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内容

1 INTRODUCTION 简介

In the coking industry, fine generation refers to the production of small particles, typically in the size range of **<0.5 mm to 6 mm**, which are generally considered low-value or waste material. These fines are predominantly generated during the delayed coking process and should be minimized, as they negatively impact product value, handling, and overall unit efficiency.

在焦化行业中，细粉指的是焦炭小颗粒的产生，通常尺寸在<0.5 毫米到 6 毫米之间，这些细粉通常被视为低价值或废弃物。这些细粉主要在延迟焦化过程中产生，应尽量减少，因为它们会对产品价值、操作性和整体效率产生负面影响。

Although fines are often observed in downstream systems, their origin is closely linked to the conditions under which coke is formed, stressed, and initially broken within the coke drum. Key factors such as feedstock quality, furnace operation, cutting practices, and overall operational control play a decisive role in determining coke structure and its tendency to generate fines.

虽然细粉在下游系统中常见，但其起源与焦炭在焦炭塔内的生成、受力和最初破裂的条件密切相关。原料质量、加热炉运行、切割方式及整体操作控制等关键因素，在决定焦炭结构及其产生细粉的倾向中起着决定性作用

The objective of this case study is therefore to identify the main sources of fines generation within the coking process and assess their relative contribution, with particular focus on the coke drum stage. In addition, the study aims to evaluate the role of ECHO within this context, examining how it may influence fines formation in this context.

本案例研究的目标是识别焦化过程中细粉产生的主要来源，并评估其相对贡献，特别关注焦炭塔阶段。此外，研究还旨在评估 ECHO 系统在该背景下的作用，探讨其可能对细粉的形成的影响程度。

2 METHODOLOGY – PARTICLE SIZE AND FINES DETERMINATION 研究方法 – 颗粒尺寸和细粉的定义

Particle size distribution (PSD) and fines content are determined using standardized sieve analysis.

颗粒粒径分布（PSD）和细粒含量通过标准化筛分分析确定。

A representative petroleum coke sample is mechanically sieved through a series of calibrated screens with decreasing mesh sizes. The material retained on each sieve is weighed, and the particle size distribution is expressed as the **cumulative mass percentage passing** each sieve size relative to the total sample mass.

代表性的石油焦样品通过一系列网格尺寸逐渐减小的标准筛进行机械筛分。每个筛子上保留的物质会被称重，颗粒粒径分布以累计质量百分比表示，即通过每个尺寸的筛子的样品质量相对于总样品质量的累计质量百分比。

3 CASE STUDY IN COOPERATION WITH CLIENT 与客户合作的案例研究

The Figure 1 illustrates the particle size distribution of petroleum coke measured at two locations in the DCU solids handling system:

图 1 展示了延迟焦化装置的固体处理系统中两个不同位置测量所得的石油焦颗粒粒径分布：

- **Before Crusher** (orange curve): coke discharged from the coke drum prior to size reduction.
- **After Crusher** (blue curve): coke downstream of the crusher, prior to slurry basin transfer.
- 破碎机前（橙色曲线）：焦炭从焦炭塔中排出，进入破碎机前。
- 破碎机后（蓝色曲线）：破碎机下游的焦炭，进入焦浆池前。

The PSD is presented as **cumulative mass percentage passing**.

PSD 以累计通过质量百分比表示。

Example interpretation 曲线示例解释

- At 25 mm, a cumulative passing of 65% (After Crusher) indicates that 65% of the coke mass consists of particles smaller than 25 mm.
- At 3 mm, a cumulative passing of 14% (After Crusher) indicates that 14% of the total coke mass consists of fines (<3 mm) at this location.
- 在 25 毫米处，累计通过率为 65%（破碎后），表明焦炭质量中有 65%是小于 25 毫米的颗粒。

