RESIDUAL FUEL OIL AS A SUPPLEMENTARY FUEL

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Abstract

The need for supplementary fuel in local sugar mill steam raising plant has long been accepted. While solid fuels have always been used for this purpose, the alternative liquid petroleum fuel oil may well find a place for such a service. The basic needs, requirements and techniques when considering the use of heavy fuel oil for this service are discussed in this paper.

Introduction

To appreciate that supplementary fuels are extensively used in our sugar industry, it has been reported that during the 1961-62 milling season 130,150 tons of coal and wood were used as additional fuel to bagasse at an average cost of R0.60.3 per ton of sugar produced. For various reasons shortages of bagasse occur from time to time necessitating the use of an additional fuel to maintain steam for factory needs. Despite frequent enquiries and discussions relating to the use of such fuels they continue to be used. Coal, and to a lesser degree, wood, have been the supplementary fuels used. Economics and supply have always been the reason for their selection. Whether convenience has played an important part in their selection is immaterial, for they have enjoyed widespread use and apparently continue to do so.

More recently residual fuel oils have become readily available locally and some interest has already been shown in the use of such a fuel for this purpose. It is the intention to provide some basic information such as characteristics of this type of fuel oil, the storage and handling of such a product and some operating techniques regarding its preparation for firing. Some thoughts on equipment and conversion problems are included.

The Economics of using Fuel Oil

It will be appreciated that the economics will vary largely from mill to mill when considering the use of a specific supplementary fuel.

A direct thermal comparison will reveal that coal is more economical to use than fuel oil, but this is not conclusive, as many other factors bear consideration. The prospective users' present needs, e.g. existing firing arrangements, location, labour force, etc., etc., can and will influence the selection of the particular type of fuel to be used. Directly related to these factors should be production and profit losses due to shut down and/or change over from one fuel to another. The easiest and most rapid method is obviously advantageous. Only by considering the complete operation can a true and factual assessment be made of the economical necessity for incurring the capital expense to convert to supplementary fuel oil firing or continue with one of the more conventional methods practiced today. Factors such as basic fuel costs, handling and storage, ash disposal, operating costs, capital expenditure and labour charges have to be thoroughly investigated to determine the most desirable arrangement.

The Need for Oil Firing

Boilers originally designed for bagasse firing present certain physical problems when oil burning equipment has to be installed. It should be appreciated that the conversion to oil is of a supplementary nature and is to be used when the normally available fuel, i.e. bagasse, is in short supply or is unavailable due to breakdown or stoppage.

The question of bagasse shortages have been the subject of many thorough and probably controversial investigations in the past, but despite this such shortages persist to a varying degree necessitating the provision of supplementary fuelling arrangements.

A question asked is whether a bagasse fired boiler can operate satisfactorily on fuel oil. The prospective user may even expect a boiler efficiency of up to 80 per cent under such conditions, because this can be readily obtained with fuel oil equipment. As the proposed conversion is intended to cater for emergency periods when the normal fuel — bagasse — cannot be provided the user will be pleased to be in a position to supply steam for his requirements, even at an increased cost, thus maintaining production and not reducing or even entirely losing profits through a complete shut-down. Under such conditions the question of efficiencies will be of secondary importance.

Therefore, bearing in mind that although economics reveal boiler operating costs to be high, when comparing oil against coal, and that such conversion will probably not result in the high efficiencies of oil-fired systems, or that the boiler manufacturer may consider it impractical to convert because of either of the above reasons, basic economics demand that the mill continues to operate and produce.

Legitimate practical objections presented by the boiler manufacturer can probably be overcome by modification of their normal conversion techniques and thus assist the user to maintain the continuous supply of steam so necessary for his plant.

