Total Energy Concept for Integrated pulp and paper Mills

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"Total Energy" is a system in which the needs of power and heat of a plant are met through a prime-mover also integrated with fullest possible waste heat recovery and utilisation. An integrated pulp and paper mill is a typical application of this principle due to its requirement of large quantities of power and low pressure steam in the process as well as the availability of by-product fuels from process wastes. The fact that the paper industry is a follower of this concept is evident from the substantial or total in plant power generation by most integrated mills, which has also resulted in their survival in the present power crisis.

The ideal power and steam system for a mill is shown in Fig. 1, where all the energy remaining in the steam after power generaation is utilised in the process. The reasons for this not being achievable in practice have been elaborated. In Fig. 2 the increased power generation possible at different initial steam conditions per Kg steam required in the process have been plotted.

Alternate systems normally followed for over-coming the steam and power imbalance in an integrated mill have been discussed and the energy utilization efficiency of a total energy system has been compared with condensing power generation in Fig 3. The advantages of a Gas Turbine in the mill's energy system have been detailed and a typical arrangement is shown in Fig 4.

Some of the steps to be taken in the design and operation of integrated pulp and paper mills for improved utilisation have been listed.

For the manufacture of pulp and paper, energy is required in the form of electricity, steam, hot air etc. Demand for electric power, has increased at a very fast rate, all over the world in the last few years both for domestic and industrial consumption and the increase in generation capacity is not able to keep pace. This acute shortage of power is also the experience in our country. and it has become detrimental to industrial production and growth, although our total annual energy consumption is estimated at 0.1×10^{12} watt years (about 3% of the U. S. A.). The problem has been further aggravated by the restricted imports and inadequate availability of Fossil fuels (coal, oil, gas etc.). While it is certain that the power shortage will be overcome in the course of time, by optimum utilisation of the available facilities and by installation of additional facilities, possibly based on Nuclear fuels, the need for maximum and efficient utilisation of the energy inputs will always remain a critical factor in process system design and operation.

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Another important aspect in this connection is the recovery and utilisation of energy from process by-products and wastes. 'Total Energy" is a system in which the needs of power and heat of a plant are met through a prime mover also integrated with fullest possible waste heat recovery and utilisation. Some practical attempts towards this concept in integrated pulp and paper mills are discussed here.

In an integrated pulp and paper mill the residue of the fibrous raw material is an important source of energy. The spent cooking liquor processed through the chemical recovery boiler often provides about half the total energy requirement. Burning the Barks, Fines and other wastes in an incinerator to produce hot water, lowpressure steam or hot air is another means of utilising this source. The availability of this inexpensive source of energy, the requirement of large quantities of low and medium pressure steam in the process and the isolated locations have motivated and resulted in substantial or total in-plant steam and power generation by most of the integrated pulp and paper mills. But for this inplant power generation, many mills would not be operating in the present power crisis.

From the total energy concept, the ideal steam and power system of an integrated mill is as shown Fig 1. This is based on generating steam at substantially higher energy level than required for the process and converting this excess energy into electric power. The best total energy utilisation will be achieved when all the energy remaining in the steam after power generation can be utilised in the process and the energy losses at different stages are the minimum possible. The energy level at which steam will be generated will be determined by the quantities of steam required at different energy levels in the process to make a tonne of paper. For an analysis a medium sized integrated mill making writing printing papers from Bamboo and Hard Woods may be considered, where the different quantities are likely to

