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关于水泥窑排放水银的测试问题

(2)

Cement Kiln Mercury (Hg) Emission Testing Issues

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引 言 Introduction

There is a growing level of concern about mercury emissions from cement kilns and interest in the industry in developing cost effective options for controlling these emissions. Cement plants have a wide range of mercury inputs and resulting emissions because of the wide variety of raw materials and fuels used in the process. Further, the current level of mercury emission control at cement plants varies from 0% to as high as 95% using existing particulate control systems. **This is the second in a new series of GCI TechNotes that will examine this issue.**

Mercury emissions are regulated based on concern for mercury entering the food chain and bioaccummulating to significant levels that could impact people eating fish. The following is a brief review of the factors that impact the issue of testing modern cement kilns to determine accurate emission rates.

由于人们对水泥窑排放水银的关注日益高涨，工业界才有兴趣发展节约且有效的办法来控制这些排放. 水泥厂因为在生产过程中使用的生料和燃料中可能含有不同程度的水银，因此会排放水银. 而且当前一些水泥厂对水银排放的控制程度由 0%至最高的 95%不等，使用的是微粒控制系统. 在新的一系例 GCI 技术摘要中，这是探讨这个问题的第 2 篇。

水银排放的监控是基于人们的关注水银会进入我们的食物链，长时期的积累在生物系统里，对一些吃鱼的人会有影响. 以下是对那些影响到测试新法干窑，以肯定准确的[水银]排放率的因素作一个简短的复审。

Mercury Emission Testing from Wet Process and Older Straight Dry Cement Kilns

Older wet process and straight dry cement kilns typically remove from the process a small portion of the dust captured in the APCD system on a continuous basis. This process of dust removal combined with essentially steady state operation of the raw feed system allows these older kiln systems to come to fairly quick equilibrium relative to volatile metals - generally within 6-14 hours of any increase or decrease in the metal input rate, depending on the size of the surge tank used to store APCD dust prior to feeding back into the kiln. For these reasons it has been possible to test mercury emissions from these kiln systems and produce successful mass balances of the systems for mercury and other trace metals. GCI has a long track record of producing successful trace mass balances on cement kilns. (Papers relating the results of these tests, the mass balance results and guidance on how to perform this sort of mass balance are available in the library at our website.)

对湿窑和旧式的笔直干窑进行的水泥排放测试

典型的做法是从旧式的湿窑和笔直的干窑设置的防止空气污染的系统（APCD）里，移除小量被捕捉到的窑灰. 这种移除窑灰的方法与生料给料系统根本稳定的状态相结合，会使这些旧式的水泥窑系统相当快地与挥发性的金属达至平衡 - 任何金属的输入率的增加或减少一般是在 6-14 小时之内，于回笼至水泥窑之前，视乎用来储存APCD尘埃的缓冲罐的大小. 由于这些理由，才可能测试这些水泥窑系统的水银排放，并得出对水银和痕量金属在系统内确切的物料衡算. GCI 对找出水泥窑内确切的痕量物料衡算有悠久的业绩记录。（关于这些测试的文章、物料衡算的结果和指导如何执行这类物料衡算，可以在我们的网站图书馆里找到）。

Mercury Emissions from Modern Precalciner Kilns with In-line Raw Mills

When GCI began testing modern precalciner kilns for mercury and other metal emissions in the early 90's we began to see the disturbing trend of poor mass balances on mercury and thallium. Subsequent research into the issue has allowed us to work on the development of a dynamic model that focuses on the feed rate of mercury to the kiln itself during the long term operation of precalciner kilns with in-line raw mills. Because it is typically the case that all of the dust captured in the main APCD is returned to the kiln and because these systems periodically go through a maintenance cycle where the raw mill is shut down and the exhaust gases from the kiln bypass directly to the APCD device, mercury emissions never come to a short term equilibrium and can typically take weeks to come to a long term equilibrium.