Key to Fig. 1:

A. Cold Oil Filters — Coarse.

B. Fuel Oil Pumps.

C. Fuel Oil Preheaters.

D. Hot Oil Filters — Fine.

E. Oil Feed Line to Additional Burners.

F. Burner.

G. Oil Return Line from Burners.

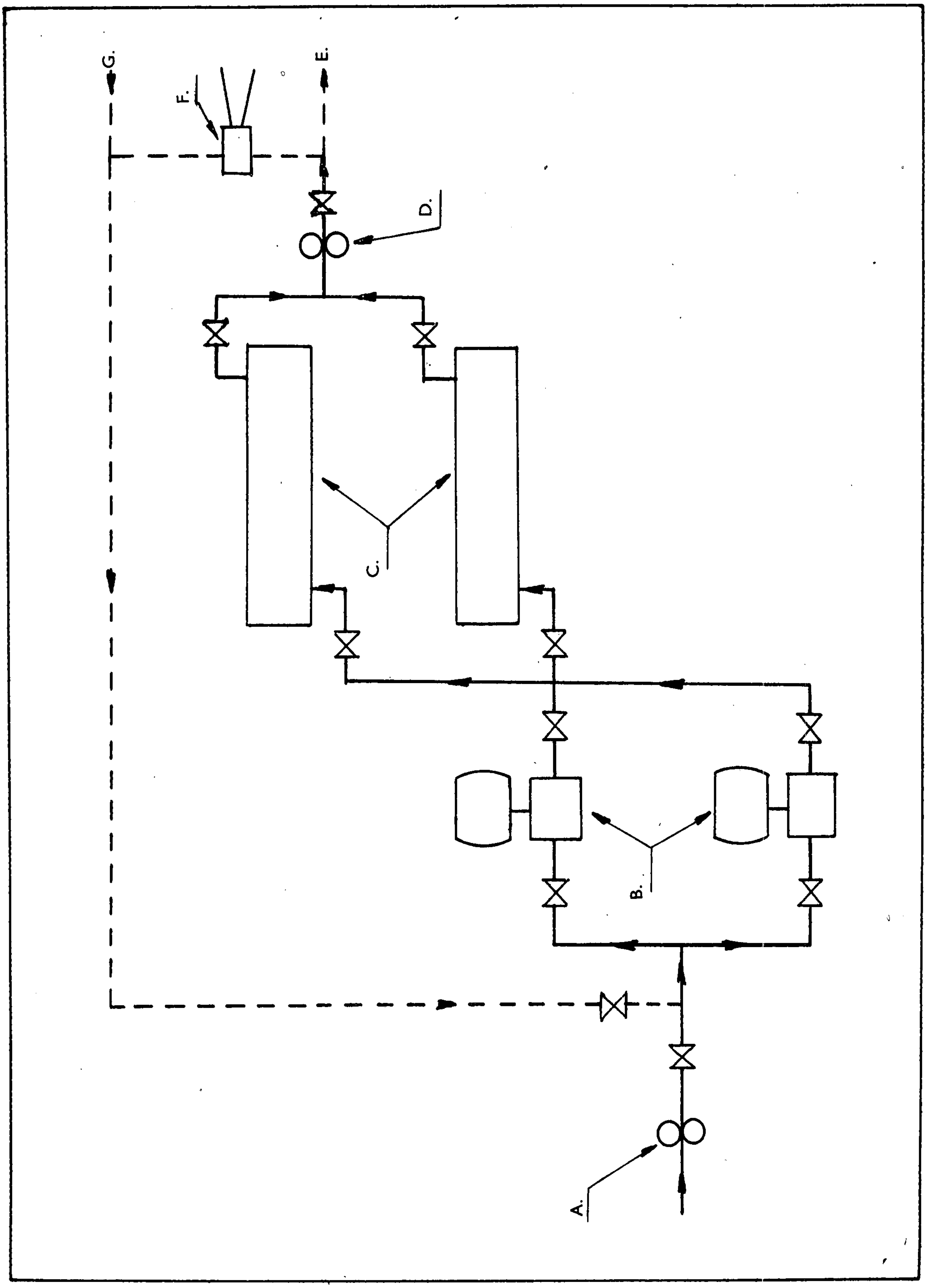

FIGURE 1.—Basic Layout of Ring Main Equipment

Residual Fuel Oils

The specification shown below is typical of a heavy residual fuel oil obtainable here and is suitable for a wide range of applications including that of a boiler fuel.

