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固体二次燃料的储存、计量和输送——设计基础和设
备介绍

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**Storing, metering and conveying solid
secondary fuels – design basis and equipment**

摘要

固态二次燃料的处理，包括把它们输送到回转窑燃烧器或（和）分解炉燃烧器，通常可以分为工厂3个相连接的区域，即：物料的接收和存储，物料的计量和称重，以及将其运输到燃烧器。物料一般通过载重汽车接受，并集中到中间储库。适用的中间储库可以是筒仓、平底料斗和容器。如果必要的话，这些料仓也可以被制成带传输装置且抗压力振动的形式。送来的原料经过中间储库进入工艺流程。然而，基于“及时”原则，在物料接收后，燃料也可以直接送到工艺流程。物料是直接从运输汽车通过处理坞站或集装箱倒卸站直接进行转运。在所有异物和超大颗粒产品清除之后，物料用带式或螺旋式称重喂料装置计量和称重。称重喂料装置连接控制技术中的提取装置，并且，根据二次燃料的危险性，还可被做成抗压抗震形式的。物料能以机械或风动方式传送到回转窑或煅烧炉燃烧器。在此情况下，机械式输送通常是通过链槽式输送机或带式输送机。与风动输送相比，机械式输送块状物料，不会发生任何问题，但是机械式输送机明显缺乏灵活性。燃料由一个专门定制的吹除式回转叶轮喂料器(**blow-through rotary-vane feeder**)送入风动传送线。即使存在很大的压力差，这个喂料器仍有很高的耐磨性和可靠性。本文描述由Schenck Process公司开发和使用的固态二次燃料计量组件，并介绍了为不同设备的设计基础。

Summary

The handling of solid secondary fuels, including their transport to the rotary kiln burner and/or calciner burner, can normally be divided into three linked areas of the plant, namely material acceptance and storage, metering and weighing of the material, and transport to the burner. The material is normally received in lorries and can be held in intermediate storage. Suitable intermediate storage can be provided by silos, flat-bottomed hoppers and containers, which can also – if necessary – be made resistant to pressure surges, including the transport equipment. The material that has been delivered then passes from the intermediate store into the process. However, after acceptance of the material the fuels can also be passed on directly to the process on a “just in time” basis. This material transfer is carried out directly from the delivery lorries via docking stations or container tipping stations. After elimination of any foreign bodies and removal of oversize particles the material is metered and weighed with belt or screw weigh-feeders that incorporate the preceding extraction devices in the control technology and, depending on the dangers posed by the secondary fuel, can be made resistant to pressure surges. The material can be transported to the kiln or calciner burners either mechanically or pneumatically. In this case the mechanical transport is generally by troughed chain conveyors or belt conveyors. In contrast to pneumatic conveying it is also possible to convey lumpy materials mechanically without any problem, but mechanical conveyors are significantly less flexible. The fuel is introduced into the pneumatic delivery line by a specially developed blow-through rotary-vane feeder. Even with large pressure differences this feeder has a high level of wear resistance and reliability. This article describes the components that have been developed and used by Schenck Process for metering solid secondary fuels and introduces the design basis for different plants.

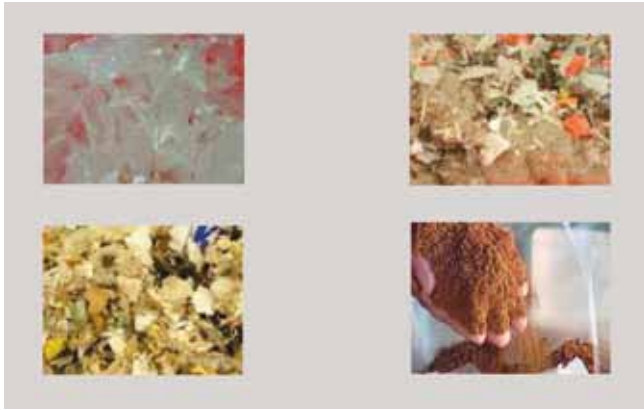


图 1: 经过处理的固体二次燃料样品

Figure 1: Examples of processed solid secondary fuels

1 引言

在水泥工业中，尤其在欧洲国家，用二次燃料替代日趋昂贵的二次燃料已经十分普遍。这些废弃物或循环使用的材料通常含有高能量，非常适用于燃烧回转窑和分解炉。燃烧过程中产生的高温确保这些燃料得到环境兼容、节能理想的利用。目前在众多的国家中，煅烧熟料所需的热能，其超过50%都通过系统利用二次燃料而产生。使用二次燃料通常还能降低CO₂的排放，为环境保护也做出了重大的贡献。

二次燃料自身的可利用率决定了它的重要程度。因此，设备的操作者首先应就材料在燃烧过程中的适用性做好充分的考虑，例如排放物的产生、采用二次燃料产生的资金成本和操作成本。可用的二次燃料具有广泛且不同的性能。这些性能使其在计量、存储和传输都有特殊的要求。本文陈述了固态二次燃料利用的需求，以及如何满足这些需求

2 二次燃料

一般来说，二次燃料来自工业中完全不同的部门，并且不同种类的二次燃料性能差异很大。目前二次燃料主要有轮胎和废橡胶、纸张和包装废弃物、木屑、涂料、污泥和废弃塑料碎片（图1）。大多上述材料都需要通过机械加工进行切碎、筛分和分离来获得具有确切发热值的均质产品。一般来说，这些加工并不是在水泥厂进行的，而是委托与该地区水泥厂供应合同的专业加工公司来实现（图2）。大多数二次燃料的容量只有一次燃料的10%-20%，意味着不得不运输、存储和计量大体积的燃料。通常5t/h的燃料吞吐量，每天将需要处理1200m³的物料。因此，运输和存储成本是衡量经济可行性的重要因素。

1 Introduction

It has long been common practice in the cement industry, especially in European countries, to replace the increasingly expensive primary fuels with secondary fuels. These waste or recycled materials, which often have a high energy content, are suitable for firing both the rotary kiln and the calciner. The high temperatures involved in the burning process ensure ideal utilization of these materials in a way that is environmentally compatible and energy efficient. Numerous countries now cover over 50 % of the specific heat requirement for burning clinker by the systematic use of secondary fuels. This is often accompanied by a reduction in CO₂ emissions, which makes an important contribution to environmental protection.