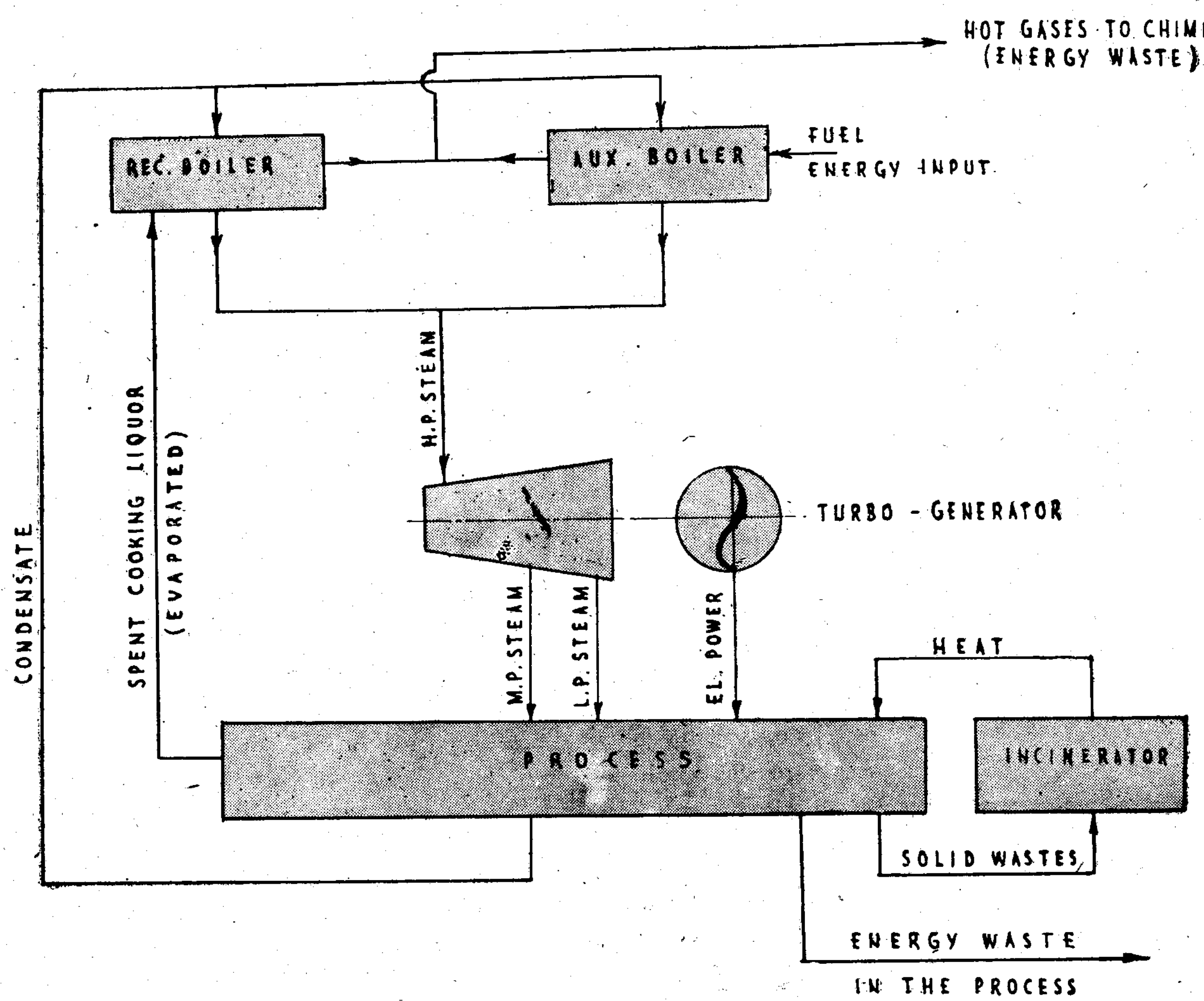

Fig. 1—Total Energy System With Steam Turbo-Generator

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(a) Process steam equirement	tonne/tonne paper
Low pressure (3.0 Kg/cm²) for Paper drying, liquor evaporation etc.	8.0
Medium pressure (7.0Kg/cm²) for cooking and other usage.	3.0
	11.0
(b) Power requirement	1400kwh/tonne paper

In Fig, 2 the Kgs steam required to generate one kwh power while exhausting at 3 and 7 Kg/Cm² respectively has been plotted against different initial steam conditions. From this it will be seen that by generating steam at about 40 Kg/cm² gauge and 335°C at the rate of 11 tonnes/tonne paper and reducing 8 tonnes to 3 Kg/cm² and 3 tonnes to 7 Kg/cm² in a steam turbine the total energy requirement of the process by way of steam and power can be met.