- 在 3 毫米处，累计通过率为 14%（破碎后），表明该处焦炭总质量中有 14%为 <3 毫米的颗粒（即细粉）。

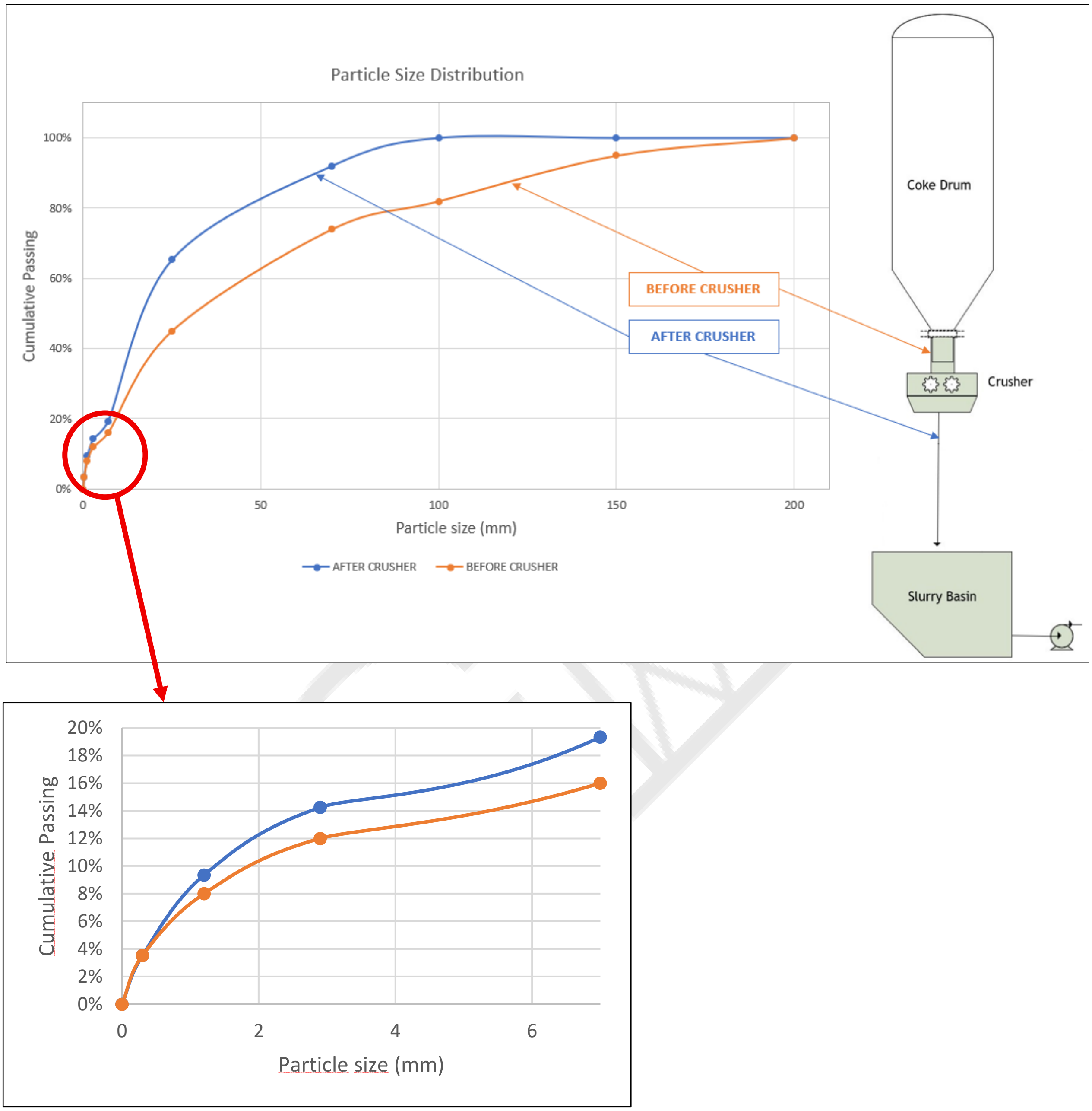

Figure 1 Diagram Fines Production in ECHO

图 1 ECHO 工艺石油焦细粉分布图

The objective of this test was to quantify both the fines content present within the ECHO system and the extent to which fines are generated by it. To achieve this, a defined quantity of coke was sampled during the production cycle (upstream of the crusher), and an equivalent sample was taken from the dewatering bin (downstream of the rotating equipment).