The use of a secondary fuel is determined to a crucial extent by its local availability. The plant operator must therefore first give serious consideration to the suitability of the materials for use in the burning process, to the generation of emissions and to the capital and operating costs incurred for handling secondary fuels. The secondary fuels that are available can have widely differing properties. These properties place special demands on the metering technology, storage and transport. This article examines the requirements for utilization of solid secondary fuels and how they can be met.

2 Secondary fuels

As a rule secondary fuels come from very different sectors of industry and have materials properties that differ widely from one another. Nowadays this often involves used tyres and rubber waste, paper and packaging waste, sawdust, paints, sewage sludge and shredded plastic waste (» Fig. 1). Many of these materials require mechanical processing by shredding, screening and separating to obtain a homogenized product with a specifiable calorific value. As a rule the processing is not carried out at the cement works but is undertaken by specialist processing firms that then arrange supply contracts with the cement works in the region (» Fig. 2). When compared with primary fuels a great many secondary fuels have bulk densities that are only 10 to 20% of the density of a primary fuel, which means that large volumes have to be transported, stored and metered. At the very common fuel throughput of 5 t/h it can be necessary to handle as much as 1,200 m³ per day. The transport and storage costs are therefore major factors when considering the economic viability.

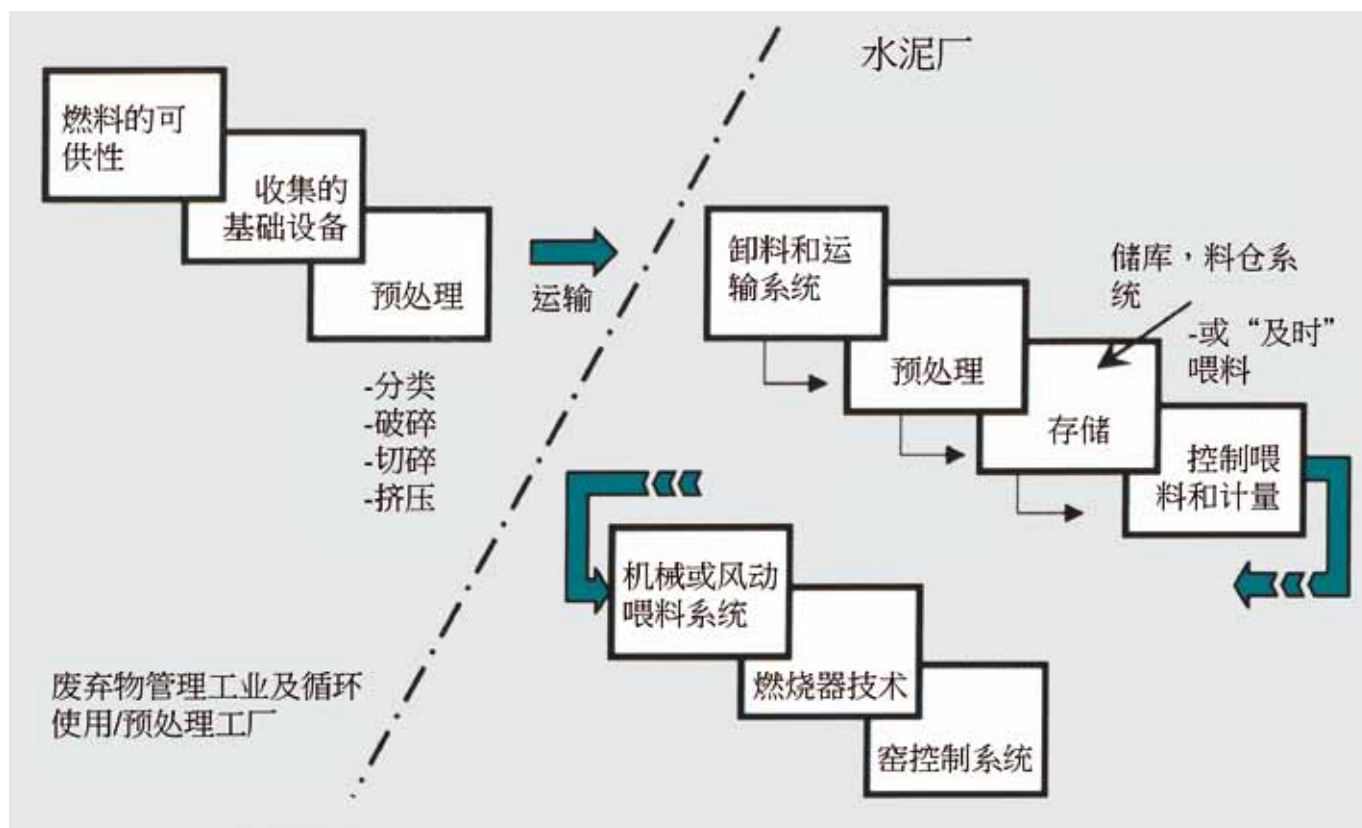


图 2: 二次燃料利用方案

Figure 2: Scheme for utilization of secondary fuel

3 设备

3.1 存储

二次燃料的存储指的是物料的接收以及它的储存。要区别“及时”和“中间存储”两种原理。“及时”意味着把物料从载重汽车直接提供到工艺流程。这可在坞站或倒料站进行。若采用中间存储，则燃料在进入工艺流程之前存储在储库、平底料斗或容器中。如果必要，中间存储也能在抗压抗震的容器中进行。

