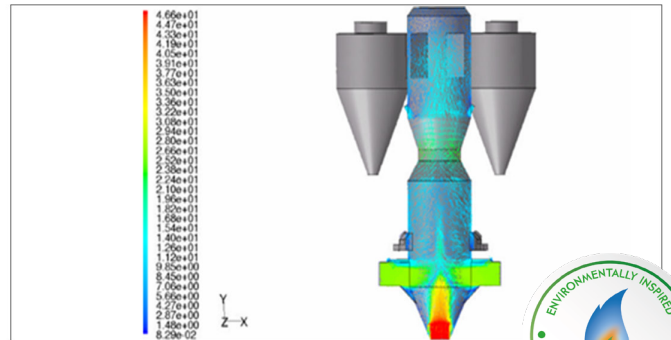
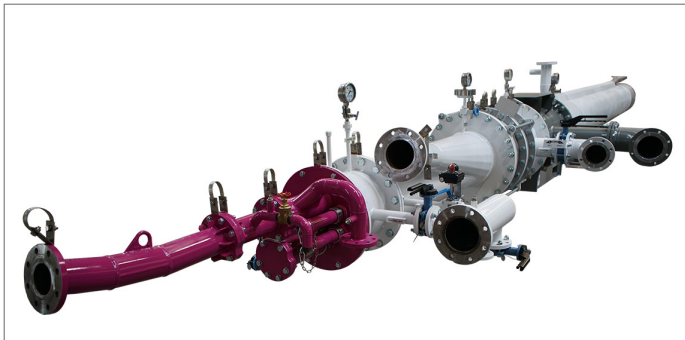
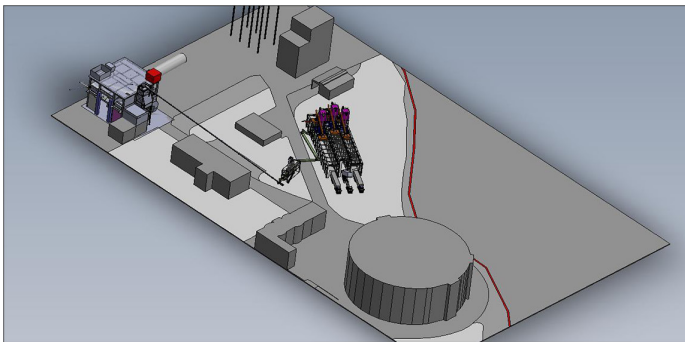


ASF solutions for the cement industry

Alternative solid fuel combustion solutions



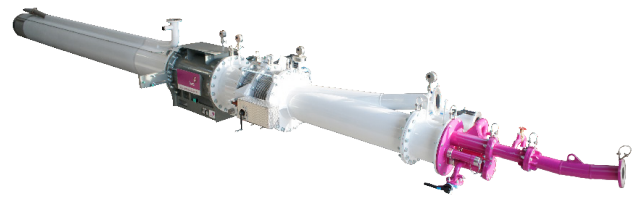
Efficient ASF storage, handling and combustion solutions for CO₂ reduction

- Pillard NOVAFLAM® Evolution: a premium rotary kiln burner
- Pillard PFZ™: a satellite burner specifically for ASF
- “In-house” CFD modeling applied to ASF combustion in kilns and calciners for increased efficiency
- Complete ASF handling systems from ASF storage up to the firing point
- Pillard PRECAJET™ solution for precalciner

Pillard NOVAFLAM® Evolution: the leading kiln burner for ASF firing

The Pillard NOVAFLAM® Evolution, an upgrade of the revolutionary Pillard NOVAFLAM® burner dedicated to rotary cement kilns, includes several innovations which enables an unparalleled performance:

- Lower specific fuel consumption and better clinker quality
- Reduced CO₂ impact and cost savings thanks to an enhanced ASF substitution rate
- A more flexible burner with easy flame shaping and momentum adjustment
- Lower primary air flow and NO_x emissions
- Increased burner lifetime and reduced kiln downtime



REDUCED CO₂ IMPACT AND COST SAVINGS THANKS TO ENHANCED ALTERNATIVE FUELS SUBSTITUTION RATE



NEW ASF INJECTORS TO ACHIEVE A MAXIMUM SUBSTITUTION RATE OF ALTERNATIVE SOLID FUELS

Fives has defined a series of injectors with a design adapted to the high diversity of alternative fuel availability: biomass, plastics, domestic waste, etc. enabling enhanced ASF substitution rates. The Pillard NOVAFLAM® Evolution allows the firing of large quantities of alternative fuels, thus saving fossil fuel consumption and reducing CO₂ emissions.