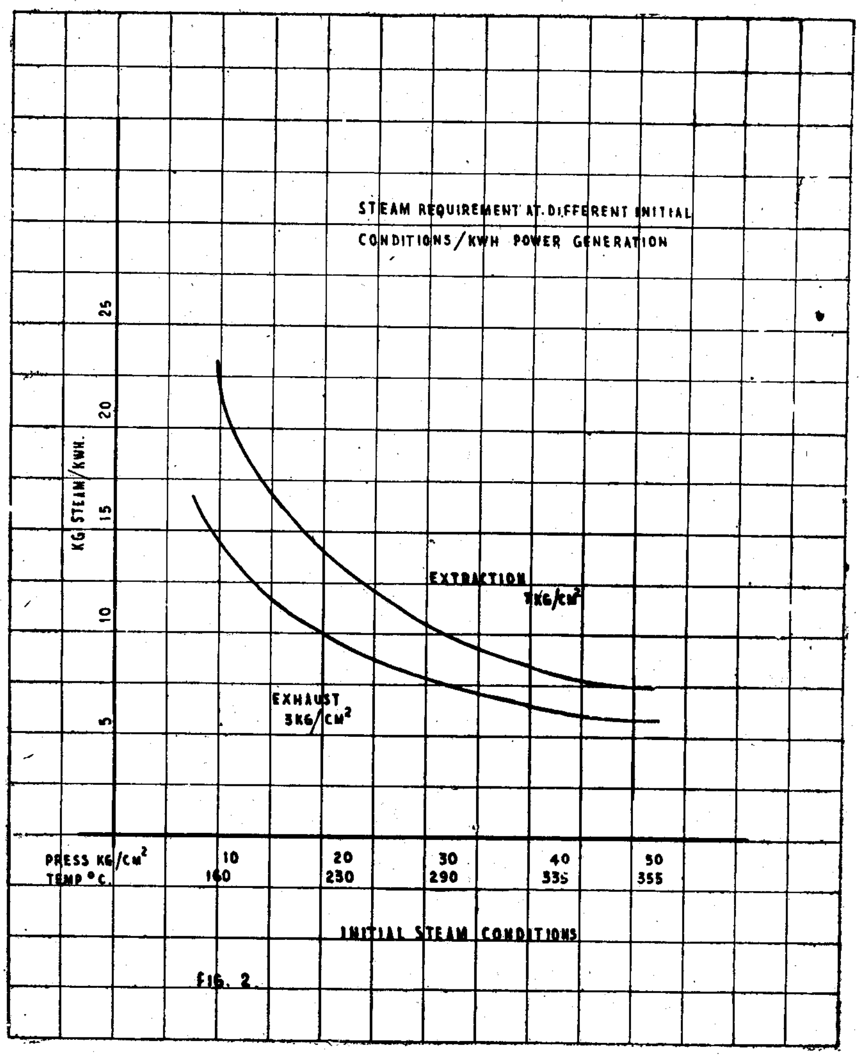

Fig. 2

In practice, however there is always an acute imbalance between the amount of steam required for total power generation and for the process mainly due to the following reasons :

1. Fluctuations in process demand of steam and power. Some of the major power consumers in the process like the raw material handling and preparation etc. do not consume any steam and similarly some of the major steam consumers require very little power. Hence interruption in the steady operation of any section causes substantial upsets in the steam and power balance.

2. The recent trends in process development is towards increased use of power i.e. mechanical action in converting the fibrous raw material to pulp and to develop desired fibre properties. A study of U. S. mills reveal that the installed H. P. per tonne Kraft paper has increased over the years as under :

Year	1950	1955	1960	1965	1970
H/P Tonne	62	68	73	83	100

The projected figure for 1975 is 112.