3.1.1 带行走式底盘的集装箱

现在的固体二次燃料也经常以散装形式装在带行走式底盘卸料系统的挂车里供应的。这些挂车系统在世界范围内使用，并被特别改制成可运送多达90m³散状物料的挂车。挂车可在处理坞站前倒退到精确卸料位置。一套充气密封系统用一个防尘密封套罩住挂车边以便在卸料过程中不会有任何物料泄入周围环境。然后，牵引车与挂车脱开，行走式底盘排料系统被连接到液压装置（见图3）。带行走式集装箱的各单元仅按预定的节奏运动——在螺旋排料盘方向是同步移动的，在返回方向是单独移动并以这种移动顺序卸载挂车。如果在螺旋排料底盘上的物料太多，安全开关会切断液压系统，在液压压力适当下降后再次启动液压系统。螺旋取料底盘是处理坞站的一个组成部分，将二次燃

3 Equipment

3.1 Storing

The storing of a secondary fuel is taken to mean acceptance of the material as well as its storage. A distinction is made in principle between the approaches of “just in time” and intermediate storage. “Just in time” implies direct supply of the material from lorries to the process, which can take place through docking stations or container tipping stations. With intermediate storage the fuel is stored in silos, flat-bottomed hoppers or containers before it is introduced into the process. If necessary the intermediate storage can also take place in containers that are resistant to pressure surges.

3.1.1 Walking floor containers

Nowadays solid secondary fuels are also often supplied in bulk in semitrailers with walking floor discharge systems. These trailer systems are used worldwide and have been developed specifically for transporting up to 90 m³ of bulk material. The semitrailer is backed into the exact unloading position in front of the docking station. An inflatable sealing system encloses the trailer on



图 3: 带行走式底盘集装箱的处理均站

Figure 3: Docking Station with Walking Floor Container

料输送到通常衔接的链槽式输送机。入口截面必须做得足够大以防止物料在螺旋取料底盘上起拱，同时确保物料稳定地排入链槽式输送机中。对许多二次燃料来说，单螺旋是不够的。一般来说需要4个螺旋，并且依据需要的输送速度，要不使用全部4个，要不只使用1对螺旋（见图4）。

3.1.2 倾翻式集装箱

除了行走式底盘集装箱外，标准集装箱也能用来存储物料。这些集装箱由牵引车驱动至倾卸站，并通过有控制的倾翻集装箱将物料卸至螺旋取料底盘上。然而，由于集装箱仅有大约40m³的容量，在决定是否采用标准集装箱时，必须考虑到物流的需求增长的情况（见图5）。

3.1.3 存储料仓

固体燃料也可储存在存储料仓中。这在水泥厂中，能保证更久的供料量。在基础设施薄弱或散装物料取料较难的情况下，如动物骨粉，存储料仓特别合适。二次燃料存储在合适尺寸的料仓中，并从那里送到工艺流程中去。从料仓中取料必须可靠和可控，以确保稳定供料。一种合适的取料系统是直接装在料仓底板水平上、在料仓内循环运转的料仓排空螺旋。螺旋将二次燃料运送到料仓底板中心，在那里进行取料（见图6）。料仓可用钢或混凝土制成。如果料仓带有垂直围墙，则可以实际消除物料起拱现象。如果需要，耙齿可制成耐磨的，通常装在螺旋上，以辅助取料。

3.2 物料的计量

不同种类的二次燃料对计量设备提出了很高的要求，使其必须被设计成可处理多种属性的物料，如：颗粒粒度组成，松散密度，流动特性等。为了确保稳定的水泥熟料的高质量，

all sides with a dust-tight seal so that no material can escape into the atmosphere during the unloading. The tractor unit is then uncoupled from the trailer and the walking floor extraction system is connected to a hydraulic plant (» Fig. 3).

The elements of a walking floor container only move in a predetermined rhythm – simultaneously in the direction of the screw extractor floor, and separately in the return direction – and use this sequence of movements to unload the trailer. trough docking stations or container tipping stations. With intermediate storage the fuel is stored in silos, flat-bottomed hoppers or containers before it is introduced into the process. If necessary the intermediate storage can also take place in containers that are resistant to pressure surges. A safety switch cuts off the hydraulic system if there is too much material in the screw extractor floor and switches it on again after an appropriate drop in the hydraulic pressure. The screw extractor floor, which is an integral part of the docking station, transports the secondary fuel into the troughed chain conveyor that usually follows. The inlet crosssection must be made large enough to prevent the material from bridging over the screw extractor floor and to ensure a constant feed of material into the troughed chain conveyor. For many secondary fuels a single screw is not sufficient. As a rule there are four screws and either all four screws or only one pair of screws are used depending on the transport rate required (» Fig. 4).

3.1.2 Tipping containers

Standard containers can also be used instead of walking floor containers for storing the material. These containers are driven to the tipping station by the tractor unit and are unloaded into the screw extractor floor by controlled tipping of the container. However, the smaller volume of only about 40 m³ makes increased demands on the logistics and must be taken into account when deciding whether to use a standard container (» Fig. 5).

