403  | 25.521  |
| 8 | 0.0449  | 0.2957  | 0.0023  | 0.1801  | 0.1386  | 25.443  |
| 9 | 0.0409  | 0.2966  | 0.0015  | 0.1806  | 0.1394  | 25.696  |
| 10 | 0.0402  | 0.2943  | 0.0018  | 0.1805  | 0.1391  | 25.474  |
| 11 | 0.0411  | 0.2944  | 0.0021  | 0.1797  | 0.1372  | 25.505  |
| 平均值 | 0.0411  | 0.2967  | 0.0019  | 0.1800  | 0.1385  | 25.530  |
| SD | 0.0014  | 0.0053  | 0.0004  | 0.0013  | 0.0015  | 0.0686  |
| RSD | 3.33  | 1.78  | 18.98  | 0.74  | 1.07  | 0.27  |

表17 9-200 精密度实验结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 测试次数 | C | Fe | Mo | Al | Si | Pr |
| 1 | 0.4688  | 1.2477  | 0.0027  | 0.0351  | 0.0344  | 33.378  |
| 2 | 0.4706  | 1.2716  | 0.0037  | 0.0356  | 0.0345  | 33.392  |
| 3 | 0.4723  | 1.2451  | 0.0025  | 0.0354  | 0.0350  | 33.231  |
| 4 | 0.4721  | 1.2702  | 0.0035  | 0.0354  | 0.0348  | 33.339  |
| 5 | 0.4706  | 1.2703  | 0.0027  | 0.0355  | 0.0346  | 33.438  |
| 6 | 0.4731  | 1.2672  | 0.0034  | 0.0356  | 0.0349  | 33.188  |
| 7 | 0.4711  | 1.2459  | 0.0038  | 0.0356  | 0.0347  | 33.327  |
| 8 | 0.4702  | 1.2765  | 0.0038  | 0.0359  | 0.0344  | 33.216  |
| 9 | 0.4675  | 1.2678  | 0.0032  | 0.0357  | 0.0344  | 33.333  |
| 10 | 0.4654  | 1.2804  | 0.0032  | 0.0358  | 0.0348  | 33.119  |
| 11 | 0.4698  | 1.2622  | 0.0040  | 0.0351  | 0.0348  | 33.335  |
| 平均值 | 0.4701  | 1.2641  | 0.0033  | 0.0355  | 0.0347  | 33.300  |
| SD | 0.0022  | 0.0124  | 0.0005  | 0.0003  | 0.0002  | 0.0976  |
| RSD | 0.48  | 0.98  | 15.30  | 0.72  | 0.62  | 0.29  |

**附录1：不同制样方式精密度原始数据**

附表1.1 PNMo-8样品40目砂带磨样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.021 | 0.124 | 0.062 | 0.018 | 0.02 | 24.034 | 75.722 |
| **SD** | 0.001 | 0.004 | 0.002 | 0.001 | 0 | 0.078 | 0.075 |
| **RSD** | 3.449 | 3.557 | 3.766 | 2.934 | 2.452 | 0.326 | 0.099 |
| 1 | 0.021 | 0.121 | 0.063 | 0.017 | 0.02 | 24.142 | 75.617 |
| 2 | 0.02 | 0.117 | 0.061 | 0.017 | 0.02 | 24.075 | 75.69 |
| 3 | 0.02 | 0.122 | 0.058 | 0.017 | 0.02 | 24.041 | 75.722 |
| 4 | 0.022 | 0.128 | 0.064 | 0.018 | 0.02 | 23.839 | 75.909 |
| 5 | 0.02 | 0.124 | 0.066 | 0.018 | 0.019 | 24.062 | 75.691 |
| 6 | 0.02 | 0.123 | 0.06 | 0.018 | 0.019 | 24.017 | 75.744 |
| 7 | 0.02 | 0.128 | 0.06 | 0.018 | 0.02 | 24.022 | 75.732 |
| 8 | 0.021 | 0.128 | 0.061 | 0.017 | 0.02 | 24.06 | 75.692 |
| 9 | 0.02 | 0.122 | 0.063 | 0.018 | 0.019 | 24.069 | 75.689 |
| 10 | 0.021 | 0.132 | 0.063 | 0.018 | 0.02 | 24.009 | 75.739 |

附表1.2 PNMo-8样品40目砂带磨样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.02 | 0.122 | 0.062 | 0.018 | 0.02 | 24.08 | 75.68 |
| **SD** | 0.001 | 0.003 | 0.001 | 0.001 | 0.001 | 0.058 | 0.06 |
| **RSD** | 2.824 | 2.839 | 2.388 | 2.934 | 2.703 | 0.242 | 0.08 |
| 1 | 0.019 | 0.126 | 0.064 | 0.018 | 0.02 | 24.105 | 75.648 |
| 2 | 0.02 | 0.12 | 0.06 | 0.018 | 0.02 | 24.111 | 75.653 |
| 3 | 0.02 | 0.126 | 0.062 | 0.018 | 0.02 | 24.118 | 75.637 |
| 4 | 0.021 | 0.127 | 0.062 | 0.017 | 0.02 | 24.048 | 75.705 |
| 5 | 0.02 | 0.12 | 0.062 | 0.018 | 0.02 | 24.08 | 75.68 |
| 6 | 0.02 | 0.117 | 0.059 | 0.017 | 0.019 | 23.938 | 75.83 |
| 7 | 0.02 | 0.121 | 0.063 | 0.018 | 0.019 | 24.059 | 75.7 |
| 8 | 0.02 | 0.122 | 0.061 | 0.017 | 0.019 | 24.074 | 75.686 |
| 9 | 0.02 | 0.121 | 0.063 | 0.017 | 0.019 | 24.113 | 75.646 |
| 10 | 0.021 | 0.118 | 0.062 | 0.018 | 0.019 | 24.15 | 75.612 |