Table I

Typical Physical Characteristics

A.P.I. Gravity	17.5
Specific Gravity	0.95
Viscosity — Redwood No. 1 at 100° F. secs.	950
Pour Point, ° F.	20
Flash Point — Minimum °F.	150
Typical ° F.	220
Sulphur — % Maximum	3.5
Ash %	0.05
Calorific Value — Btu per lb.	18,500
Btu per gallon	176,000
Imperial gallons per ton	237

Under certain circumstances, these relating to some specialised applications, it may be possible to obtain a residual fuel oil basically the same as shown above, but having a lower viscosity. However, a fuel oil of the type shown is entirely suitable for steam raising purposes as now primarily under discussion.

Internationally, the Redwood Viscosity at 100° F. is extensively used to describe a fuel oil and that shown here would refer to a "950 second" fuel oil.

Storage and Handling

Because of the physical properties of residual fuels certain conditions and facilities are needed for their satisfactory handling and preparation for service. The storage facilities necessary may vary and are dependent upon consumptions and the location of the mill. An indication of what may normally be required is shown below.

Storage Tanks — the capacity of these would be dependent upon estimated consumptions, the distance from supply point and the method of delivery, normally rail tank cars. Their size and location is determined by available space at the mill, always considering rail facilities and distance to the boiler house.

Outflow Heater — this is fitted to the tank and is either electric or steam/electric and is sized to maintain the oil at a suitable viscosity for pumping so as to supply maximum operational requirements.

Tank Valves and Piping — suitable piping and valves for filling and discharge lines are needed and should be traced and lagged where necessary.

Transfer Pumps — these may be required and they too should be sized to supply the maximum plant requirement from the main storage tank to the service or day tanks.

As this is a viscous product, the ambient temperature plays an important part in the handling of the fuel oil. Minimum temperatures should be observed and the pumps used must be capable of handling the fuel at the lower temperatures, thus outflow heaters are installed to increase the temperature and reduce the viscosity that this may be achieved.

It is not intended to enlarge on the storage aspect but to conclude by noting that safety should never be overlooked. Location, relative to thoroughfares and fire hazards are important, and the design of such storage facilities should always be based on sound engineering principles and practice.

This aspect is normally handled by the supplier of the fuel, who is able to advise on the best practical arrangements.

Fuel Firing Equipment

The type of burner selected will determine the method of supplying fuel oil to them.

On boilers of the type and size under discussion, the distribution of the fuel oil to the boiler by means of a ring main is preferred. In this manner the fuel oil can be supplied to the burner at a constant pressure as well as at the desired temperature for efficient atomisation and burning. The pressure in such a ring main is dependent upon the burner selected, but can be adjusted to suit varying conditions should they arise. A typical system is illustrated in Fig. 1, which shows the various items of equipment that should be provided. Some comments on the type of equipment used on a typical ring main system handling heavy fuel oil are given.

Pumps

Positive displacement pumps are recommended and readily obtainable. The most common types used are rotary pumps which can handle high viscosity fuel oils. They are reliable even when pumping hot oil continuously and are not oversensitive to the presence of vapour in the oil. They can be either electric motor or steam driven, but as the power requirement is not excessive, electrically driven pumps are preferred. Built in relief valves are necessary and avoid any damage to the system, particularly when starting up from cold. The pump size should be such as to supply oil in excess of what is intended to be burnt in the boiler. A pump capacity of 50 per cent to 100 per cent in excess of the maximum hourly consumption rate of the boiler would be considered satisfactory. It is normal to provide a dual pumping system for such a service.