3.1.3 Storage silos

Solid fuels can also be held in storage silos. This guarantees longer availability in the cement works. Storage silos are particularly appropriate where there is a poor infrastructure or for bulk materials that are difficult to extract, such as animal meals. The secondary fuel is then stored in appropriately dimensioned silos from where it is introduced into the process. The extraction from the silo must be reliable and controlled to ensure a constant supply. One suitable extraction system is a silo emptying screw that circulates inside the silo imme-



图 4: 处理坞站中的螺旋取料底板

Figure 4: Schneckenboden in der Andockstation

对二次燃料必须进行高度精确和稳定的计量。计量系统也必须是极度可靠，甚至在物料含有异物和粗颗粒时也能没有任何问题地正常运行。计量设备必须能方便地整合到现有工厂之中并只需尽可能少的维护。下面将介绍几种可靠计量所必需的计量系统和附加装备。

3.2.1 链式输送机

链式输送机是用来在竖直、水平或倾斜方向上和有限的距离内运输物料的。输送机应是防尘的、低维护的、可靠的及速度可控的。当调节到适用于各种不同的传输速度和物料时，这些输送机应能合理地调剂物料到带式称量喂料装置上。Schenck Process公司使用的链式输送机通常有一套监测系统以探测链条断裂。

3.2.2 磁选机

磁选机通常用于从物料流中排除铁块，以防止其损坏下游的计量和输送设备，并避免传送至回转窑或分解炉燃烧器途中可能的堵塞。二次燃料经过一个磁鼓，



图 5: 带倾翻式集装箱的处理坞站

Figure 5: Docking Station with tipped container

diately above horizontal silo floor. The screw carries the secondary fuel to the centre of the silo floor where the extraction takes place (» Fig. 6). The silo can be built of steel or concrete. Bridging can be practically eliminated if silos with vertical walls are used. Ripper teeth, which if necessary can be made wear-resistant, are usually fitted to the spirals to assist the extraction of the material.

3.2 Metering

The different types of secondary fuels place heavy demands on the metering equipment, which has to be designed to cope with a wide range of material properties, such as particle size composition, bulk density, flow characteristics, etc. Highly accurate and constant metering of the secondary fuels is necessary to ensure a consistently high clinker quality. The metering systems must also be extremely reliable and be able to function without any problems even with materials that contain foreign bodies and oversize particles. The metering equipment must be easy to integrate into existing plants and require as little maintenance as possible. Various metering systems and the additional equipment that is required for reliable metering are described below.

3.2.1 Chain conveyors

Chain conveyors are used for transporting materials over limited distances in vertical, horizontal or inclined directions. The conveyors are dust-tight, low-maintenance and reliable, and the speed can be controlled. When adapted to suit the widely differing conveying rates and materials these conveyors have proved to be suitable for dispensing material to belt weighfeeders. The chain conveyors used by Schenck Process usually have a monitoring system to detect chain breakage.

3.2.2 Magnetic separators

Magnetic separators are used for removing pieces of iron from the flow of material to prevent damage to the downstream metering and conveying equipment and avoid possible blockages in the delivery line to the rotary kiln and/ or calciner burners. The secondary fuel is passed through a magnetic drum and the pieces of iron that have been removed are ejected automatically into a waste bin. The cleaned fuel is then transported onwards through a chute.

3.2.3 Star screen

A star screen in a plant for handling secondary fuels has the task of protecting downstream equipment reliably from disruptive materials. These machines do not undertake a classifying function in the strict sense of the word but are only used to remove oversize disruptive



图 6: 料仓排料螺旋

Figure 6: Silo extraction screw

排除的铁块自动进入废料箱。干净的燃料继续向前输送至1个溜槽。

3.2.3 星形筛

星形筛在处理二次燃料的过程中的主要任务是保护下游设备防止被破坏性的物料损坏。严格的意义上讲，此设备并不承担分级功能，而仅仅是从料流中不同程度地排除有破坏性的粗粒物料（图7）。分离粒度取决于筛分星的几何尺寸以及筛分轴的旋转速度。在操作过程中分离粒度可通过调节筛分轴的转速在一定的范围内予以变动。具有破坏性的物料经整个筛板被输送到废弃物箱内，而符合要求的物料通过筛轴之间的缝隙漏下。

3.2.4 带式称量喂料机

特别设计的MULTIDOS带式称量喂料装置是用于固体二次燃料的计量，非常适合于满足上述需求。带式称量喂料装置可以用于几乎所有类型的二次燃料。因为中心及带宽之间的距离可以有效的调节成适合于各种



图 7: 星筛

Figure 7: View of a star screen

materials to varying extents from the flow of material (» Fig. 7). The cut-off size is determined by the geometry of the screening stars and by the rotational speed of the screening shafts. During operation the cut-off size can be varied within certain limits. The belt weighfeeder is the key component in the control system of any plant for handling solid secondary fuels. The associated control loop controls not only the belt speed of the belt weighfeeder itself but also the speeds of the upstream feed conveyors, such as troughed chain conveyors and screw extractor floors. This ensures a constant belt loading, which is a basic requirement for highly accurate weighing of a flow of material, and avoids overloading the belt weighfeeder and the downstream blowthrough rotary-vane feeder. Highly accurate metering is an essential precondition for pulsation-free delivery of the fuel to the rotary kiln and calciner burners, and therefore for achieving a uniformly high clinker quality with the lowest possible emissions.

3.2.5 Screw weighfeeder

Like belt weighfeeders, the screw weighfeeder used by Schenck Process undertakes continuous gravimetric metering of the stream of material. The screw weighfeeder is completely enclosed (dust-tight) and is resistant to pressure surges. The bulk material in a screw conveyor is weighed, its flow rate is determined and the flow of material being conveyed is continuously corrected on the basis of the measured value by the rotational speed of the screw (» Fig. 9). The measured transport rate is checked at a higher level on the basis of the loss in weight in the complete weigher including the feed hopper. Any deviations are corrected automatically. The screw weighfeeder is equipped with a double screw to ensure a large inlet cross-section to the screws.

3.3 Material transport to the burner

3.3.1 Mechanical conveying

The secondary fuel can be conveyed mechanically or pneumatically. Mechanical conveying tends to take place in troughed chain conveyors. Another option is to use belt conveyors. One advantage of mechanical conveying lies in the troublefree transport of lumpy materials; the disadvantages are the comparatively high capital costs and the poor flexibility.

