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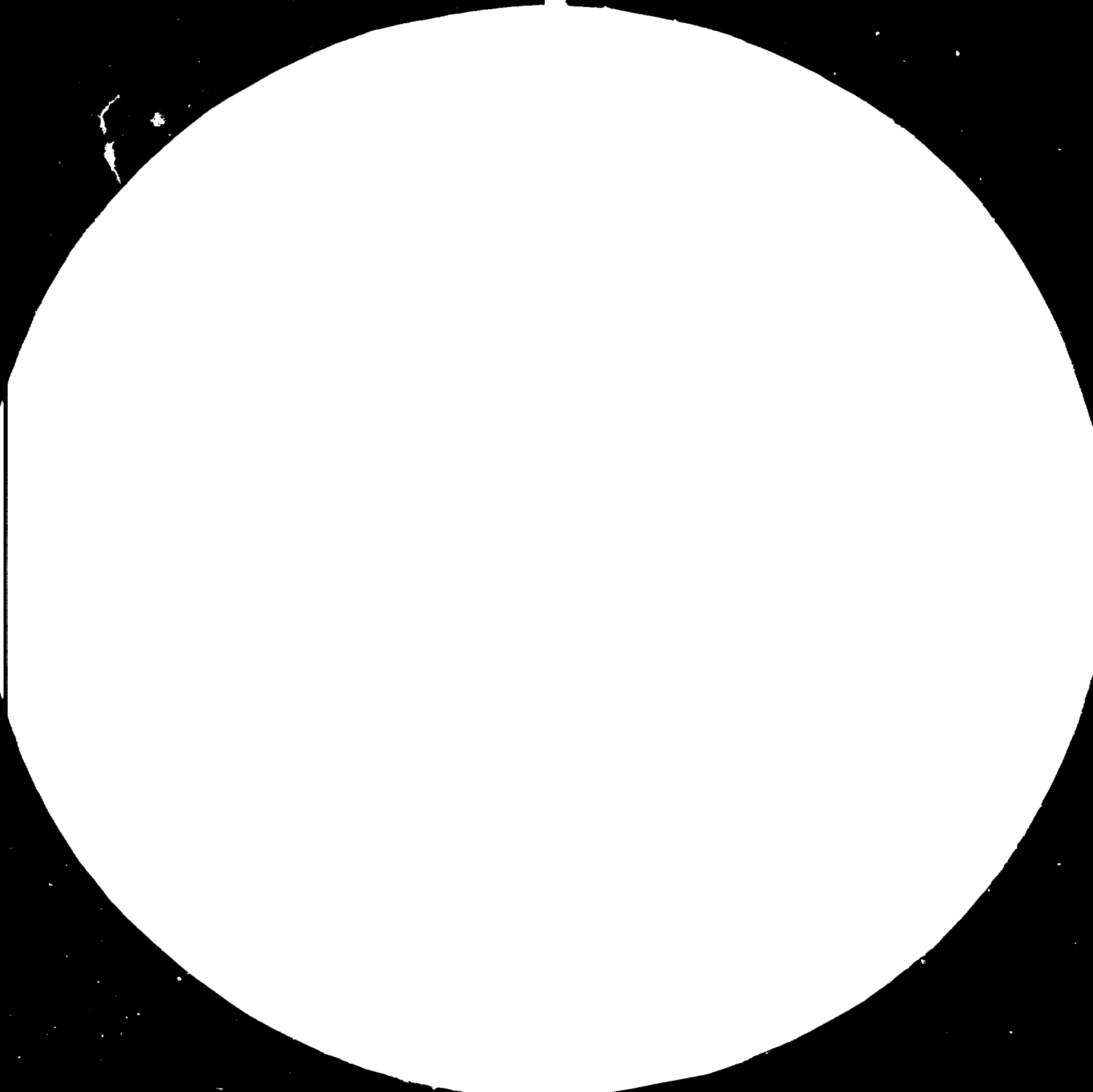
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1.8

2.0



Resolution Test Chart
1963 Edition
NBS Monograph No. 17

RESTRICTED

12502

DP/ID/SER.B/397
24 May 1983
English

TEXTILE DEVELOPMENT CENTRE (PHASE II)

DP/EGY/77/008

EGYPT

Terminal report *

Prepared for the Government of the Arab Republic of Egypt
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Dr. John G. Roberts,
adviser in energy conservation in textile mills

United Nations Industrial Development Organization
Vienna

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1 Purpose of Mission

The mission was undertaken at the request of the Government of the Arab Republic of Egypt to examine the possibilities for energy conservation in textile mills.

1.1 Duty Station

Alexandria with travel within the country.