Preheaters

It may be considered desirable to install a steam and electric fuel oil preheater, but capital and operational costs may decide against this. Steam preheaters of suitable capacities can be obtained and should be fitted with a reliable thermostat control system. Excellent thermostatic controls are obtainable which will maintain the oil temperature within a range of 5° F.

Although atomising temperature may be known, it sometimes occurs that under actual operating conditions it is found necessary to vary this temperature for improved atomisation and more satisfactory burning. Bearing this in mind the preheater should be

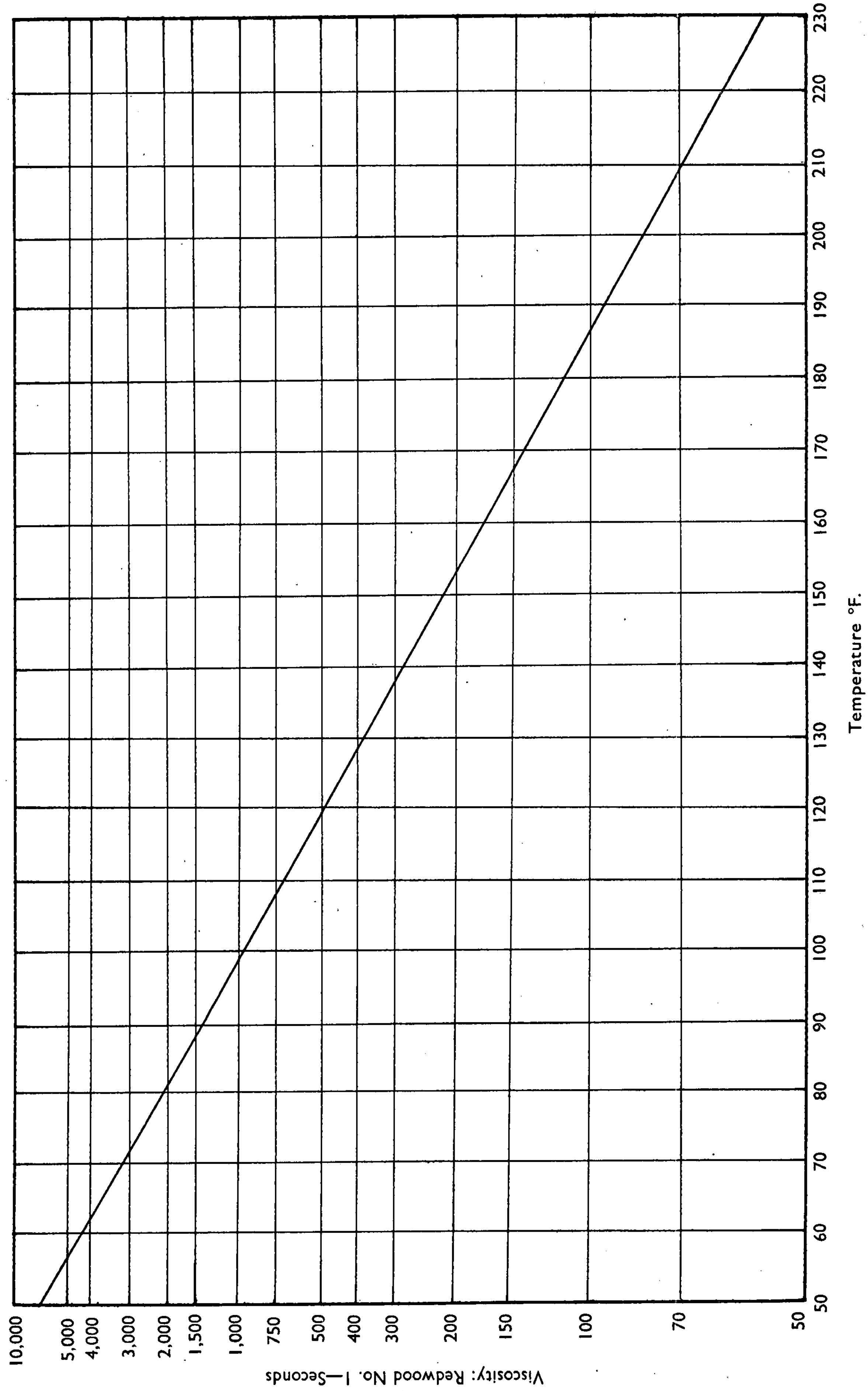

FIGURE 2.—Temperature—Viscosity Relation

able to provide the maximum quantity of fuel oil at required temperature and in addition be so designed, to supply at a higher temperature, as it is frequently necessary to vary these oil temperatures until the most satisfactory burning conditions are determined.

Slight variations in the viscosity of the fuel oil as supplied may occur. If a particular burner is sensitive to viscosity and will not atomise the oil satisfactorily a change in preheat temperature will be needed. This is another reason that some flexibility is required.

With regards to electric preheaters these should be so designed that element loadings do no exceed 10 watts per square inch of heating surface. Oxidised fuel oil deposits on the elements may occur if this is exceeded. The recommended design factors for oil preheaters are given in B.S.S. 799. Fig. 2 shows the temperature-viscosity relationship for residual fuel oils. The curve is that of a typical fuel oil and from it the desired preheat temperature can be obtained when knowing the viscosity at which the oil should be supplied to the burner. The curve is for a "950 Second" fuel oil. Viscosities of other fuel oils can be determined by drawing a line parallel to that shown after plotting the known viscosity at 100° F.

Filters

In order to protect the fuel oil pumps, coarse filters are fitted in the supply line from the storage tanks to the pumps. In addition, fine filters are located on the hot oil side. This serves to protect any equipment having fine clearances and minimises the possibility of burner deposits. Effective straining of the oil before it is circulated to the burners is essential as any restriction or clogging of the burner nozzle will impair atomisation causing poor burning conditions. Basket perforations can be 1/16 in. and 1/32 in. diameter for the cold and hot lines, but burner design features may necessitate the provision of different sizes to these.