3.3.2 Pneumatic conveying

Pneumatic conveying, on the other hand, can be integrated relatively easily into existing plants. The pneumatic conveyor is designed using a specially developed design program. After the basic data, i.e. the vertical and

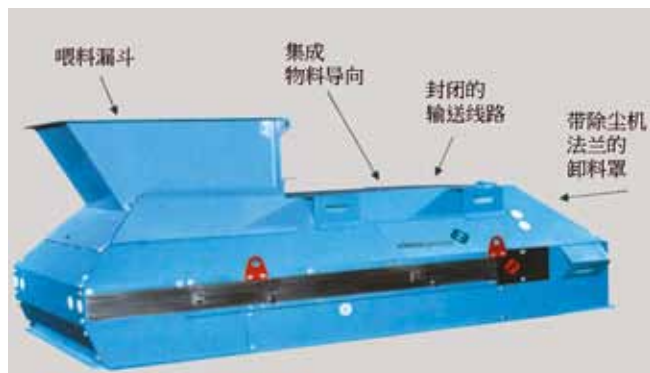


图 8: MULTIDOS 带式称量喂料装置
Figure 8: MULTIDOS® belt weighfeeder

输送的距离和速率，它们能够较容易与现有的设备整合。来自喂料器的物料向前输送并直接在秤上称重，这有效地消除了物料的阻塞。考虑到二次燃料的松散密度低，以及采用了轻质高强、防静电的胶带运输低密度的二次燃料，一个伸长的称量台。被称量物料与称量台上的皮重之比大于1——这是取得高精度计量的重要前提。为了除尘，带式称量喂料装置配备了防护罩及连接法兰（图8）。

带式称量喂料装置是任何处理固体二次燃料的工厂控制系统中的关键组分。关联的控制环路不但控制着带式称量喂料装置自身的带速，还控制着上游的喂料输送机的速度，如链槽式输送机和螺旋排料底板。这确保了稳定的皮带负载，而稳定的皮带负载是料流高精度称重的基本要求，并可避免带式称量喂料器及下游的气流式回转叶片喂料器的过载。高精度计量是燃料无脉动传递到回转窑或煅烧炉燃烧器并由此达到最低排放均匀一致的高熟料质量的基本前提。



图 9: 螺旋式喂料器原理
Figure 9: Principle of a screw weighfeeder

horizontal conveying distances, the number of bends, the conveying rate and the pressure drop of the burner, have been input the program calculates the internal diameter required for the delivery line, the fan pressure need and the requisite intake by adjusting the rotational speed of the screening shafts. The disruptive materials are transported over the entire screen deck into a waste bin, while the “good” material passes between the screening shafts over the full length of the screen.

3.2.4 Belt weighfeeder

The MULTIDOS® belt weighfeeders used are specifically designed for metering solid secondary fuels and are therefore particularly suitable for fulfilling the requirements mentioned above. The belt weighfeeders are used for almost all types of secondary fuel. Because of the distances between centres and belt widths that are available they can be adapted to suit the very varied conveying distances and rates and are relatively easy to integrate into existing plants. The material coming from the feeders is transported onwards and weighed directly on the weigher, which virtually eliminates any back-up of the material. The low bulk density of secondary fuels is taken into account by using a very lightweight, high-strength antistatic belt as well as an extended weighing bridge. The ratio of material being measured to the tare weight on the weighing bridge is greater than 1 – an important precondition for achieving high metering accuracies. The belt weighfeeders used are completely enclosed and are provided with discharge hoods with connecting flanges for dedusting purposes (» Fig. 8).vol ume. When the delivery lines are being installed it is then necessary to fulfil any requirements such as sufficiently large bend radii, smooth joints in the pipelines, and the specification of wear-protection linings in the bends.

3.3.3 Blow-through rotary-vane feeder

An injector blow-through measuring rotary-vane feeder (IDMS) can be used for feeding the secondary fuel into the pneumatic delivery line. This feeder was developed at Schenck Process and adapted specifically to suit the requirements for metering solid secondary fuels. The blow-through rotary-vane feeder is a vertical rotary-vane feeder in which the bulk material discharge is achieved by forced clearance of the compartments between the rotary vanes by transport air from the pneumatic conveying system that has been accelerated by the injector (» Fig. 10). A blade, which cuts up oversized particles as well as foreign bodies, is placed in the inlet shaft in the direction of rotation of the cellular rotor.



3.2.5 螺旋式称量喂料机

如同带式称量喂料机，Schenck Process也使用螺旋式称量喂料机来进行料流的连续重量计量。螺旋式称量喂料机是全封闭（防尘）和抗压抗震的。螺旋称量输送机中的散状物料被称量，并在由螺旋的回转速度测定值基础上确定及连续地校正被输送料流速率及物料流动（见图9）。在不计包括喂料漏斗在内的整个称量喂料机重量损失基础上，更严格地检查被测定的运输速率。任何误差自动进行校正。螺旋式称量喂料机装配了一套双螺旋以确保螺旋推进的入口截面较大。

3.3 燃料输送到燃烧器

3.3.1 机械式输送

二次燃料可用机械输送或气力输送。机械式输送通常采用槽型链式输送机。另外也可采用带式输送机。机械式输送的优点在于能够顺利的运输块状物料，而缺点是相对来说要有较高的投资成本且灵活性较低。

3.3.2 气力输送

气力输送相对来说更容易整合到现有的设备中去。气力输送机采用一种专门开发的设计程序。在基本数据输入程序后，即水平和垂直输送距离、弯管的数量、运输速率和燃烧器的压降等，计算出输送管路的内径、所需的风机风压和必要的进风量。安装输送管路时，必须落实一些要求，例如足够大的弯曲半径、管线的平滑连接以及弯管中耐磨保护衬里的规格。