1.2 Background Information

The importance of the textile industry to the country's economy is well known. Recent developments in textile technology and the increased awareness in consumer demand for end-use properties make it imperative that adequate facilities be made available to assist the industry in surviving the competition in external markets and producing goods for the local market at a reasonable cost.

There is already a modern, well equipped, Textile Testing and Quality Control Centre in Alexandria, established with the assistance of UNDP and UNIDO, which has generated quality consciousness in the industry.

It is now being expanded into a fully-fledged Textile Development Centre with further assistance from UNDP and UNIDO. The chief objectives of the Textile Development Centre when it is fully established will be the following:

- a) to provide pilot plant and testing facilities to carry out applied research work on industrial problems, both of short and long-term duration, which will be of immediate use to the textile industry;

- b) to carry out pilot plant studies on the materials, particularly cotton and its blends, and the machines involved in the conversion of fibres into finished products. This will include investigations into the new fibres, dyes, finishes, machines and processes which are being developed elsewhere and at the Centre itself;
- c) to carry out qualitative and operational studies of industrial processes in textile mills with a view to increasing productivity and efficiency by modern industrial engineering techniques;
- d) to provide technical consultancy in management technological problems and extend modern testing facilities to textile mills;
- e) to communicate at all levels of the industry by organising conferences, seminars, symposia and group discussions on various technical subjects and training courses for mill technicians, etc.;
- f) to disseminate technical information to the industry by issuing periodical bulletins to assist the mill technicians in keeping abreast of the latest developments in textiles;
- g) to assist the industry in setting and maintaining standards.

1.5 Duties of Consultant

As a member of an international team assigned to the Textile Development Centre and under the direct supervision of the Project Manager, the expert will specifically be expected to:

1. Visit textile mills to study their problems in energy conservation;
2. Give practical advice on how the problems can be overcome;
3. Give a seminar to mill engineers and chemists on modern techniques in energy conservation in textile mills;
4. Train members of the staff of the TDC, to the extent possible.

The expert will also be expected to prepare a final report, setting out the findings of the mission and recommendations to the Government on further action which might be taken.

2 Activities

The work programme undertaken is shown in Annex 1.

2.1 Survey of Sample Textile Mills

Visits were made to twelve mills to examine energy conservation possibilities and to discuss energy problems. Details of these visits will be found in the series of visit reports in Annex 2.

2.2 Quantitative Survey of Energy Use in the Textile Industry

A questionnaire asking for details of energy use, production and main steam usage was produced and distributed to all factories visited. Analysis of this data has provided a data base for future examination of energy consumption possibilities. The questionnaire and the factories to which it was sent are to be found in Annex 3. The analysis of returns is to be found in Annex 4. Plans were made with TDC staff for the survey to continue to cover the whole textile industry.

2.3 Instruction of Staff in Energy Conservation

Staff of TDC were instructed on energy conservation by discussion and observation during visits to factories and by discussion at TDC. Literature covering many aspects of efficient use of energy, how to conduct energy surveys and audits and results of surveys carried out in the UK were examined and discussed. This literature was presented to the TDC library.

2.4 Technical Committee

The opportunity was taken to present and discuss the findings and recommendations arising from this mission to the Technical Committee on 21st February 1983. The meeting was chaired by Dr Mohamed El Sayed El Ghorury Chairman of Misr Spinning and Weaving Co. Mehalla El Kubra. Present were Dr El Sayed Ahmed Dahmouch Chairman of Arab and United Spinning & Weaving Co. Alexandria, Eng. Mahmoud Abraham Chairman of Misr Fine Spinning and Weaving Co. Kafr El Dawar, Eng. Fathy Ahmed Aly Chairman of Alexandria Spinning and Weaving Co., Eng. Magdi Elaref Deputy Manager for Technical Affairs Textile Consolidation Fund.

At this meeting it was resolved that the Technical Committee should embark upon a programme for energy conservation in the textile industry of Egypt.

2.5 Seminar

A one day seminar on Energy in Textiles was given on 21st February 1985 at the TDC to an invited audience from the Egyptian Textile Industry and staff from TDC. In spite of bad weather conditions 45 staff from the textile industry attended. Notes on the four seminar papers appear as Annex 5.

3 Findings

1. There are major opportunities for energy conservation in the textile industry of Egypt.
2. An estimate is that at least 20% of total energy used could be saved at the present time.
3. A major problem exists which inhibits energy conservation this is the low price of heavy oil (L.E. 7.5 to 8 per tonne) and of electricity (less than 1 piastre per Kwh).
4. The real cost of energy is much higher, approximately 90% is borne by the Egyptian Government through subsidies. Discussion suggests that the total subsidy for the whole country is L.E. 2.7 billion per year.
5. Energy conservation would save Government money.