The Pillard NOVAFLAM® Evolution burner enables the central injection of ASF by means of dedicated injectors, specially engineered to avoid the “double flame” effect. The injection method is adapted according to the various ASF criteria such as density, moisture, size, combustion kinetics...

Various arrangements of ASF injection are possible to achieve the best combustion and thermal efficiency.



SEVERAL REFERENCES ALREADY IN OPERATION

At one of our client's in Romania in 2020, on a 3,700 tpd clinker rotary kiln, with a 140 MW burner firing up to 16 t/h in shredded solid waste (SSW) and 3 t/h in fluff.

The ASF is mainly fluff and RDF, which represents about 71% in substitution rate. In terms of decarbonisation, this installation saves about 150,000 t/year CO₂ emissions.

In Italy in 2021, on a 3,600 tpd clinker rotary kiln, with a 61 MW burner firing up to 8 t/h ASF.

The ASF is mainly fluff, which represents a 67% substitution rate. In terms of decarbonization, this installation saves about 59,000 t/year CO₂ emissions.

For a project in Korea in 2021, Fives commissioned 9 Pillard NOVAFLAM® Evolution burners for rotary kilns with production ranging from 2,000 tpd to 7,800 tpd for two plants. It includes waste oil, synthetic waste and reaches up to 9,000 kg/h ASF flow rate at site.

Pillard PFZ™: to further enhance ASF combustion in rotary kilns

The Pillard PFZ™ system is a satellite injection method for improved ASF firing in the rotary kiln. It is well suited to further increase the co-firing ratio of coarser ASF particles into the main burner flame.

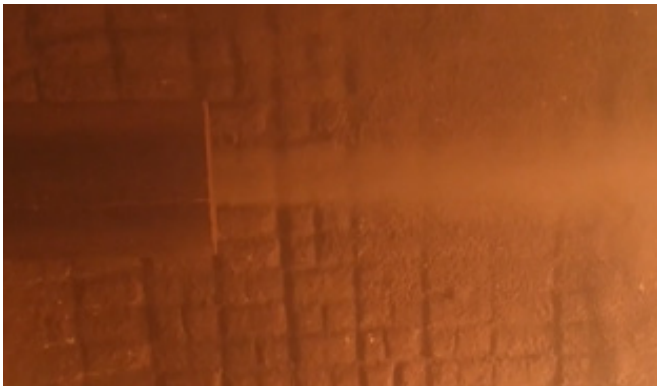
The Pillard PFZ™ system is used in combination with a high efficiency Pillard NOVAFLAM® Evolution burner in order to obtain improved better ASF injection flexibility and co-firing ratio.



STRAIGHT TO THE RIGHT POINT

The Pillard PFZ™ device enables ASF injection in the most favorable zone for efficient particle combustion and good kiln operation. Indeed, particles have to remain in the most turbulent, hot and oxygen-rich region near the burner zone as much as possible.

Depending on their size and specific surface area, particles can reach this favorable zone using the burner's internal injection device. However for coarse and high moisture particles which need a pre-drying and pre-heating time, the external injection can be the solution so long as kiln geometry and the operating mode is well assessed.



AN ADJUSTABLE TOOL

To master the ideal injection point, the Pillard PFZ™ device allows to modify not only injection orientation and penetration in the kiln, but also solid fuel injection velocity for the best results possible.

More than an injection device, it is an essential tool to adapt to any variation of fuel supply characteristics.



SEVERAL PILLARD PFZ™ ALREADY IN OPERATION

In Japan in 2021, we installed a Pillard PFZ™ injector on a 1,200 tpd clinker rotary kiln. ASF is mainly waste plastic, dry sludge and waste oil which represents a 50% substitution rate. In terms of decarbonization, this installation saves about 38 000 t/year CO₂ emissions.