附表1.3 PNMo-8样品60目砂带磨样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.021 | 0.123 | 0.061 | 0.018 | 0.02 | 24.097 | 75.659 |
| **SD** | 0.001 | 0.001 | 0.002 | 0 | 0 | 0.04 | 0.039 |
| **RSD** | 3.865 | 1.198 | 2.556 | 1.767 | 2.452 | 0.166 | 0.052 |
| 1 | 0.022 | 0.12 | 0.062 | 0.017 | 0.02 | 24.097 | 75.663 |
| 2 | 0.021 | 0.123 | 0.064 | 0.018 | 0.02 | 24.097 | 75.657 |
| 3 | 0.022 | 0.122 | 0.063 | 0.018 | 0.019 | 24.127 | 75.629 |
| 4 | 0.021 | 0.123 | 0.061 | 0.018 | 0.019 | 24.113 | 75.645 |
| 5 | 0.021 | 0.123 | 0.061 | 0.018 | 0.02 | 24.093 | 75.665 |
| 6 | 0.021 | 0.125 | 0.059 | 0.018 | 0.02 | 24.157 | 75.601 |
| 7 | 0.02 | 0.125 | 0.062 | 0.018 | 0.02 | 24.007 | 75.748 |
| 8 | 0.023 | 0.124 | 0.061 | 0.018 | 0.02 | 24.085 | 75.669 |
| 9 | 0.021 | 0.123 | 0.061 | 0.018 | 0.02 | 24.073 | 75.684 |
| 10 | 0.021 | 0.124 | 0.059 | 0.018 | 0.019 | 24.125 | 75.633 |

附表1.4 PNMo-8样品60目砂带磨样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.021 | 0.124 | 0.061 | 0.018 | 0.02 | 24.099 | 75.658 |
| **SD** | 0.001 | 0.003 | 0.003 | 0 | 0 | 0.064 | 0.066 |
| **RSD** | 2.983 | 2.381 | 4.92 | 1.767 | 2.129 | 0.266 | 0.087 |
| 1 | 0.021 | 0.128 | 0.065 | 0.018 | 0.02 | 24.081 | 75.667 |
| 2 | 0.021 | 0.122 | 0.064 | 0.018 | 0.02 | 24.099 | 75.657 |
| 3 | 0.02 | 0.126 | 0.062 | 0.018 | 0.019 | 24.037 | 75.717 |
| 4 | 0.021 | 0.122 | 0.059 | 0.018 | 0.02 | 24.032 | 75.728 |
| 5 | 0.021 | 0.122 | 0.056 | 0.018 | 0.02 | 24.073 | 75.69 |
| 6 | 0.021 | 0.125 | 0.061 | 0.018 | 0.019 | 24.205 | 75.551 |
| 7 | 0.022 | 0.127 | 0.065 | 0.018 | 0.02 | 24.193 | 75.555 |
| 8 | 0.022 | 0.124 | 0.058 | 0.017 | 0.02 | 24.081 | 75.678 |
| 9 | 0.021 | 0.123 | 0.06 | 0.018 | 0.02 | 24.033 | 75.726 |
| 10 | 0.022 | 0.118 | 0.062 | 0.018 | 0.02 | 24.153 | 75.607 |

附表1.5 PNMo-8样品80目砂带磨样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.02 | 0.124 | 0.061 | 0.018 | 0.02 | 24.205 | 75.553 |
| **SD** | 0.001 | 0.003 | 0.002 | 0.001 | 0 | 0.035 | 0.035 |
| **RSD** | 6.086 | 2.782 | 3.314 | 4.536 | 2.452 | 0.143 | 0.047 |
| 1 | 0.023 | 0.128 | 0.058 | 0.017 | 0.02 | 24.256 | 75.498 |
| 2 | 0.02 | 0.125 | 0.059 | 0.018 | 0.02 | 24.234 | 75.524 |
| 3 | 0.019 | 0.125 | 0.06 | 0.018 | 0.02 | 24.196 | 75.562 |
| 4 | 0.02 | 0.118 | 0.063 | 0.018 | 0.02 | 24.214 | 75.548 |
| 5 | 0.02 | 0.124 | 0.061 | 0.018 | 0.019 | 24.234 | 75.524 |
| 6 | 0.02 | 0.127 | 0.065 | 0.02 | 0.02 | 24.162 | 75.586 |
| 7 | 0.021 | 0.118 | 0.062 | 0.017 | 0.019 | 24.149 | 75.614 |
| 8 | 0.019 | 0.123 | 0.061 | 0.018 | 0.02 | 24.217 | 75.542 |
| 9 | 0.019 | 0.122 | 0.06 | 0.018 | 0.019 | 24.171 | 75.59 |
| 10 | 0.021 | 0.126 | 0.062 | 0.018 | 0.02 | 24.212 | 75.542 |