该测试的目的是量化 ECHO 系统中存在的细粉含量及其产生细粉的程度。为此，在生产周期（破碎机上游）取样一定量的焦炭，并从脱水仓（旋转设备下游）对焦炭进行同等取样。

Key observations from the chart 图表中的关键观察

1. **Overall effect of crushing 破碎的整体影响**
   The “After Crusher” curve lies consistently above the “Before Crusher” curve, indicating effective size reduction and redistribution toward smaller size fractions. “破碎后”曲线始终高于“破碎前”曲线，表明有效尺寸缩小并向更小尺寸分区重新分布。
2. **Top size control 最大尺寸的控制**
   Both curves reach 100% cumulative passing at approximately **150–200 mm**, demonstrating effective control of the maximum coke particle size and the absence of significant oversize material. 两条曲线在约 150–200 毫米处均达到 100%累计通过率，显示出对最大焦炭颗粒尺寸的有效控制，且无显著超大颗粒。
3. **Mid-size material generation 中间尺寸颗粒的生成**
   The largest separation between the curves occurs in the **25–70 mm** range, confirming that crushing primarily converts large coke pieces into usable mid-size fractions rather than excessive fines. 两条曲线间的最大偏差出现在 25–70 毫米区间，证实破碎主要将大块焦炭转化为可用的中等粒度，而非过量的细颗粒。
4. **Fine particle content (<6 mm) 细粉的含量(<6 mm)**
   The relatively small separation between the curves below **6 mm** indicates that the crusher contributes only a limited incremental increase in fines, reflecting controlled breakage rather than attrition-dominated crushing. 两条曲线低于 6 毫米的偏差非常较小，表明破碎机仅带来有限的细粉增量，反映的是破碎机是焦炭尺寸优化的受控破碎而不是增加细粉含量的粉碎。
5. **Dust formation (<0.3 mm) 粉尘的产生(<0.3 mm)**
   At very fine sizes (<0.3 mm), both curves converge at very low cumulative mass percentages, indicating minimal dust generation and negligible impact of the crusher on airborne or slurry-related fines. 在非常细小的颗粒尺度上（<0.3 毫米），两条曲线的累计质量百分比都非常低且基本没有差别，表明粉尘的生成极少，ECHO 系统的破碎对空气中或浆液相关细粉的影响可忽略不计。

Overall, the PSD demonstrates effective mid-size generation with controlled fines production, supporting reliable downstream handling and compliance with fines-related specifications.

This indicates that the amount of fines generated within the ECHO system is negligible, and that the majority of fines are already present before the coke enters the system.

总体而言，PSD 曲线展示了 ECHO 工艺有效优化的中间尺寸颗粒的生成，并严格控制了细粉的产生，可靠的满足下游处理的要求，符合细粉的相关规范。这表明 ECHO 系统内产生的焦炭细粉数量可以忽略不计，绝大多数的细粉在焦炭进入 ECHO 系统之前就已存在。

BASED ON THAT FACT, WE GUARANTEE LESS THAN 2.9 % FINE GENERATION IN THE BATTERY LIMITS OF ECHO

基于上述结论，我们可以保证在 ECHO 工艺界区内焦炭细粉的额外增加量低于 2.9%

4 IMPORTANCE OF PROPER CUTTING TOOL 正确的切焦工具和切焦操作的重要性

The following comparison illustrates the impact of cutting tool design and jet quality on coke fragmentation.
以下比较展示了切焦工具的设计和切焦水质量对焦炭破碎的影响。