In France in 2022, we installed a Pillard PFZ™ device on a 1,500 tpd clinker rotary kiln firing up to 5 t/h ASF. ASF is mainly plastic, which represents about a 39% substitution rate. In terms of decarbonation, this installation saves about 40,000 t/year CO₂ emissions.

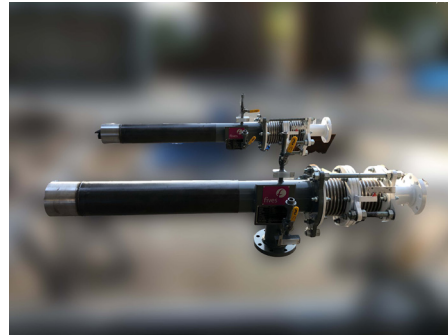
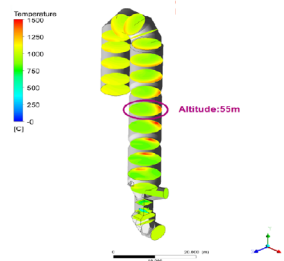
ASF injection solutions in precalciners

Fives proposes a dedicated solution for precalciner ASF injection.

This solution includes a precalciner specific burner **Pillard PRECAJET™** and a customized computational fluid dynamics study (CFD) fluent study.

The **Pillard PRECAJET™** is a multi-fuel, mono-channel injector. It offers the versatile precalciner injector design among the solutions proposed by Fives. The burner is easily customizable: for example, it offers the choice of central or annular injection.

This injector is dedicated to precalciners that combine multiple horizontal low-power burners (<30 MW) to optimize CO and NOx emission reduction. Thanks to its optimized design, it is easily customizable according to any type of fuel configuration.



IN COMBINATION WITH A CFD FLUENT STUDY

Fives is constantly finding new ways to improve the efficiency of our industrial burners and precalciner combustion technology. Thanks to our state-of-the-art CFD expertise and practical experience, we can conduct more detailed combustion engineering projects in order to deliver custom made solutions fitted for each specific preheater or precalciner challenge.

Through our in-house simulations of precalciners, the **Pillard PRECAJET™** delivers excellent results in terms of NOx and CO emissions reduction. This, in turn, lowers the operational cost of the Selective Non-Catalytic Reduction (SNCR) System.

CASE STUDY: 26% of solid AFR (PPE Waste) substitution through Pillard PRECAJET™

Injecting ASF into a region of the precalciner where there is not enough oxygen or without the proper residence time may lead to excessive CO, a buildup in cyclone, an excessive temperature at the calciner outlet, unburnt ASF particles and carbon in the hot meal.

Fives has developed a solution based on a combination of in-house CFD study and the supply of specifically designed **Pillard PRECAJET™** injectors to appropriately locate and maximize ASF firing in the precalciners.

The CFD analysis provided by Fives is key to identify where the O₂ richest zone is and implement accordingly **Pillard PRECAJET™** injectors.

For a big cement player in Southern India, Fives supplied four **Pillard PRECAJET™** injectors (45 MW total load) on a precalciner.

These injectors have been designed to fire PPE waste with a capacity of 7.5 tph.

The CFD analysis has helped to identify the O₂ richest mixing zone in order to:

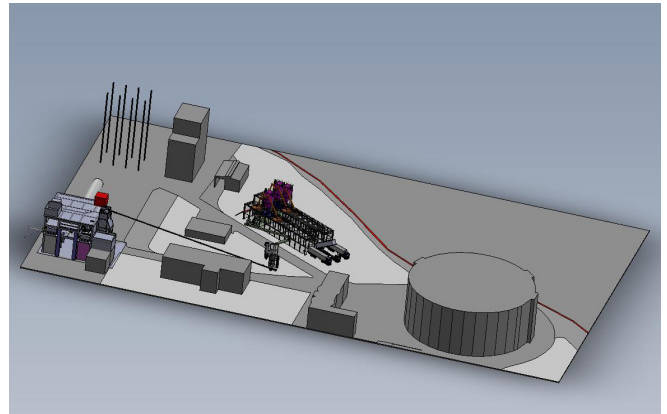
- Rightfully locate the **Pillard PRECAJET™** injectors
- Select the number of additional air injectors
- Define the proper ballistic/impulse/penetration parameters of the injectors fuel and air jets

The additional air injectors provide sufficient jet penetration so that the flows meet in the middle of the calciner and generate an enhanced turbulent mixing, thanks to the ratio between the momentum of the jet and the momentum of the upcoming gas stream from the kiln.