附表1.6 PNMo-8样品80目砂带磨样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.019 | 0.124 | 0.062 | 0.018 | 0.02 | 24.173 | 75.584 |
| **SD** | 0 | 0.002 | 0.003 | 0.001 | 0.001 | 0.048 | 0.049 |
| **RSD** | 2.503 | 1.574 | 4.202 | 5.184 | 2.635 | 0.2 | 0.065 |
| 1 | 0.02 | 0.128 | 0.06 | 0.018 | 0.02 | 24.249 | 75.505 |
| 2 | 0.019 | 0.123 | 0.058 | 0.018 | 0.02 | 24.173 | 75.59 |
| 3 | 0.02 | 0.124 | 0.06 | 0.018 | 0.02 | 24.193 | 75.565 |
| 4 | 0.019 | 0.122 | 0.06 | 0.018 | 0.02 | 24.129 | 75.633 |
| 5 | 0.019 | 0.124 | 0.067 | 0.018 | 0.019 | 24.159 | 75.594 |
| 6 | 0.019 | 0.125 | 0.064 | 0.018 | 0.02 | 24.074 | 75.681 |
| 7 | 0.019 | 0.124 | 0.064 | 0.018 | 0.019 | 24.185 | 75.57 |
| 8 | 0.02 | 0.122 | 0.062 | 0.021 | 0.019 | 24.225 | 75.529 |
| 9 | 0.019 | 0.124 | 0.062 | 0.018 | 0.02 | 24.18 | 75.578 |
| 10 | 0.019 | 0.121 | 0.062 | 0.018 | 0.019 | 24.168 | 75.592 |

附表1.7 NCS203036样品40目砂带磨样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.087 | 1.601 | 0.01 | 0.016 | 0.042 | 30.503 | 67.74 |
| **SD** | 0.003 | 0.043 | 0.001 | 0.001 | 0 | 0.049 | 0.08 |
| **RSD** | 3.567 | 2.674 | 6.723 | 3.31 | 1.142 | 0.16 | 0.118 |
| 1 | 0.087 | 1.625 | 0.01 | 0.016 | 0.042 | 30.552 | 67.667 |
| 2 | 0.088 | 1.579 | 0.01 | 0.015 | 0.042 | 30.502 | 67.764 |
| 3 | 0.083 | 1.59 | 0.011 | 0.016 | 0.043 | 30.441 | 67.816 |
| 4 | 0.085 | 1.553 | 0.011 | 0.016 | 0.042 | 30.415 | 67.877 |
| 5 | 0.087 | 1.568 | 0.011 | 0.016 | 0.042 | 30.49 | 67.786 |
| 6 | 0.082 | 1.594 | 0.011 | 0.016 | 0.042 | 30.511 | 67.744 |
| 7 | 0.089 | 1.621 | 0.01 | 0.015 | 0.042 | 30.503 | 67.719 |
| 8 | 0.093 | 1.688 | 0.009 | 0.015 | 0.043 | 30.508 | 67.644 |
| 9 | 0.086 | 1.641 | 0.01 | 0.015 | 0.043 | 30.584 | 67.621 |
| 10 | 0.087 | 1.553 | 0.011 | 0.016 | 0.042 | 30.526 | 67.766 |

附表1.8 NCS203036样品40目砂带磨样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.086 | 1.58 | 0.01 | 0.016 | 0.042 | 30.484 | 67.781 |
| **SD** | 0.003 | 0.016 | 0.001 | 0 | 0 | 0.077 | 0.07 |
| **RSD** | 3.048 | 1.04 | 5.019 | 1.989 | 0.999 | 0.253 | 0.104 |
| 1 | 0.084 | 1.55 | 0.01 | 0.015 | 0.042 | 30.579 | 67.72 |
| 2 | 0.087 | 1.573 | 0.011 | 0.016 | 0.042 | 30.545 | 67.727 |
| 3 | 0.09 | 1.569 | 0.011 | 0.016 | 0.042 | 30.543 | 67.728 |
| 4 | 0.081 | 1.569 | 0.01 | 0.016 | 0.042 | 30.452 | 67.829 |
| 5 | 0.088 | 1.568 | 0.011 | 0.016 | 0.043 | 30.387 | 67.887 |
| 6 | 0.086 | 1.593 | 0.01 | 0.016 | 0.042 | 30.442 | 67.811 |
| 7 | 0.088 | 1.592 | 0.011 | 0.016 | 0.042 | 30.447 | 67.804 |
| 8 | 0.089 | 1.604 | 0.01 | 0.016 | 0.043 | 30.372 | 67.867 |
| 9 | 0.085 | 1.588 | 0.01 | 0.016 | 0.042 | 30.59 | 67.669 |
| 10 | 0.086 | 1.592 | 0.011 | 0.016 | 0.042 | 30.486 | 67.766 |