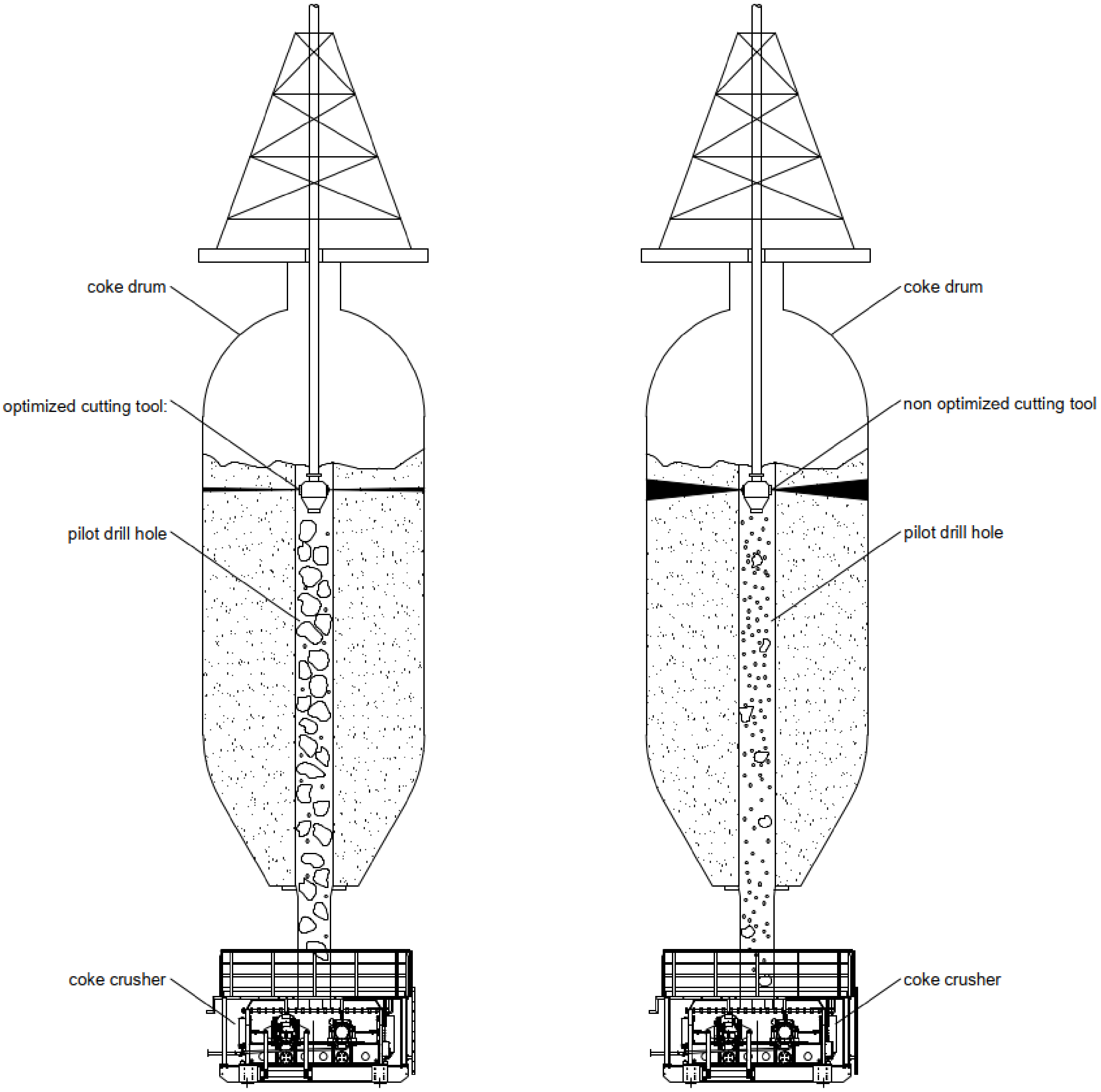

Figure 2: Effects of jet quality on fines generation

图 2：喷射质量对细粉生成的影响

On the left, optimized cutting using a customized tool with high-quality nozzles and proper calibration produces a focused, coherent jet with minimal spreading, resulting in clean cuts and reduced fines generation.