3.3.3 吹除式回转叶片喂料机

可以采用喷射吹除式测量回转叶片喂料机（IDMS）将二次燃料喂入气力输送线。这种喂料机由申克公司发明，并专门改造成能满足固态二次燃料计量的要求。气力回转叶片喂料机是一种立式回转叶片喂料机，在其中，散状物料从气力输送系统经过喷射器加速的空气从回转叶片之间的间隔空隙通过（见图10）。将过大的颗粒以及异物劈裂的叶片按照蜂窝式转子的旋转方向安装在入口轴处。判断一台回转叶片喂料机成功使用的重要标准是它的使用寿命。吹除式回转叶片喂料机在径向上安装了耐磨条，轴向上通过螺钉固定到蜂窝式转子上以防止磨蚀。径向耐磨条可以在无需拆除整体喂料机的情况下进行更换。甚至于更换轴向耐磨条也无需任何附加调整。吹除式回转叶片喂料机的罩以及净化通道也是防磨损的。由于能长时间保持低磨损，这种坚实密封的喂料机可以确保有稳定的泄漏空气。众所周知，吹除式回转叶片中泄漏空气数量的增长会导致腔室填充量的减少和运输速率的下降。这样，由于空气进入速度的下降，气力输送系统变得不稳定并可能在传送线上发生阻塞。Schenck公司开发的吹除式回转叶片喂料机是针对1年的服务周期而设计的，即使在传输线高压情况下也能实现，而这是传统的软密封喂料机不可能达到的。在蜂窝式转子的腔室内产生剧烈的碰撞意味着吹除式喂料机比任何正常的排料喂料机更具工作可靠性，特

One important criterion for successful use of a rotaryvane feeder is its service life. The blow-through rotary-vane feeder is protected against wear by wear strips attached radially and axially by screws to the cellular rotor. The radial wear strips can be replaced without dismantling the entire feeder and even the replacement of the axial strips does not require any additional adjustment work. The casing of the blow-through rotary-vane feeder itself as well as the purging channel are also protected against wear. Because of the low level of wear over a long period this feeder with its hard seal ensures that there is a substantially constant quantity of leakage air. It is well known that an increase in the quantity of leakage air in a blow-through rotary valve causes poorer filling of the chambers and a reduction in the transport rate. The pneumatic conveying system then becomes unstable due to the falling velocity of the air and blockages can occur in the delivery line. The blow-through rotary-vane feeder developed by Schenck Process is designed for a service life of a year, even with high pressures in the delivery line – a value that is not as a rule achieved by conventional, softsealing, feeders.

The active blast through the chambers of the cellular rotor means that a blow-through feeder achieves greater operational reliability than any normal discharge feeder, especially with adhesive materials.

The blow-through feeder described here is available in two sizes for maximum volume throughputs of 50 and 100 m³/h respectively. This feed principle has even been used successfully for pneumatic conveying of animal meals.

4 Plant design basis

Two different plant designs that are representative of the majority of plants that have already been designed and built are described below.

4.1 Plant with walking floor containers

The plant in » Fig. 11 consists of the following main components:

- ❖ Two docking stations with controlled discharge screw extractor floors and common hydraulic plant for receiving the material from the lorry trailers
- ❖ Troughed chain conveyor for controlled transport of the secondary fuel to the belt weighfeeder
- ❖ Magnetic separator for removing disruptive ferrous materials
- ❖ Star screen for removing oversize material
- ❖ Belt weighfeeder for measuring and controlling the flow of material
- ❖ Blow-throw rotary-vane feeder for introducing the secondary fuel into the delivery line



图 10: 吹除式回转叶片喂料机 IDMS 100

Figure 10: Blow-through rotary valve IDMS 100

别是对于粘性物料。此处介绍的吹除式喂料机有50m³/h和100m³/h两种最大通过率的规格。这种喂料原理早已成功地运用于动物骨粉的气力输送。

4 厂房设计基础

下面描述代表大多数已被设计和建立工厂的3种不同的工厂设计。

- ❖ Fan and delivery line for pneumatic transport of the secondary fuel to the burner

- ❖ Sampling device for monitoring the product

The plant is intended to receive the material, meter it and supply the burners with secondary fuels at a rate of 10 t/h, corresponding to a volume throughput of about 100 m³/h. The material is delivered in sliding floor lorry trailers that are equipped with hydraulically activated extraction floors using the walking floor or cargo floor principle. The plant is operated for 24 hours per day and seven days per week, with a total annual operating time of 8000 hours.

The operating sequence is as follows: the lorry backs its trailer up to the input opening of a docking station. After disconnecting the tractor unit the lorry driver connects the trailer to the hydraulic system. The secondary fuel is pressed into the following troughed chain conveyor by the screw extractor floor in the docking station and is transported to the weighing platform where it passes via a magnetic separator to the downstream star screen and then onto the belt weighfeeder.