附表1.9 NCS203036样品60目砂带磨样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.085 | 1.568 | 0.011 | 0.016 | 0.042 | 30.673 | 67.606 |
| **SD** | 0.003 | 0.026 | 0.001 | 0.001 | 0 | 0.046 | 0.051 |
| **RSD** | 3.444 | 1.673 | 4.872 | 7.713 | 0.755 | 0.151 | 0.076 |
| 1 | 0.085 | 1.54 | 0.011 | 0.016 | 0.041 | 30.671 | 67.636 |
| 2 | 0.081 | 1.546 | 0.011 | 0.016 | 0.042 | 30.673 | 67.632 |
| 3 | 0.084 | 1.567 | 0.011 | 0.016 | 0.042 | 30.711 | 67.57 |
| 4 | 0.085 | 1.59 | 0.01 | 0.016 | 0.042 | 30.586 | 67.67 |
| 5 | 0.082 | 1.553 | 0.011 | 0.016 | 0.042 | 30.716 | 67.58 |
| 6 | 0.088 | 1.563 | 0.01 | 0.016 | 0.042 | 30.73 | 67.552 |
| 7 | 0.08 | 1.54 | 0.011 | 0.016 | 0.042 | 30.65 | 67.66 |
| 8 | 0.086 | 1.59 | 0.01 | 0.016 | 0.042 | 30.699 | 67.558 |
| 9 | 0.089 | 1.622 | 0.01 | 0.016 | 0.042 | 30.68 | 67.541 |
| 10 | 0.086 | 1.566 | 0.011 | 0.02 | 0.042 | 30.61 | 67.665 |

附表1.10 NCS203036样品60目砂带磨样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.085 | 1.573 | 0.011 | 0.016 | 0.042 | 30.644 | 67.629 |
| **SD** | 0.003 | 0.05 | 0.001 | 0 | 0.001 | 0.093 | 0.122 |
| **RSD** | 3.101 | 3.185 | 8.571 | 1.964 | 1.355 | 0.302 | 0.18 |
| 1 | 0.089 | 1.575 | 0.011 | 0.016 | 0.042 | 30.786 | 67.48 |
| 2 | 0.085 | 1.562 | 0.011 | 0.016 | 0.042 | 30.593 | 67.69 |
| 3 | 0.081 | 1.537 | 0.012 | 0.016 | 0.041 | 30.486 | 67.827 |
| 4 | 0.084 | 1.522 | 0.012 | 0.016 | 0.041 | 30.681 | 67.644 |
| 5 | 0.084 | 1.556 | 0.012 | 0.016 | 0.042 | 30.572 | 67.719 |
| 6 | 0.082 | 1.551 | 0.011 | 0.016 | 0.042 | 30.638 | 67.659 |
| 7 | 0.085 | 1.566 | 0.011 | 0.016 | 0.042 | 30.719 | 67.561 |
| 8 | 0.089 | 1.678 | 0.009 | 0.017 | 0.043 | 30.631 | 67.533 |
| 9 | 0.085 | 1.645 | 0.01 | 0.016 | 0.042 | 30.758 | 67.444 |
| 10 | 0.083 | 1.534 | 0.011 | 0.016 | 0.042 | 30.579 | 67.735 |

附表1.11 NCS203036样品80目砂带磨样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.084 | 1.576 | 0.011 | 0.016 | 0.042 | 30.733 | 67.538 |
| **SD** | 0.003 | 0.025 | 0 | 0 | 0 | 0.069 | 0.075 |
| **RSD** | 3.265 | 1.561 | 4.514 | 0 | 1.122 | 0.223 | 0.112 |
| 1 | 0.08 | 1.566 | 0.011 | 0.016 | 0.042 | 30.849 | 67.436 |
| 2 | 0.082 | 1.556 | 0.011 | 0.016 | 0.041 | 30.674 | 67.618 |
| 3 | 0.084 | 1.607 | 0.01 | 0.016 | 0.042 | 30.703 | 67.538 |
| 4 | 0.088 | 1.617 | 0.01 | 0.016 | 0.043 | 30.754 | 67.472 |
| 5 | 0.088 | 1.576 | 0.011 | 0.016 | 0.042 | 30.64 | 67.627 |
| 6 | 0.082 | 1.556 | 0.011 | 0.016 | 0.042 | 30.719 | 67.575 |
| 7 | 0.086 | 1.566 | 0.011 | 0.016 | 0.042 | 30.653 | 67.625 |
| 8 | 0.083 | 1.551 | 0.011 | 0.016 | 0.042 | 30.777 | 67.519 |
| 9 | 0.087 | 1.561 | 0.011 | 0.016 | 0.042 | 30.741 | 67.543 |
| 10 | 0.085 | 1.607 | 0.01 | 0.016 | 0.042 | 30.815 | 67.425 |