左侧则使用定制工具配合高质量喷嘴和适当校准进行优化切割，产生聚焦、连贯且扩散最小的切焦水喷流，从而实现干净切割和减少细粒生成。

On the right, a non-optimized system shows a widely dispersed jet, caused by unsuitable nozzles or poor calibration, which leads to inefficient cutting, increased coke breakage, and significantly higher fines production.

右侧的未优化系统显示喷流分散，原因为喷嘴不合适或校准不良，导致切割效率低下、焦炭断裂增加以及细粉产量显著增加。

5 RESULTS 总结

The formation of coke fines is closely linked to feed quality and operating conditions within the DCU itself:

石油焦粉焦的形成与延迟焦化自身的原料性质和操作条件密切相关：

- Feedstock Quality: High asphaltene, metals and heavy residue feeds (vacuum residue) tend to form hard, brittle "shot coke," with more porous structure which breaks into smaller pieces and generates fines during cutting, unlike spongy coke.
- Furnace Operations: Inadequate heater velocity or improper temperature control can lead to increased thermal cracking (overcracking). This leads to highly porous and low-density coke. Such coke has poor mechanical strength and fractures easily.
- Cutting: Proper coke cutting relates to the drum diameter in conjunction with a customized cutting tool or suitable nozzles that prevent the jet from spreading along its length. The spreading produces fine particles, as well as poor cutting technique increases fragmentation.
- Operational Control: Proper management of recycling ratios (usually < 1.27:1) and coke drum velocity is crucial to minimizing the amount of heavy material that turns into coke fines.
- 原料性质：高沥青、金属和重质渣油原料（减压渣油）倾向于形成坚硬、脆性的“弹丸焦”，结构更为多孔，切割时会碎裂成更小的颗粒，产生细粒，这与海绵焦完全不同。
- 加热炉的运行：加热速度不足或温度控制不当可能导致原料的热裂解反应程度

增加（过度裂化）。这导致焦炭产品的孔隙率高且密度低。这种焦炭的机械强度较差，非常容易破裂粉化。

- 切焦操作：正确的切焦操作与焦炭塔直径相匹配，结合定制的切割工具或合适的切焦水喷嘴进行，以防止切焦水喷流随着距离发生扩散。射流的扩散会产生粉焦细颗粒，且切割技术不佳会加剧粉焦的产生。
- 操作优化：合理管理焦化的循环比（通常<1.27：1）和焦炭塔的流速，这些操作对于减少原料的重组分转化为石油焦粉焦而言至关重要。

6 CONCLUSION 结论

Coke fines in a DCU are primarily generated within the coke drum and during decoking because the key factors that determine coke strength and integrity act at this stage. Feedstock quality (high asphaltenes, metals, and residues) and furnace operation (overcracking due to poor temperature or velocity control) already produce porous, brittle coke that is predisposed to break into fines.

延迟焦化中的石油焦粉焦主要在焦炭塔内和切焦除焦过程中所产生，因为决定焦炭强度和完整性的关键因素均发生在这些阶段。原料性质（高沥青质、金属和减渣）和炉子运行（因温度或流速控制不佳而导致过裂解）已经生成了孔隙率高、脆性高的焦炭产品，导致石油焦产品容易破碎成粉焦。

Additionally, improper cutting practices can directly fragment this weak coke, while suboptimal operational control (e.g., high recycle ratios or low drum velocities) further increase the formation of fine-producing structures.

此外，不当的切焦方法会使这些高脆性的焦炭直接碎裂粉化，而操作控制不佳（如高循环比或低焦炭塔流速）则进一步增加粉焦结构焦炭产品的生成。

By the time coke leaves the drum, its structure and fines content are largely established, so downstream equipment contributes only marginally to additional fines generation.

焦炭离开焦炭塔时，其结构和粉焦含量已经基本完全确定，因此下游设备对额外细粉产生贡献非常有限。

7 EXAMPLE PICTURES 现场示例图片

Figure 3 Coke pit without Crusher

图 3 无破碎机的焦炭坑

Figure 4 Coke after Crusher with ECHO

图 4 安装 ECHO 系统破碎机后的焦炭