An internal control loop uses the predetermined set-point to control not only the belt weighfeeder but also

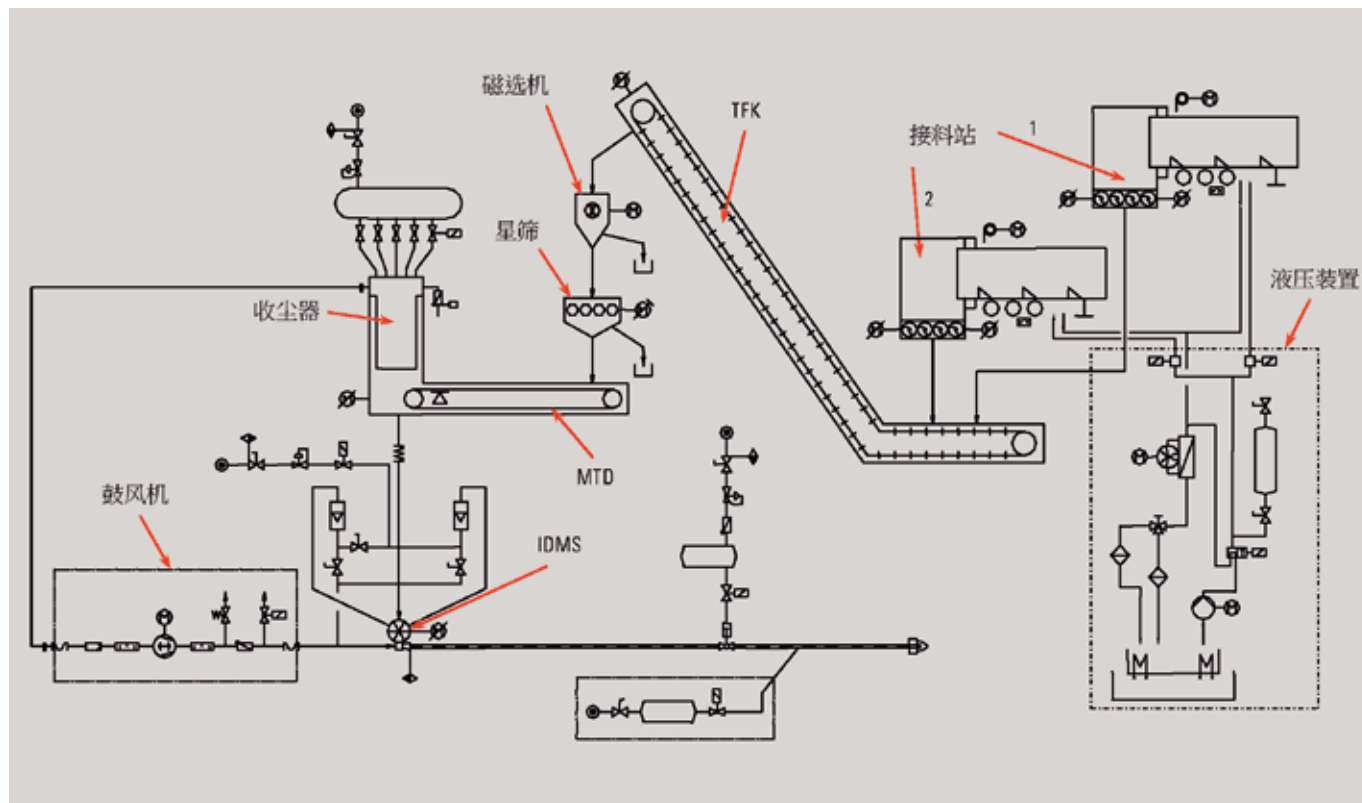


图 11: 配置行走式底板存储器的厂房: TKF: 链槽式输送机; MTD: Schenck MULTIDOS 带式计量秤; IDMS: 带铲刀注入式的吹除式回转叶片喂料机

Figure 11: Plant with walking floor container

TKF: troughed chain conveyor; MTD: Schenck Process MULTIDOS® belt weighfeeder; IDMS: injector blow-through rotary valve with knife