3. For mills using increased mechnical power in the process like for semi-chemical or mechanical pulping or having ancilliaries process like electrolysis plant for producing cooking and bleaching chemicals which require considerable electric power, the total power generation by steam pressure reduction may not be possible even

at the highest practicable initial steam conditions. (about 70 Kg/cm² 650°C)

4. More efficient steam usage by improvements in the process and equipment design, as well as increased use of higher pressure steam in the process have set a trend towards reduced quantity of steam requirement per tonne paper.

5. Existing generation and other facilities, often preclude the use of most favourable steam conditions, even during expansion and modernisation.

This inbalance betweeu the steam requirement for the process and power generation can be overcome by operating the mill's power generator in parrallel with an electricity supply grid or by adding a condensing stage to the Turbo generator. A recent development has been inclusion of a Gas Turbine cycle in the energy system. Although, from the point of view of conservation of energy sources and their efficient utilisation, operation of the Mill's back pressure Turbo generator in parallel with the Electricity supply grid is ideal, this is rarely allowed for various reasons. Hence, it is the normal practice to instal Turbo generators with a condensing stage and to provide a by-pass steam supply to the process through pressure reducing systems. Both these are wasteful processes, particularly the generation of power by condensing steam. In Fig. 3, the energy distribution diagrams of power generation by condensing steam and with the exhaust utilised in the process are shown. It will be noted that while the total energy losses in the former system is about 71%it is as low as 17% in the latter arrange-