Furthermore, **Pillard PRECAJET™** injectors are equipped with a special **Pillard RST™** air swirling system which, helps to provide the required rotational twists flow of the calciner gases.

Our solutions for ASF storage and handling

Fives proposes a complete scope for ASF handling to feed their burners (Pillard NOVAFLAM® Evolution, Pillard PRECAJET™, and Pillard PFZ™), from storage to injection. Fives supplies tailor-made solutions for temporary AFR injection test purposes or for full production using reliable and sturdy equipment.



WHAT IS THE ASF?

ASF is the term commonly used to characterize solid fuels which are the end product of waste and biomass processing such as:

- Biomass (rice husk, peanut shells, sawdust, sewage sludge)
- refuse derived fuel (RDF)
- solid recovered fuel (SRF)
- solid shredded waste (SSW)
- Fluff

The four lastly mentioned one being a mix of plastics, foam, textile and others.

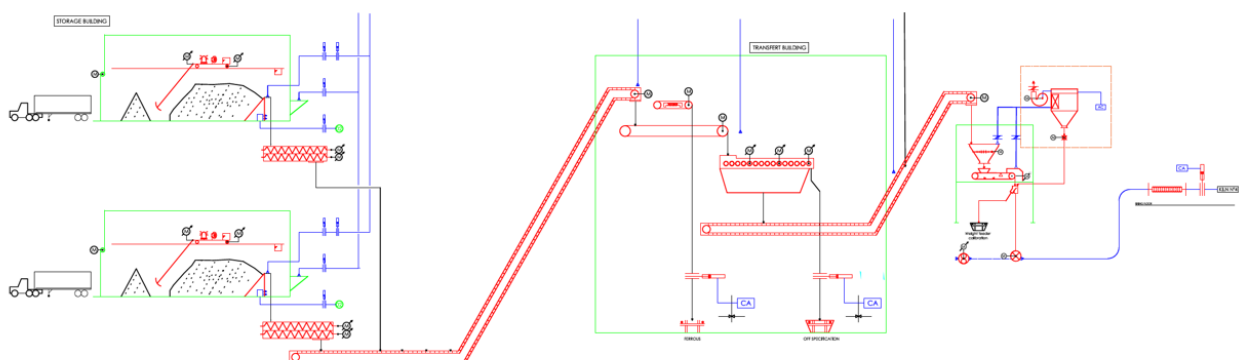


The ASF is usually stored and handled with dimensions of the order of tenth of millimeters compared to conventional fossil fuels which are handled with dimensions in the micron size.

FIVES SUPPLIES A COMPLETE SCOPE

ASF handling systems comprise the following functions:

- Flat storage cells with overhead scraper or bin storage with extraction by a flat band conveyor
- Mechanical conveying
- Sorting of oversized and metallic parts
- Dosing
- Pneumatic injection or mechanical injection



Which solution is the best for you?

Pillard NOVAFLAM® Evolution is adapted:

As a main rotary kiln burner for clinkers, up to 200 MW load, to fire any type of fuel. Burner ASF injection is integral to the burner and enables up to 100% ASF substitution rate (depending on the ASF type).

Pillard PFZ™ is adapted:

Pillard PFZ™ is able to fire up to 80% of kiln capacity (depending on the plants and the ASF involved). In some plants, the total ASF injection capacity from the main burner and the Pillard PFZ™ device potentially reach over 100% kiln capacity. Combined with a Pillard NOVAFLAM® Evolution kiln burner, the Pillard PFZ™ enables significant versatility in terms of usable fuels, and a permanent maximal substitution rate by prioritizing available ASF.

ASF injections within precalciner (Pillard PRECAJET™ and CFD) are adapted:

A global approach by Fives exerts including tailor designed Pillard PRECAJET™ injectors and adapted computational fluid dynamics study CFD complementary study makes it possible to determine the most appropriate injection location to get the best combustion quality and efficiency.

ASF preparations are adapted:

To prepare (store, sort, dose, inject) any kind of ASF to fire them either in the burners rotary kiln burner, or in the precalciner.

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