附表1.12 NCS203036样品80目砂带磨样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.086 | 1.582 | 0.011 | 0.016 | 0.042 | 30.669 | 67.595 |
| **SD** | 0.003 | 0.019 | 0 | 0 | 0 | 0.083 | 0.092 |
| **RSD** | 3.082 | 1.201 | 4.514 | 0 | 0.751 | 0.27 | 0.135 |
| 1 | 0.088 | 1.598 | 0.01 | 0.016 | 0.043 | 30.843 | 67.401 |
| 2 | 0.087 | 1.578 | 0.011 | 0.016 | 0.042 | 30.719 | 67.546 |
| 3 | 0.087 | 1.572 | 0.011 | 0.016 | 0.042 | 30.723 | 67.549 |
| 4 | 0.081 | 1.596 | 0.011 | 0.016 | 0.042 | 30.619 | 67.635 |
| 5 | 0.084 | 1.555 | 0.011 | 0.016 | 0.042 | 30.666 | 67.626 |
| 6 | 0.089 | 1.594 | 0.011 | 0.016 | 0.042 | 30.64 | 67.608 |
| 7 | 0.082 | 1.598 | 0.01 | 0.016 | 0.042 | 30.603 | 67.649 |
| 8 | 0.084 | 1.576 | 0.011 | 0.016 | 0.042 | 30.562 | 67.708 |
| 9 | 0.086 | 1.548 | 0.011 | 0.016 | 0.042 | 30.599 | 67.697 |
| 10 | 0.087 | 1.601 | 0.01 | 0.016 | 0.042 | 30.715 | 67.528 |

附表1.13 PNMo-8样品90r/min铣床制样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.023 | 0.13 | 0.051 | 0.014 | 0.018 | 23.488 | 76.277 |
| **SD** | 0.001 | 0.003 | 0.003 | 0.001 | 0 | 0.061 | 0.061 |
| **RSD** | 4.53 | 2.158 | 6.171 | 4.72 | 2.729 | 0.26 | 0.08 |
| 1 | 0.024 | 0.129 | 0.047 | 0.013 | 0.018 | 23.569 | 76.199 |
| 2 | 0.022 | 0.127 | 0.05 | 0.014 | 0.017 | 23.459 | 76.311 |
| 3 | 0.021 | 0.132 | 0.052 | 0.015 | 0.018 | 23.5 | 76.263 |
| 4 | 0.024 | 0.133 | 0.044 | 0.014 | 0.018 | 23.593 | 76.174 |
| 5 | 0.023 | 0.132 | 0.052 | 0.014 | 0.018 | 23.464 | 76.297 |
| 6 | 0.023 | 0.129 | 0.052 | 0.015 | 0.017 | 23.47 | 76.294 |
| 7 | 0.024 | 0.125 | 0.055 | 0.015 | 0.018 | 23.428 | 76.335 |
| 8 | 0.022 | 0.133 | 0.053 | 0.014 | 0.018 | 23.536 | 76.224 |
| 9 | 0.023 | 0.127 | 0.051 | 0.014 | 0.017 | 23.455 | 76.313 |
| 10 | 0.022 | 0.129 | 0.051 | 0.015 | 0.018 | 23.404 | 76.361 |

附表1.14 PNMo-8样品90r/min铣床制样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.023 | 0.13 | 0.047 | 0.014 | 0.018 | 23.751 | 76.016 |
| **SD** | 0.002 | 0.006 | 0.004 | 0.001 | 0.001 | 0.179 | 0.177 |
| **RSD** | 8.57 | 4.415 | 9.234 | 6.659 | 3.813 | 0.753 | 0.233 |
| 1 | 0.022 | 0.13 | 0.048 | 0.014 | 0.018 | 23.548 | 76.22 |
| 2 | 0.022 | 0.129 | 0.054 | 0.014 | 0.018 | 23.487 | 76.276 |
| 3 | 0.022 | 0.123 | 0.051 | 0.015 | 0.017 | 23.838 | 75.934 |
| 4 | 0.024 | 0.127 | 0.046 | 0.013 | 0.017 | 23.945 | 75.829 |
| 5 | 0.025 | 0.134 | 0.043 | 0.014 | 0.018 | 23.976 | 75.79 |
| 6 | 0.022 | 0.122 | 0.052 | 0.015 | 0.017 | 23.963 | 75.809 |
| 7 | 0.023 | 0.132 | 0.047 | 0.014 | 0.018 | 23.706 | 76.061 |
| 8 | 0.025 | 0.133 | 0.046 | 0.013 | 0.018 | 23.644 | 76.121 |
| 9 | 0.028 | 0.142 | 0.039 | 0.012 | 0.019 | 23.799 | 75.962 |
| 10 | 0.022 | 0.129 | 0.048 | 0.014 | 0.017 | 23.609 | 76.16 |