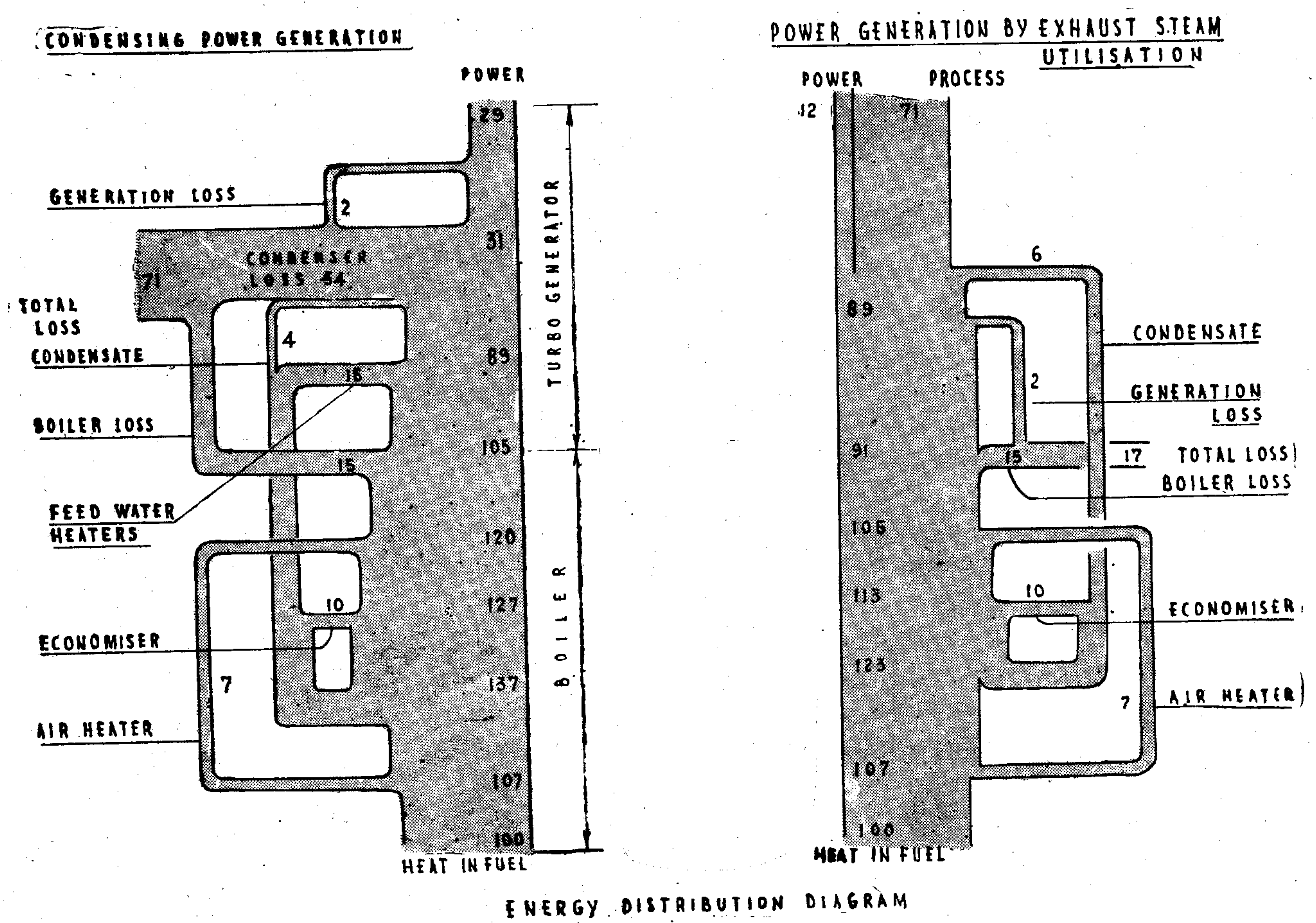

Fig. 3

ment, and hence the utilisation of the condenser should be as low as possible.

Some means of achieving improved energy utilisation are :

1. Reducing fluctuations in process steam and power balance by installing energy storage facilities like Accumulators.

2. Proper balancing of power and steam requirement in process plant design and choice of equipment. If necessary additional steam consuming cycles like feed water heating to Boiler temperature etc can be included in the system, and similarly electrical power requirement can be curtailed by chosing equipment with lower requirement of motive power like conveyors instead of pneumatic transport system:

3. Suitable choice of pressure and temperature for steam generation.

4. Planned process, to maintain the balance between steam requirement and the corresponding power generation.

The inclusion of the Gas Turbine, in the power and heat system mentioned earlier, has its best application where natural gas is available as fuel, but other fuels like light and heavy fuel oils and even coal can be used. There are several alternative possibilities of combining the gas turbine and the steam power plant system depending on the utilisation of its exhaust. A typical system is shown in Fig 4, where the gas turbine exhaust is used in the boiler. In some installations, however, the exhaust is directly used in the process to meet the hot air requirement as in the paper machine hood etc. In addition to providing additional power generation without increasing the steam supply, other significant advantages claimed by incl-

