

Environment Affecting Grate Design

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The problems facing consultants, operators and/or any ultimate user is a lack of intimate knowledge of the considerations that are imposed on the stoker designer. It is the intent of this discussion to review many of these items briefly. Naturally, this cannot be a treatise on machine design nor should it be expected. A review of the environments which influence the designer may be tabulated as follows:

TYPE OF SERVICE

- a) Impact Loading
- b) Ambient Temperature
- c) Maximum Service Temperature
- d) Abrasiveness of Fuel
- e) Fineness of Fuel

DESIGN CONSIDERATIONS

- a) Length of Service – Service Factors
- b) Type of Drive – Intermittent – Continuous
- c) Material Considerations for
 - 1) Stress & Temperature (Radiation)
 - 2) Abrasiveness & Shock
- d) Ease of Maintenance
- e) Air Flow Characteristics
- f) Cost Factors
- g) Speed of Surface
- h) Seals – Power – Cleanout

APPLICATIONS

- a) Standard Sizes & Modules
Each will be discussed separately.

TYPE OF SERVICE

IMPACT LOADING

Basically, all stoker designs have one thing in common, i.e., a fuel supporting surface must be provided. If this surface is to be loaded, considerations must be given to the static load and the impact load. The impact load is always greater than the static load and a factor of 5 to 1 is generally applied. Even then, this may not be sufficient because impact is dependent on the coefficient of restitution. In other words, ten pounds of putty dropped on a grate would not have the same effect as a ten pound cube of steel nor would the impact be the same if the cube landed on a side rather than a sharp edge.

The fuel supporting surface should also be designed to consider deflection under a static load. This deflection is usually less than 1/8 to 3/16 of an inch.

AMBIENT TEMPERATURE

The design of any stoker has to take into consideration the ambient temperature. For normal service, temperatures should be restricted to 350° although special applications outside of the incinerator

field have been designed for temperatures as high as 1000 F under down-draft conditions. In the design, consideration has to be given to provide for expansion. Normally, this means that one side of the machine must be fixed. Temperatures of the compartments may differ widely from the surface temperature of the fuel supporting surface and provision for independent adequate expansion must be provided. A rigorous analysis of the temperature conditions must be undertaken before any new design is considered. Background on all fuels is important in this area.

MAXIMUM SERVICE TEMPERATURE

The maximum service temperature of the grate surface shall be held at a temperature not exceeding 1000 F for a reasonable life expectancy. For grate surfaces, toughness and ductility are not requirements. The ability of the surface to be as ductile as steel at atmospheric temperature is unnecessary. What is important, is that those parts exposed to the fire have the ability to resist high temperatures and subsequent growth and be more ductile at elevated temperatures, at the same time be produced economically. Resistance to oxidation increases with silicon content in cast iron and is excellent at 6 percent; the casing, however, is extremely brittle. Where shock resistance is not required, high chrome nickel alloys are used for elevated preheated air temperatures.

ABRASIVENESS OF FUEL

While this is a design factor for consideration, normally good sound machine design practices preclude trouble in this area. Bearing surfaces should be shielded and protected from dust laden atmosphere. They should be external wherever practical, as well as easily accessible. Normally, friction factor is not an item and rolling surfaces frequently do not roll. The increase in friction factor due to abrasiveness is considered in the torque requirements and the friction factor itself.

FINENESS OF FUEL

The grate supporting surface should be designed to minimize siftings which result from superfines in the fuel and moving parts should be shielded so that superfines do not accumulate or agglomerate on them.

DESIGN CONDITIONS

a) Service Factor — All units, regardless of the type, should be designed for 100 percent service factor capable of starting under full torque.

b) Type of Drive — The largest single factor in the selection of drive is whether it is intended for intermittent or continuous operation. A safety factor should be applied to the torque input. All drives should be equipped with some overload protection device such as a shear key or slip clutch. Drives should be located external to the machine where they can be properly inspected, lubricated, cleaned and maintained.

c) To appreciate fully why metals have specific uses and why they are cast or worked in a particular way, it is necessary to understand what metals are, and what gives them their useful properties. Such information provides a background for intelligent manufacture of the material best suited to a particular application and enables one to determine why an article may or may not be expected to perform the service required of it.

When an engineer designs a metal article, he must select the best and least expensive material and the best and cheapest manufacturing process and see to it that the material and processes used are the ones he has specified. His work requires that he be able to consult with the metallurgist and understand the possibilities and limitations of his materials and processes. For this he must first understand the nature of the metals and the conditions to which the metal will be exposed.

Resistance to deformation is one of the many important engineering properties common to most metals. Many metals preserve their shape well and are useful for materials from which to make articles subjected to stress in service, but the resistance to deformation must not be so great that it is impossible to shape the metal into useful form by some practical means. The various metals resist deformation to a greater or lesser degree and represent a wide range of compromise between ease of manufacture and ability to withstand service and temperature stresses.