水银排放来自设有在线生料磨的预分解窑（即新法干窑）

在 90 代早期 GCI 开始为新法干窑测试水银和其他金属的排放时，开始看到一种不安的趋势；对水银和铊（音：他）的糟糕物料恒算. 其后对这问题的研究使得我们发展出一种动态的模型，那是专注于，在设有在线生料磨的预分解窑于长时期运作中，水泥窑本身的水银输入率. 因为那是典型的情况，所有那些被主要的 APCD 捕捉到的窑灰被回笼入窑，也因为那些系统定期进行周期维修，那时候的生料磨会被关掉，窑里的废气经旁通管直接进入 APCD, 水银的排放从未有暂短的平衡，而且可能会典型地经过数周才能达至长期的平衡。

图一在下页

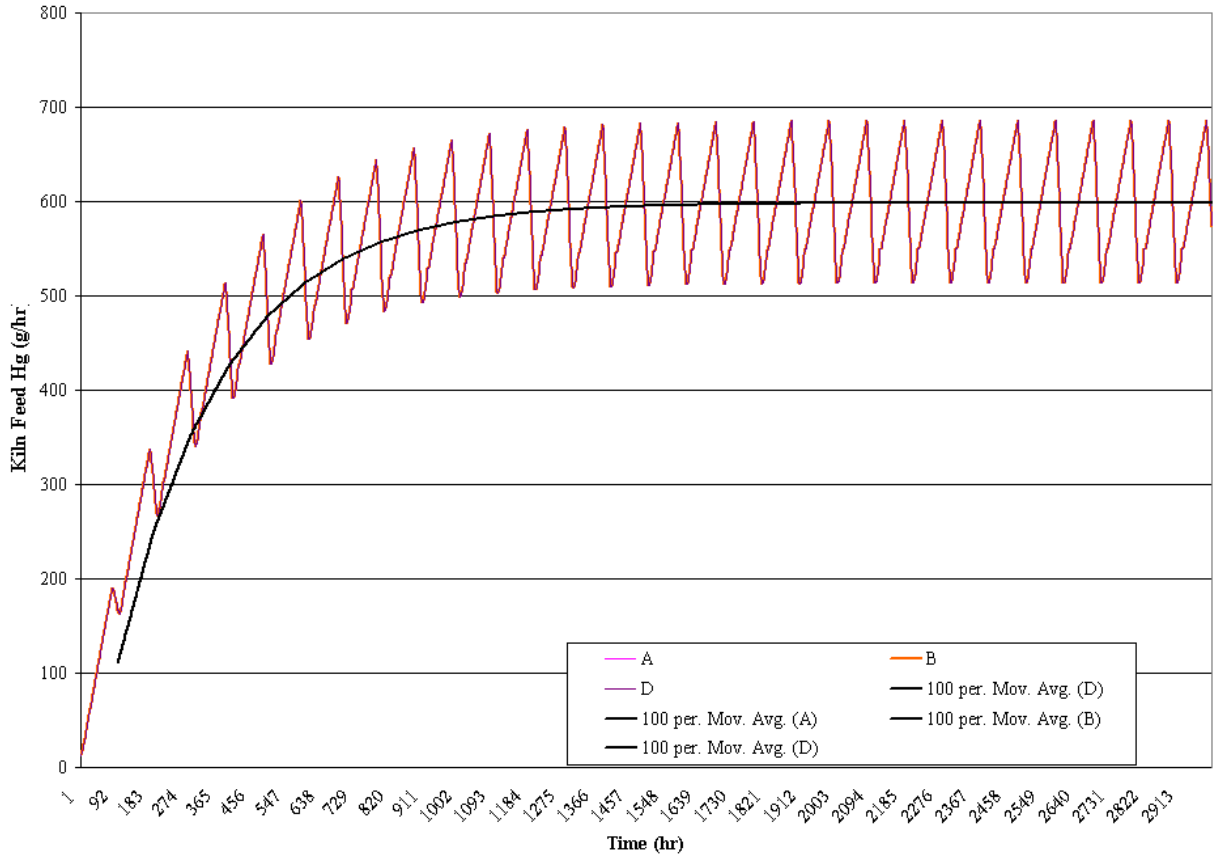


Figure 1

Figure 1 illustrates a typical operation Hg input rate where the mercury concentration is approximately 1 ppm relative to the feed and the raw feed rate is about 300 tons per hour. The raw mill maintenance cycle has been modeled as 15 hours out of every 100 hours. Actual operations typically can vary week to week in this regard but for the purposes of understanding the data and the model, randomization of these factors was not deemed necessary. Looking at the model it is easy to see that there is no 3 hour, 12 hour, or even 24 hour period during which the system comes to equilibrium allowing a representative stack test to occur. No wonder the US EPA has expressed confusion over some of the recent stack test results from precalciner cement kilns. It is also worth noting that it takes about 1700 hours (over two months) for the system to reach a long term equilibrium. Only at this point is the long term emissions of mercury equal to the long term input rate. Given the frequency that precalciner kilns are down and require maintenance, the times when the system is in a long term equilibrium will be infrequent.