The strainer area should be in the range of 300 per cent larger than pipe cross-sectional area.

It is usual to install dual filters in order to maintain continuous operation when filters have to be opened for cleaning.

Pressure Sustaining Valves

It is necessary to maintain the circulating fuel oil pressure at a constant value. To attain this a pressure sustaining valve is located in the pipe system at a suitable point. Such a valve should be sized to handle the maximum flow of oil and may be spring loaded or of the diaphragm type. It is considered essential to provide a hand operated bypass valve to be used under cold start up conditions or should the pressure regulating valve fail.

Lagging of Fuel Pipes

Ring mains should be suitably lagged in order to reduce the heat loss and maintain the circulating oil at the required temperature during operational periods.

Under certain conditions it may even be necessary to provide steam or electric tracing over which the lagging is fixed. Piping containing static fuel oil should be traced and lagged to enable rapid start-up when necessary. When installed and operating the system should be able to handle and supply to the burners mounted on the boiler the desired amount of fuel oil at the required temperature. In designing the system dual arrangements for filters, pumps and preheaters should be incorporated, that continual operation is assured. It will be appreciated that actual ring main design is determined by the type of burner installed. Therefore in Fig. 1 the filters, pumps and heaters shown may be suitable for many systems, but the piping arrangements from the fine filters, D, to the burners, together with any return piping and oil pressure controls would vary from system to system.

Oil Burners

Because of excellent flame radiation, improved evaporation rates may be expected providing the combustion chamber construction with respect to refractories and insulating bricks is suitable for the higher thermal load when operating on fuel oil.

It is probable that steam temperatures may be reduced due to lower gas temperatures at the superheater. If it is not possible to maintain the required steam temperature, the quantity of excess air can be increased thereby reducing the flame temperature, and flame radiation, thus allowing higher gas temperatures, and improving the superheat conditions. This, however, results in high backend and stack temperatures with a corresponding reduction in efficiency. Boiler design with respect to these items, i.e. combustion chambers, gas flow rates and fans will have to be examined and the necessary modifications provided which will ensure acceptable operating conditions.