附表1.15 PNMo-8样品187r/min铣床制样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.025 | 0.131 | 0.054 | 0.014 | 0.018 | 23.23 | 76.528 |
| **SD** | 0.002 | 0.005 | 0.007 | 0.002 | 0.001 | 0.264 | 0.262 |
| **RSD** | 7.154 | 4.119 | 12.872 | 11.834 | 2.934 | 1.136 | 0.343 |
| 1 | 0.027 | 0.139 | 0.045 | 0.013 | 0.018 | 23.455 | 76.304 |
| 2 | 0.021 | 0.126 | 0.06 | 0.015 | 0.017 | 23.224 | 76.536 |
| 3 | 0.024 | 0.133 | 0.053 | 0.013 | 0.018 | 23.282 | 76.477 |
| 4 | 0.024 | 0.134 | 0.044 | 0.012 | 0.018 | 23.392 | 76.375 |
| 5 | 0.026 | 0.133 | 0.047 | 0.013 | 0.018 | 23.515 | 76.248 |
| 6 | 0.025 | 0.125 | 0.058 | 0.017 | 0.018 | 23.018 | 76.739 |
| 7 | 0.024 | 0.127 | 0.059 | 0.016 | 0.017 | 22.863 | 76.893 |
| 8 | 0.024 | 0.129 | 0.063 | 0.016 | 0.017 | 22.855 | 76.896 |
| 9 | 0.025 | 0.125 | 0.058 | 0.016 | 0.017 | 23.105 | 76.655 |
| 10 | 0.027 | 0.139 | 0.049 | 0.014 | 0.018 | 23.591 | 76.161 |

附表1.16 PNMo-8样品187r/min铣床制样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.023 | 0.131 | 0.05 | 0.014 | 0.018 | 23.158 | 76.607 |
| **SD** | 0.002 | 0.004 | 0.006 | 0.001 | 0 | 0.149 | 0.148 |
| **RSD** | 9.528 | 3.395 | 12.662 | 6.659 | 1.767 | 0.644 | 0.194 |
| 1 | 0.023 | 0.126 | 0.053 | 0.014 | 0.018 | 23.115 | 76.652 |
| 2 | 0.024 | 0.134 | 0.049 | 0.014 | 0.018 | 23.248 | 76.513 |
| 3 | 0.023 | 0.135 | 0.048 | 0.013 | 0.018 | 23.255 | 76.508 |
| 4 | 0.021 | 0.125 | 0.055 | 0.015 | 0.017 | 23.063 | 76.704 |
| 5 | 0.023 | 0.131 | 0.045 | 0.013 | 0.018 | 23.236 | 76.534 |
| 6 | 0.021 | 0.129 | 0.057 | 0.014 | 0.018 | 23.04 | 76.722 |
| 7 | 0.021 | 0.127 | 0.058 | 0.015 | 0.018 | 23.041 | 76.72 |
| 8 | 0.022 | 0.13 | 0.047 | 0.014 | 0.018 | 23.258 | 76.512 |
| 9 | 0.028 | 0.139 | 0.037 | 0.012 | 0.018 | 23.416 | 76.35 |
| 10 | 0.021 | 0.128 | 0.053 | 0.014 | 0.018 | 22.91 | 76.856 |

附表1.17 PNMo-8样品270r/min铣床制样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.021 | 0.128 | 0.052 | 0.014 | 0.018 | 23.346 | 76.42 |
| **SD** | 0.002 | 0.004 | 0.006 | 0.001 | 0 | 0.14 | 0.139 |
| **RSD** | 11.379 | 3.159 | 11.422 | 7.995 | 2.729 | 0.601 | 0.182 |
| 1 | 0.023 | 0.132 | 0.043 | 0.012 | 0.018 | 23.485 | 76.287 |
| 2 | 0.026 | 0.133 | 0.043 | 0.013 | 0.018 | 23.597 | 76.17 |
| 3 | 0.022 | 0.133 | 0.048 | 0.013 | 0.018 | 23.523 | 76.243 |
| 4 | 0.02 | 0.122 | 0.052 | 0.015 | 0.017 | 23.28 | 76.493 |
| 5 | 0.02 | 0.13 | 0.057 | 0.014 | 0.018 | 23.256 | 76.504 |
| 6 | 0.019 | 0.124 | 0.058 | 0.015 | 0.017 | 23.276 | 76.489 |
| 7 | 0.018 | 0.124 | 0.056 | 0.015 | 0.018 | 23.185 | 76.585 |
| 8 | 0.02 | 0.126 | 0.054 | 0.015 | 0.018 | 23.298 | 76.47 |
| 9 | 0.019 | 0.126 | 0.06 | 0.015 | 0.017 | 23.213 | 76.548 |
| 10 | 0.022 | 0.129 | 0.053 | 0.015 | 0.018 | 23.348 | 76.415 |

附表1.18 PNMo-8样品270r/min铣床制样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.02 | 0.127 | 0.053 | 0.015 | 0.017 | 23.235 | 76.532 |
| **SD** | 0.002 | 0.006 | 0.005 | 0.001 | 0.001 | 0.152 | 0.153 |
| **RSD** | 8.681 | 4.382 | 9.859 | 5.861 | 3.012 | 0.653 | 0.2 |
| 1 | 0.02 | 0.124 | 0.054 | 0.015 | 0.018 | 23.282 | 76.488 |
| 2 | 0.019 | 0.122 | 0.057 | 0.015 | 0.017 | 23.336 | 76.434 |
| 3 | 0.02 | 0.128 | 0.06 | 0.015 | 0.018 | 23.208 | 76.551 |
| 4 | 0.02 | 0.127 | 0.049 | 0.014 | 0.017 | 23.219 | 76.553 |
| 5 | 0.025 | 0.14 | 0.042 | 0.013 | 0.018 | 23.528 | 76.233 |
| 6 | 0.02 | 0.122 | 0.057 | 0.015 | 0.017 | 23.239 | 76.529 |
| 7 | 0.02 | 0.131 | 0.053 | 0.015 | 0.018 | 23.151 | 76.613 |
| 8 | 0.022 | 0.131 | 0.049 | 0.013 | 0.018 | 23.336 | 76.431 |
| 9 | 0.02 | 0.125 | 0.055 | 0.015 | 0.017 | 23.033 | 76.735 |
| 10 | 0.019 | 0.123 | 0.056 | 0.015 | 0.017 | 23.012 | 76.757 |