图一中的图解说明一个典型的水银输入率的运作例子，那里的水银浓度约莫是 1ppm 相对的输入和生料的输入率是每小时 300 吨. 生料磨的维修周期模拟为每 100 小时中的 15 小时. 关于这一点于实际的运作上，周与周之间会有所不同，但是为了理解数据和模型，没必要把这些因素不规则化. 在这个模型里可容易看到那里没有 3 小时、12 小时、或者甚至 24 小时的时段里这个系统达至平衡，允许做一个有代表性的烟囱测试. 怪不得美国环保局被最近从一些分解窑烟囱测试的结果搞得糊涂了. 值得注意的是那要经过 1700 小时（多于两个月）才能使这个系统达至长期的平衡. 只有这时候长期的水银的排放等于长期的输入率. 假设那个分解窑需要关掉进行维修频繁，那么这个系统在长期平衡的时间肯定会稀少。

It should also be noted that it is commonly the case that with the raw mill down these systems have higher temperatures in the APCD system and are less likely to have as high a sorption capacity on the dust in the system. This change in capture efficiency of the system would then need to be superimposed on the feed rate, thus resulting in an even more complex and quite likely more variable plot of emission rate.

也应该注意到那是普遍的情况，生料磨关掉后这些系统在 APCD 里的温度颇高，而且在系统里吸收窑灰的能力不大可能会有那么高. 这种捕捉效率的变更会需要附加在输入率，因而造成一种更复杂和更易变动的排放率的情况。

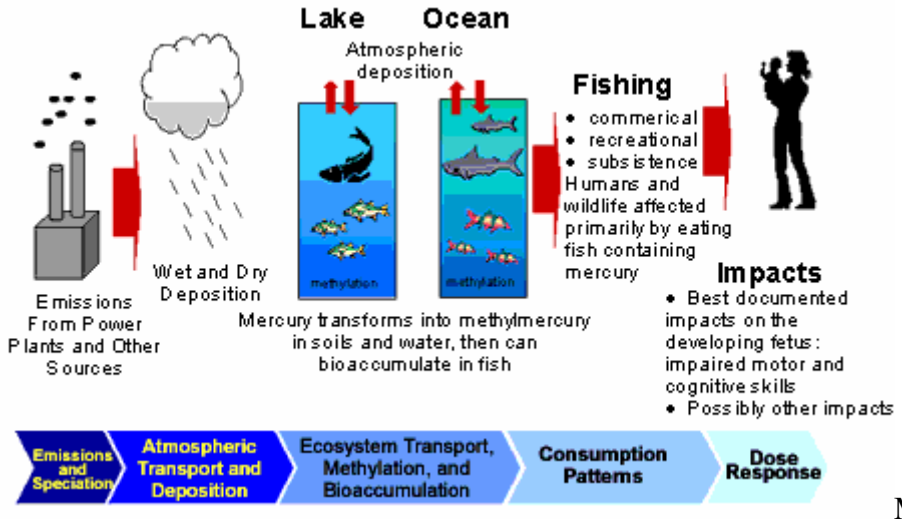
Conclusion

Attempts to test mercury emission rates from modern precalciner cement kilns are inherently invalid representations based on the non-steady-state operation of these kiln systems relative to mercury input rates and changing capture efficiencies. The establishment by authorities of any short term emission limit and testing requirement can only be considered to be based on "junk science" or a gross misunderstanding of how these systems operate. If limits and testing are to be performed, the limits need to be based on long term input rates combined with capture efficiencies determined by comparing the amount of mercury entering the system with that captured and withdrawn from the thermal processing steps in the cement kiln process.

结 论

企图测试分解窑的水银排放是徒劳，因为根据这些窑的系统的不稳定运作，关系到水银输入率和捕捉效率的变化. 有关当局设立任何短期的排放限度和测试的规定，只能被认为是严重的误解这些系统的运作. 如果限度和测试是要执行的话，这个限度应该是基于长期的输入率与捕捉效率相结合来确定，把水银进入系统的量和捕捉到的量相比，劈开水泥窑工艺的热加工步骤。

如欲获得更多资料请与高士曼先生联系 dgossman@gcisolutions.com 也可以通过 GCI 驻中国香港的代表 - 张启明联系 dennis.june@gcisolutions.com



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