The selection of any particular type of burning arrangement would largely depend upon the recommendation of the boiler manufacturer. As he is fully aware of the specific design features of his boiler and the need to operate satisfactorily on fuel oil, his recommendations should be conscientiously considered.

He, in turn, should bear in mind that any potential conversion to fuel oil is done to maintain steam supply during comparatively short emergency periods when the normally used fuel, i.e. bagasse, is in short supply. He will then be providing an essential service to his customer even should his converted boiler not operate at the efficiency rate that his regular oil-fired units do. Modern fuel oil burners are designed to supply oil at a suitable degree of atomisation and vaporisation to ensure rapid ignition and continuous clean burning characteristics. To do this the fuel oil must be supplied at the correct temperature and pressure. This means that the equipment installed, i.e. filters, pumps, heaters must be complementary to the burners selected. It is not intended to discuss burners in great detail but rather to provide a brief description of certain types. Several types are used on larger steam boilers, the more frequent being:

1. Steam Atomising Burners.
2. Pressure Atomising Burners.
3. Rotary Cup Burners.

1. *Steam Atomising Burners:* These are designed for use on medium to large boilers where several burners are installed to supply the required quantity of fuel oil.

Oil is supplied at the comparatively low pressure of 30-60 p.s.i., and steam at a higher pressure of 80-140 p.s.i., or approximately double the oil pressure. A steam consumption of below 2 per cent of boiler evaporation is acceptable but a figure of 1 per cent is desirable on large units and should be aimed at. Turn-down ratios of up to 10-1 are obtainable on steam atomising burners.

2. *Pressure or Mechanical Atomising Burners:* Atomisation of the fuel oil is achieved by supplying heated fuel to the nozzle at pressures in excess of 300 p.s.i. An advantage of this type of burner is that operating costs are lower as no air or steam is needed for atomisation. In addition maintenance costs are usually found to be lower. Mechanical atomising burners can be of the return flow or straight through flow type and also have turn-down ratios of up to 10-1.

3. *Rotary Cup Burners:* Rotary cup burners are supplied as a complete unit which includes motor, fan, oil pump, burner cup and oil preheater. In addition ignition devices and flame failure controls are included. The initial cost of such a unit is somewhat high but large units are available and can be used for conversions of the certain types of boilers.

Rotary cup burners achieve atomisation from the centrifugal action of the cup into which oil is fed. Air from the fan mixes with the spray of oil resulting in fine atomisation.

Ignition Systems

For the type of operation under discussion a sophisticated ignition system using gas, oil and electric spark is not considered necessary. Torch ignition has certain disadvantages mainly concerning safety or fire hazard, but proper procedures can eliminate any dangers thus reducing installation and operating costs. Rotary cup burners have an ignition system incorporated.

Operating Conditions

To ensure smooth change over to fuel oil the operating personnel should be fully instructed in the new technique. They should be aware of the fuel oil temperature requirements, the layout of the system and method of operation.

It will be readily appreciated that no plant can operate satisfactorily unless the operators are properly trained and the system is kept well maintained and ready to be used when needed.

Much has been said of corrosion and slagging problems experienced with oil-fired boilers. Many theories have been advanced regarding the causes of high and low temperature corrosion of metal surfaces in boilers. The same applies to slag formation in high temperature zones of boilers and this can be related to certain fuel oil characteristics.

To overcome and reduce these problems certain operating techniques have been suggested, including the use of fuel oil additives. This aspect could well be the subject of a paper itself and will not be elaborated on here. Suffice it to say that despite these problems fuel oil is enjoying wider use and slagging and corrosion is under continual investigation to determine the most suitable means of reducing and overcoming their effects.