附表1.19 NCS203036样品90r/min铣床制样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.095 | 1.682 | 0.008 | 0.012 | 0.039 | 30.683 | 67.481 |
| **SD** | 0.005 | 0.044 | 0.001 | 0 | 0.001 | 0.123 | 0.147 |
| **RSD** | 5.339 | 2.59 | 7.803 | 3.903 | 1.545 | 0.4 | 0.218 |
| 1 | 0.099 | 1.667 | 0.009 | 0.012 | 0.038 | 30.915 | 67.259 |
| 2 | 0.086 | 1.658 | 0.009 | 0.013 | 0.039 | 30.643 | 67.551 |
| 3 | 0.094 | 1.667 | 0.009 | 0.012 | 0.038 | 30.756 | 67.424 |
| 4 | 0.095 | 1.722 | 0.008 | 0.012 | 0.039 | 30.69 | 67.434 |
| 5 | 0.094 | 1.677 | 0.008 | 0.012 | 0.039 | 30.632 | 67.538 |
| 6 | 0.088 | 1.645 | 0.009 | 0.012 | 0.039 | 30.5 | 67.709 |
| 7 | 0.095 | 1.697 | 0.009 | 0.013 | 0.039 | 30.594 | 67.553 |
| 8 | 0.093 | 1.672 | 0.009 | 0.013 | 0.039 | 30.726 | 67.448 |
| 9 | 0.093 | 1.656 | 0.008 | 0.013 | 0.039 | 30.563 | 67.629 |
| 10 | 0.094 | 1.683 | 0.008 | 0.012 | 0.04 | 30.535 | 67.628 |

附表1.20 NCS203036样品90r/min铣床制样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.1 | 1.672 | 0.009 | 0.012 | 0.039 | 30.009 | 68.16 |
| **SD** | 0.004 | 0.048 | 0.001 | 0 | 0 | 0.165 | 0.186 |
| **RSD** | 4.36 | 2.853 | 11.736 | 4.129 | 1.209 | 0.549 | 0.273 |
| 1 | 0.093 | 1.647 | 0.009 | 0.011 | 0.039 | 29.704 | 68.496 |
| 2 | 0.094 | 1.61 | 0.01 | 0.012 | 0.039 | 29.732 | 68.504 |
| 3 | 0.103 | 1.707 | 0.009 | 0.012 | 0.04 | 30.035 | 68.094 |
| 4 | 0.106 | 1.627 | 0.009 | 0.012 | 0.039 | 30.043 | 68.164 |
| 5 | 0.101 | 1.744 | 0.008 | 0.011 | 0.039 | 30.062 | 68.034 |
| 6 | 0.101 | 1.715 | 0.008 | 0.012 | 0.039 | 29.989 | 68.136 |
| 7 | 0.097 | 1.66 | 0.008 | 0.012 | 0.039 | 30.096 | 68.089 |
| 8 | 0.098 | 1.689 | 0.008 | 0.012 | 0.039 | 30.155 | 67.999 |
| 9 | 0.105 | 1.61 | 0.011 | 0.011 | 0.038 | 30.199 | 68.025 |
| 10 | 0.099 | 1.71 | 0.008 | 0.012 | 0.039 | 30.077 | 68.055 |

附表1.21 NCS203036样品187r/min铣床制样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.094 | 1.671 | 0.009 | 0.013 | 0.039 | 30.549 | 67.626 |
| **SD** | 0.004 | 0.054 | 0.001 | 0.001 | 0 | 0.141 | 0.186 |
| **RSD** | 4.21 | 3.236 | 9.368 | 4.704 | 1.206 | 0.461 | 0.275 |
| 1 | 0.089 | 1.727 | 0.009 | 0.012 | 0.039 | 30.612 | 67.511 |
| 2 | 0.09 | 1.619 | 0.009 | 0.013 | 0.038 | 30.513 | 67.717 |
| 3 | 0.093 | 1.734 | 0.008 | 0.012 | 0.039 | 30.683 | 67.43 |
| 4 | 0.093 | 1.739 | 0.008 | 0.013 | 0.039 | 30.677 | 67.431 |
| 5 | 0.092 | 1.604 | 0.009 | 0.013 | 0.038 | 30.506 | 67.737 |
| 6 | 0.095 | 1.689 | 0.008 | 0.013 | 0.039 | 30.612 | 67.543 |
| 7 | 0.094 | 1.742 | 0.008 | 0.012 | 0.039 | 30.583 | 67.523 |
| 8 | 0.096 | 1.624 | 0.01 | 0.013 | 0.038 | 30.48 | 67.74 |
| 9 | 0.092 | 1.653 | 0.009 | 0.013 | 0.039 | 30.633 | 67.561 |
| 10 | 0.087 | 1.664 | 0.009 | 0.013 | 0.039 | 30.542 | 67.646 |