COMBINED STEAM & GAS TURBINE SYSTEM

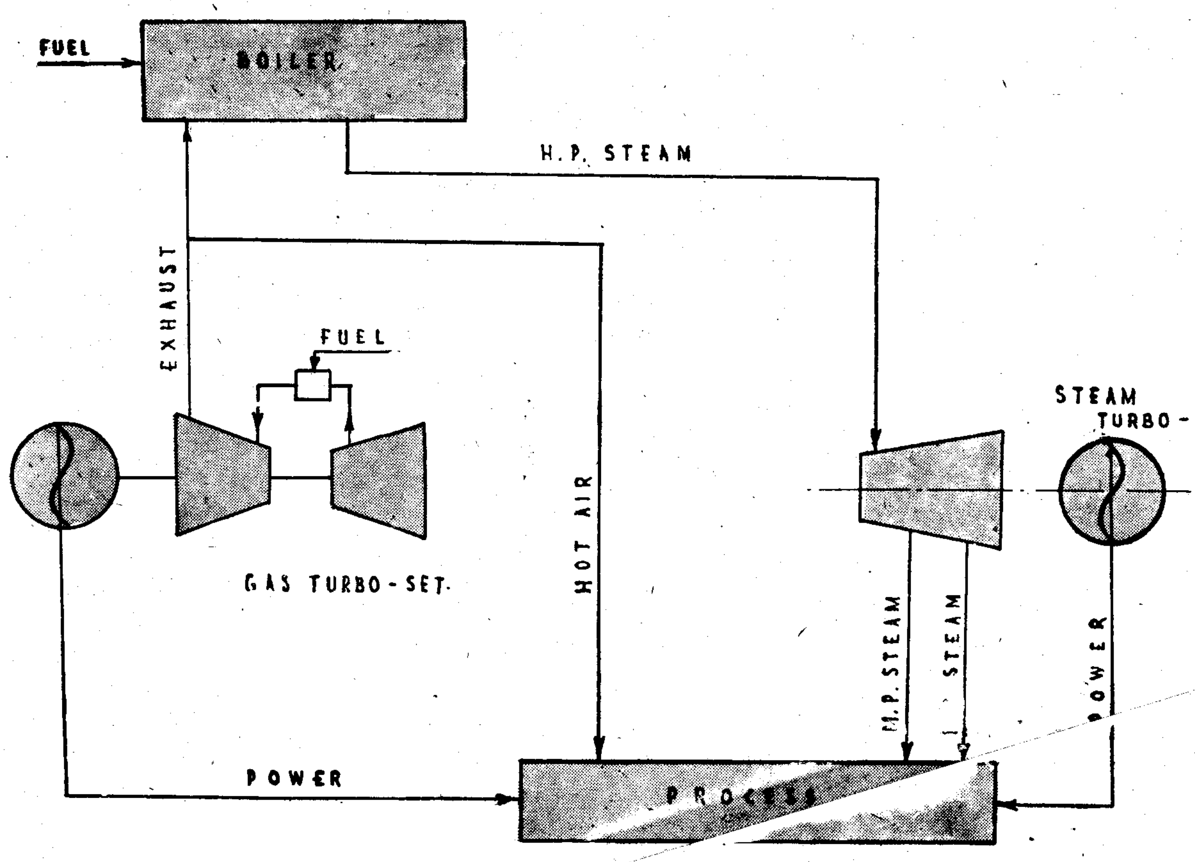

Fig. 4

usion of the gas turbine are :

1. Higher thermal efficiency, due to ideal combustion conditions with substantial excess air.
2. Quicker start up (about 5 minutes from cold) and ability to adjust to the power demand, without upsetting the process steam availability.
3. Possibility of adjustment of the exhaust gas temperature according to process and other requirements.
4. Providing an economical system of hot air supply to the process without any investment in corresponding equipment
5. The combined efficiency of gas turbine and steam power plant is higher than, either of these systems operating alone.

To sum up, in the context of today's shortage of power and energy sources, it is desirable or rather essential for integrated pulp and paper Mills to (i) have total inplant power generation (ii) ensure maximum and efficient utilisation of energy inputs including the process by-products and wastes. A significant effect of recent process improvements, is that, due to increased pulp yields and reduced process wastes the amount of by-product fuel available per tonne paper is decreasing gradually with consequeut increased requirement of fuel input.

Considering the increasing cost of the fuels and their limited availability, all possible steps are to be taken to minimise loss of energy from the system and this can mainly be achieved by :

1. Proper choice and design of steam generating system.
2. Recycling the condensate after steam usage to the maximum extent possible.
3. Recovering as much heat as possible from all discharges of the system by utilising them to heat water, air etc. before leaving the system.
4. Minimising heat losses by suitable insulation of vessels, pipe lines etc.
5. Streamlined process flow and equipment layout to avoid unnecessary loss of energy. The potential, kinetic or thermal energy gained by the material at a particular stage, should be used as far as possible in the subsequent stages.
6. Proper sizing and selection of equipment to ensure their operation at the highest possible efficiency at the particular application.
7. Elimination of power wastage by unecessary or idle operation of equipment, lighting, ventilation system etc.