The resistance of a metal to deformation bears various names depending upon the kind of stress the metal is required to resist, i.e., strength, rigidity, hardness and wear, fatigue or creep-resistance. The amount a metal can change in shape without fracture in the process of manufacture is called ductility or malleability and a combination of ductility and strength is toughness. The elasticity of a metal is its ability to return to its original shape after being deformed within certain well defined limits.

All of the above properties are taken into consideration when considering a stoker. The stress at elevated temperatures can be quite high and due

to radiation on uncovered grate surfaces, temperatures can be uncontrollable for short periods of time. The designer must recognize this and design accordingly.

d) Ease of Maintenance – Stoker maintenance is effected by many factors such as: ash content, control systems, segregation of fuel, load factor and operating techniques.

Of course, there is the mechanical type of maintenance which is handled on anormal routine basis. There can be no substitute for good design, erection, and workmanship. Replacement of parts with care and consideration is important. If a piece or part looks like it might last and you are anticipating a reasonable usage factor, replace it at the first opportunity.

Do not compromise immediate economics with prolonged outages when load carrying capacities can be critical. Inventory of more frequently used parts is essential. Deliveries can not always be made as quickly as they may be required. A good preventative maintenance program pays dividends.

The question arises as to how do the other problems manifest themselves, and what can be done to correct them. Generally many stoker operating problems become apparent when key growth or key burning occur. This situation may start in a few isolated sections but soon can become malignant unless the cause of the problem is known and immediately isolated.

We have all heard explanations as to why a grate surface burns. Insufficient air is probably the most common explanation and all to frequently incorrect. The answer is quite simple, keys burn because they get too hot. Let us explore this further in the interest of isolating cause from effect.

Manufacturers, clients and research organizations have developed some techniques which can be used to determine the cause of many grate burning problems.

The use of Tempstick or similar paints to determine grate temperatures can be used. This method consists of marking or painting the grate surface with a substance that will change color or disappear at a stipulated temperature. The results obtained from this method can give you maximum temperatures that the surface is subjected to, but unfortunately there is no way of knowing where or when the temperature peaks occurred and hence limited basis for study. It is, however, a rather simple check and may be used in conjunction with metallurgical analy-

ses when improper material selection or quality is suspected.

A more informative method is one in which thermocouples are actually peened or wedged into individual test keys or grate areas. On a travelling grate their progress in distance and time can be plotted against temperature. All other pertinent factors or known factors should be recorded.

In any analysis of this type care must be exercised to analyze the data on a time – temperature basis. Instantaneous peaks may not be as dangerous as sustained soaking heats. For unalloyed cast iron grate keys, peaks of 1000 F or higher can be reached if not sustained.

Similar tests can be used as a guide to good firing practices since they reveal many factors such as:

- Ignition Point
- Effects of Segregation
- Effects of ash content for comparison
- Fuel distribution problems
- Draft considerations

e) Air flow characteristics – All ducts should be designed with velocities not exceeding 2500 FPM. Abrupt entrance and exit conditions should be avoided and sufficient tolerances should be applied both on static and volume in the selection of fans. In order to get uniform air flow through a grate, pressure drop must be designed into the system. Flows vary as the square root of the head and fixed resistance must be designed into the system, particularly for low load operation. Unfortunately, this has to be at the expense of power consumption.

f) Cost factors – All of these items have to be done within an economical position that can be accepted. This probably is the designers biggest problem.

g) Speed of the surface – With the exception of a fixed grate, all fuel supporting surfaces must provide a means of removing the residue. With the more common incinerator designs, they also provide a means of feeding the refuse. Speed or cycles must be considered with a reasonable safety factor since the burning is based on a wide variation in Btu input.

h) Seals – Power – Cleanout – Seals provide two purposes. They prevent abrasive material from getting where it doesn't belong and permits control of air at the point where you want it. Power is directly related to the work done and the prime movers should have reasonable tolerance to compensate for our inability to estimate precisely the work required.

Cleanout serves two purposes. It provides access for inspection and maintenance.

APPLICATION

STANDARD SIZES AND MODULES

Of all the machines in operation today, stokers have had as much service as any piece of equipment. Mechanical stoker firing is credited to James Watt, who in 1785 patented a device combining a coal hopper, a fuel burning grate and provision for refuse disposal. In 1848, Jucke was awarded patents for burning coal on a continuously moving, non-agitating type of grate which is the father of many of the continuous feed stokers of today. There is evidence that in spite of our modern economic approach to standards, the stoker was one of the earlier devices

which was made up of a series of standard modules adaptable to standard size machines. The very nature of assembling multiple castings which were required for the process developed a standard component, both as to size and makeup.

It is next to impossible to specifically mention dollar maintenance because of the varying operating conditions. The designer has to take and apply sound practices, be flexible in his evaluation of his own equipment and be receptive to change and new ideas. Foremost in his mind should be the fact that no design can be static and individual components should be considered in a manner which would permit progressive economic change.