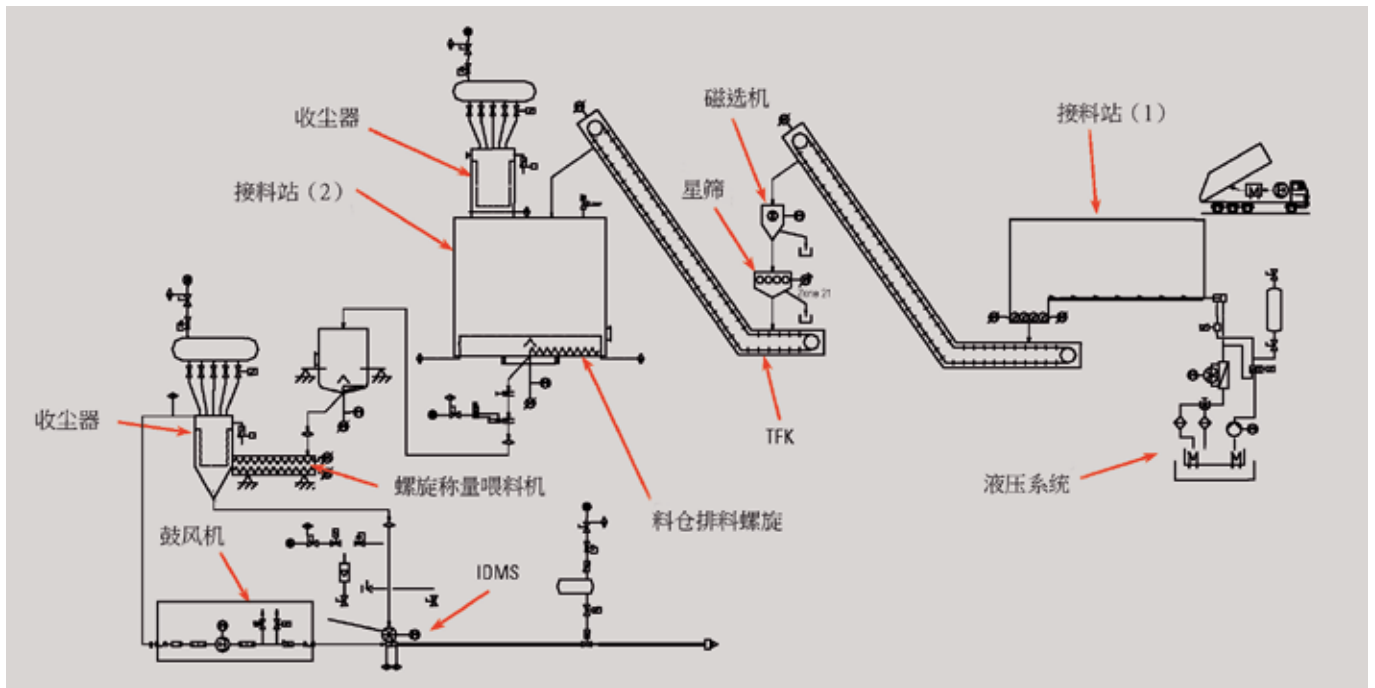


图 12: 带料仓的二次燃料处理厂

Figure 12: Plant for secondary fuels with storage silo

4.1 带行走式底板集装箱的工厂

图11中的工厂由下列主要部分构成：

- ❖ 两个带有可控卸料螺旋排料底板的处理坞站和从汽车拖车接料的液压装置。
- ❖ 可控地输送二次燃料到带式称量喂料机的链槽式输送机
- ❖ 排除破坏性亚铁物料的磁选器
- ❖ 排除大尺寸物料的星筛
- ❖ 测量及控制料流的带式称量喂料机
- ❖ 引导二次燃料到传送线的吹除式回转叶片喂料机
- ❖ 将二次燃料气力输送到燃烧炉的风机与传送线
- ❖ 监测产品的取样装置。

工厂以对应于 $100 \text{ m}^3/\text{h}$ 的通过率 10 t/h 二次燃料输送速度接收物料，称重及供应给燃烧炉。物料用滑动底板汽车运送。挂车装有按行走式底板或货车底板原理设计的液压激活排料地板。工厂每天运行24小时，每周7天，年度总计运行8000小时。运转顺序如下：汽车将其汽车背紧靠接料站入口。在断开牵引单元的连接后，汽车司机将汽车连接到液压系统。二次燃料由接料站的螺旋排料地板输入下接的链槽式输送机并将其运送到称量平台。在此，通过磁选机、下游的星筛，然后进入带式称量喂料机。一套内部控制环采用预定值不仅控制带式称量喂料机而且也控制喂料输送机的速度，如：链槽式输送机和螺旋排料地板。带式称量喂料机通过一个封闭的溜槽将燃料排入吹除式回转叶片喂料机。带式称量喂料机来料的排料点上方装有一台收尘器，以确保没有物料泄入周围环境并处理喂料

the speeds of the feed conveyors, such as troughed chain conveyors and screw extractor floor. The belt weighfeeder then discharges the fuel into the blow-through rotary-vane feeder through a closed chute. A filter mounted above the discharge point from the belt weighfeeder ensures that no material can escape to the atmosphere and also takes up the leakage air from the feeder. The feeder and the delivery line are monitored by speed alarms and pressure monitors to avoid blockages.

4.2 Plant with storage silo

The plant in » Fig. 12 consists of the following main components:

- ❖ Lorry receiving box with sliding floor and hydraulic system
- ❖ Troughed chain conveyor for transporting the secondary fuel to the processing platform
- ❖ Magnetic separator
- ❖ Star screen
- ❖ Troughed chain conveyor for transporting the secondary fuel to the silo
- ❖ Silo extraction screw
- ❖ Screw weighfeeder with feed hopper
- ❖ Blow-through rotary-vane feeder
- ❖ Fan and delivery line for transporting the secondary fuel



机的漏气。喂料机和传送线由速度警报器和压力监视器监测以避免阻塞。

4.2 带存储料仓的工厂

图12中的工厂由下列主要部分构成：

- ❖ 带滑动底板和液压系统的汽车接收箱；
- ❖ 将二次燃料输送到处理平台的链槽式输送机；
- ❖ 磁选机；
- ❖ 星筛；
- ❖ 将二次燃料输送到料仓的链槽式输送机；
- ❖ 料仓排料螺旋；
- ❖ 带喂料斗的螺旋称量喂料机；
- ❖ 吹除式回转叶片喂料机；
- ❖ 用来将二次燃料输送到燃烧器的风机与传送线。

运行顺序如下：汽车拖车背驶入接来料箱的入口，并在此翻倒拖车卸料。拖车翻倒引起的气浪保持在接料箱内，以使环境不被污染。螺旋以及排料底板将二次燃料转送到链槽式输送机。燃料然后经过磁选机、星筛和另一个链槽式输送机到达存储料仓前。在料仓中，燃料经由一个运行其内的排料螺杆排出。二次燃料通过螺旋称量喂料机到燃烧器的路线已经描述过了。

5 结论

高质量的二次燃料的可供性在将来可能会下降，并将有不同流动特性的新的二次燃料出现。这就意味着对二次燃料进行处理的要求仍将继续提高。计量系统必须被设计成针对各种物料的。并且，工厂对本身也必须保护自己免受异物破坏损伤和阻塞。只有当一个工厂的所有组成部分都能仔细地相互匹配组合，才能达到这种要求。

The operating sequence is as follows: the lorry trailer is backed into the input opening of the lorry receiving box where it is tipped. The surge of air caused by the tipping of the trailer is drawn off in the receiving box so that the surroundings are not polluted. The screw extraction floor transfers the secondary fuel into the troughed chain conveyor. The fuel then passes through a magnetic separator and a star screen before it reaches the storage silo via another troughed chain conveyor. The fuel is discharged from the silo by an extraction screw that circulates inside the silo. The route of the secondary fuel via the screw weighfeeder to the burner has already been described.

5 Final comment

The availability of good quality secondary fuels is most probably going to decrease in the future and there will be new secondary fuels with different flow properties. This means that the demands made on the handling of secondary fuels will increase still further. The metering systems must be designed for widely varying materials and the plants themselves must be protected from for only be achieved if all the components of a plant have been carefully matched to one another.



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