Conclusion

As the supply and use of coal and wood have presented problems during recent years, some thought towards the use of an alternative supplementary fuel must be given. The use of residual fuel oils as an established supplementary fuel in place of bagasse will require much investigation to determine the economics as well as the suitability for conversion. Assistance in this direction will be forthcoming from interested parties, namely, the boiler manufacturers, the suppliers of oil burning equipment and fuel oil suppliers.

In future it may well be more economical to use a supplementary fuel and divert bagasse for the manufacture of paper or similar products, which could prove to be a profitable decision.

Diesel Engines

Complementary with the use of residual fuel oils in boilers as an additional fuel is that of Diesel engines operating on such a product. A brief discussion on this is given.

The use of residual fuel oils as a Diesel engine fuel has been practiced for many years. This practice was established on marine engine applications, but, today, many large stationary engines use this type of fuel. The reason of course is economics, as the basic cost of residual fuel oils is considerably lower than the normally used automotive diesel fuel. This practice is limited to slow-speed units where high centane numbers of fuel oils are unnecessary.

With the light fuel the main requirements before supplying the fuel to the engine fuel pumps is filtration. With heavier residual fuel oils a more involved arrangement is needed. The normal procedure is to cold filter the oil, heat and centrifuge it, then store it in a service tank. There it is held in a temperature of 100-140° F. before further filtration and heating to an operating temperature of 180-200° F.

Certain operating problems must be guarded against. The higher cylinder and ring wear rate on engines is directly attributed to the ash and sulphur content of the residual fuels, ash causing abrasive wear and sulphur corrosive wear. Since the advent of this practice much development has taken place with special high additive oils for cylinder lubrication. These 'Super' oils are of high alkalinity, thus combating the ill-effects of corrosion. In addition, their excellent dispersant ability keeps the ring area free of undesirable deposits. Today, with the use of such lubricants in these large slow-speed units, wear rates approaching those of Diesel engines operating under conventional methods are obtained.

The initial cost of providing for the satisfactory preparation of residual fuels is costly as special filters, centrifuges, oil heaters, pumps and service tanks with heating arrangements must be installed. However, with proper preparation, control and operation this can be justified. This information is given for the interest it affords, but it is not anticipated that such systems will be extensively used in the sugar areas of Natal, unless comparatively large Diesel powered electric generator plants are needed.

References

A.S.T.M. 396 — Fuel Oils.

Buck W. (1962) — The Problem of Additional Fuel, S.A. Sugar Tech. Assoc.

B.S.S. 799 — Oil Burning Equipment.

B.S.S. 2869 — Oil Fuels.

Mr. Bentley (in the chair): Sugar factories on the whole probably use more additional fuel than they should. I personally prefer fuel oil to coal as a supplementary fuel but it is expensive and I wonder if Mr. Gudmanz can tell us what price fuel oil can be supplied to a factory to make it competitive with coal.

Mr. Gudmanz: Owing to railage and other charges fuel oil for the sugar industry is probably at present twice the cost of coal but it is possible that its price might come down.

Mr. Gunn: If the price of oil fuel was reduced sufficiently to make its use economical would there be sufficient available in South Africa to supply the industry's needs?

Mr. Gudmanz: The change-over would be gradual and therefore the oil fuel suppliers would have sufficient time to organise supplies.

Mr. Fokkens: When costing oil fuel against coal in Cape Town, taking into account all charges, oil fuel was R19.00 per ton against R12.50 for coal.

Mr. Hurter: What would be the cost of generating power using oil instead of coal?

Mr. Gudmanz: I do not have any figures available.

Mr. Ashe: At Umfolozi we are running a 1,000 kW alternator on residual fuel. The average load is 600 kW and we are saving R4 per hour. One disadvantage is that the fuel has to be centrifuged and the centrifuges require cleaning twice a day.

Mr. Hulett: There is no reason why molasses should not be used as fuel if you adjust your burners properly.