附表1.22 NCS203036样品187r/min铣床制样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.097 | 1.647 | 0.01 | 0.013 | 0.039 | 29.678 | 68.517 |
| **SD** | 0.006 | 0.071 | 0.001 | 0.001 | 0 | 0.195 | 0.258 |
| **RSD** | 5.704 | 4.332 | 12.472 | 5.128 | 0.813 | 0.657 | 0.377 |
| 1 | 0.086 | 1.698 | 0.009 | 0.012 | 0.039 | 29.955 | 68.202 |
| 2 | 0.09 | 1.587 | 0.011 | 0.013 | 0.039 | 29.574 | 68.686 |
| 3 | 0.1 | 1.62 | 0.011 | 0.013 | 0.039 | 29.64 | 68.579 |
| 4 | 0.103 | 1.652 | 0.009 | 0.013 | 0.039 | 29.561 | 68.623 |
| 5 | 0.1 | 1.69 | 0.009 | 0.013 | 0.039 | 29.746 | 68.403 |
| 6 | 0.1 | 1.796 | 0.008 | 0.012 | 0.039 | 29.961 | 68.084 |
| 7 | 0.101 | 1.652 | 0.01 | 0.013 | 0.038 | 29.816 | 68.37 |
| 8 | 0.1 | 1.651 | 0.01 | 0.013 | 0.039 | 29.687 | 68.5 |
| 9 | 0.096 | 1.57 | 0.011 | 0.014 | 0.039 | 29.38 | 68.89 |
| 10 | 0.093 | 1.553 | 0.012 | 0.014 | 0.039 | 29.462 | 68.827 |

附表1.23 NCS203036样品270r/min铣床制样精密度数据（第一次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.092 | 1.606 | 0.01 | 0.013 | 0.038 | 30.128 | 68.112 |
| **SD** | 0.003 | 0.027 | 0.001 | 0 | 0.001 | 0.112 | 0.124 |
| **RSD** | 3.437 | 1.674 | 9.428 | 3.804 | 1.369 | 0.371 | 0.181 |
| 1 | 0.092 | 1.58 | 0.011 | 0.013 | 0.038 | 30.195 | 68.072 |
| 2 | 0.098 | 1.628 | 0.01 | 0.013 | 0.038 | 30.258 | 67.954 |
| 3 | 0.092 | 1.59 | 0.011 | 0.013 | 0.038 | 30.157 | 68.1 |
| 4 | 0.09 | 1.592 | 0.011 | 0.013 | 0.039 | 30.108 | 68.147 |
| 5 | 0.09 | 1.616 | 0.009 | 0.013 | 0.039 | 30.291 | 67.943 |
| 6 | 0.097 | 1.604 | 0.009 | 0.012 | 0.038 | 30.166 | 68.073 |
| 7 | 0.088 | 1.636 | 0.009 | 0.013 | 0.039 | 30.094 | 68.121 |
| 8 | 0.091 | 1.648 | 0.009 | 0.012 | 0.039 | 30.048 | 68.152 |
| 9 | 0.092 | 1.61 | 0.01 | 0.012 | 0.038 | 30.06 | 68.177 |
| 10 | 0.09 | 1.56 | 0.011 | 0.013 | 0.039 | 29.905 | 68.383 |

附表1.24 NCS203036样品270r/min铣床制样精密度数据（第二次）

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **C** | **Fe** | **Mo** | **Al** | **Si** | **Pr** | **Nd** |
| **Avg** | 0.094 | 1.589 | 0.01 | 0.013 | 0.039 | 29.712 | 68.544 |
| **SD** | 0.004 | 0.048 | 0.001 | 0 | 0.001 | 0.082 | 0.098 |
| **RSD** | 4.475 | 3.028 | 7.306 | 3.804 | 1.459 | 0.277 | 0.144 |
| 1 | 0.093 | 1.592 | 0.011 | 0.012 | 0.039 | 29.725 | 68.527 |
| 2 | 0.092 | 1.584 | 0.01 | 0.013 | 0.039 | 29.768 | 68.494 |
| 3 | 0.094 | 1.567 | 0.01 | 0.013 | 0.039 | 29.759 | 68.519 |
| 4 | 0.088 | 1.519 | 0.011 | 0.013 | 0.038 | 29.84 | 68.491 |
| 5 | 0.095 | 1.655 | 0.009 | 0.013 | 0.04 | 29.727 | 68.461 |
| 6 | 0.092 | 1.626 | 0.01 | 0.012 | 0.039 | 29.732 | 68.489 |
| 7 | 0.1 | 1.63 | 0.009 | 0.012 | 0.039 | 29.751 | 68.458 |
| 8 | 0.091 | 1.53 | 0.011 | 0.013 | 0.039 | 29.563 | 68.753 |
| 9 | 0.102 | 1.638 | 0.01 | 0.013 | 0.039 | 29.633 | 68.565 |
| 10 | 0.092 | 1.543 | 0.01 | 0.013 | 0.038 | 29.619 | 68.684 |