6. Energy Conservation is not attractive to textile mills as the cost of implementation is high compared with the savings in cost which can be made on low subsidized prices.
7. There is a major potential for use of solar heat in dyeing & finishing by use of simple roof-mounted collectors.

4 Recommendations

1. TDC should continue and expand surveys of the pattern of energy use in the Textile Industry in the manner initiated during my visit. These surveys should be updated at intervals.
2. A follow-up visit should be made by an UNIDO advisor on Energy Conservation to determine progress of the surveys and to plan the next stage for the extension of implementation of energy conservation measures.
3. Practical studies of Energy related projects should be made at TDC such as:
 - a) Collection of solar heat energy to provide hot water. A pilot study should be made to determine the heat collecting capacity of a simple home-made solar collector. The findings should then be related to the practical use of hot water in dye houses.
 - b) A study should be made of frictional losses in equipment such as spinning frames.

Pilot equipment at TDC could be used to examine the changes in power requirement on spinning frames between new and old spindle "belt drives". These findings could then be translated directly to spinning mills.

- c) An examination should be made by TDC in mills of the potential for energy conservation on washing ranges by reusing hot, relatively clean water in adjacent washers and also the potential for use of heat exchangers to recycle heat in the washing range.
 - d) Obtain for TDC instrumentation for flue gas testing (Thermometer, CO₂ meter, etc) to measure boiler efficiency. These should be used to provide a routine testing service for mills to enable monitoring to be carried out regularly.
4. To Government. Examine policy on energy subsidies with a view to provide support for energy conservation projects which would provide considerable savings to government energy subsidies but which would not at present be financially attractive to factories as energy prices are low.
5. To the textile industry to support TDC in activities to promote energy conservation.

ANNEX I

Work Programme

Post: 11-11/H/31.7.B Expert in Energy Conservation in
Textile Mills.

Name: Dr. John G. Roberts.

January 1983.

27 Travel to Vienna.
28 UNIDO briefing
29 UNIDO travel to Cairo.
30 UNDP Cairo briefing.
31 Travel to Alexandria introduced to staff and TDC.

February

1 Discussion with the staff TDC.
2 - 7 Initial visit to Misr Fine Spinning & Weaving Co.
Kafr El-Dawar.
Beida Dyers Co.
8 - 9 Discussions and training TDC staff.
10 - 15 Visit to:-
"STIA" El Nasr Wool and Selected Textiles Co.
"KABO" El Nasr Clothing and Textile Co.
National Spinning and Weaving Co.
Orient Linen and Cotton Co.
Alexandria Spinning & Weaving Co.

Modern Textile Co.

El Siouf Spinning and Weaving

Arab and United Spinning and Weaving.

16 - 19 Report writing, Seminar preparation and discussion
with TDC staff.

20 Visit to El Messiri and Co. Mehalla El-Kobra
Misr Spinning and Weaving Co. Mehalla El-Kobra.

21 Seminar Energy Conservation.

22 Discussion TDC.

23 - 25 Holiday at own expense travel to Cairo UNDP.

26 Debriefing Cairo UNDP

27 Travel to Vienna.

28 UNIDO debriefing Vienna.

March 1 Travel to Manchester.

Last day of service March 1st.

ANNEX 2
(VISIT REPORTS ON MILLS)

VISIT TO MISR FINE SPINNING AND WEAVING CO.
KAFR EL DAWAR, ON WEDNESDAY, 2nd FEBRUARY 1985

JOHN G. ROBERTS
UNIDO ADVISER ON ENERGY CONSERVATION

Summary

Two areas in this large factory were identified as areas which should be examined carefully for potential energy saving. These were improvement in levels of condensate return to the boiler house and control of the air-conditioning system in No. 5 spinning mill.

PERSONNEL

Accompanied by Dr Hosney M.M. Hassanin, Mr I.G. Hassouna Mr A.S. Mohamad and Mr Samy El-Meligy two visits were made to this factory where we met Dr Galel Daakes Spinning Manager, Mr Napeh Aarer Chief of the Power Station, Mr Mahmoud EL Khamry Manager Mill No. 4 Mr Helal Mammoud Maintenance Manager Mill No. 3 spinning and Mr H.M. Kurich Engineer.

DISCUSSION

This factory is a major spinning and weaving complex having seven spinning mills and four weaving mills. The total work force is 17000 to 18000. It operates 24 hrs a day on three shifts and for 350 days per year. Equipment consists of 400,000 spindles plus 12 open end spinning machines producing 35000 tonnes of yarn with an average count of 32's. For fabric weaving there are 4000 looms with an output - 1982 of 29000 tonnes of fabric (120 million meters).

The main energy input is heavy and (mazoot) which is used to produce steam for power generation in turbines and then to provide process steam.

The total cost of energy is about 3% of production costs.

The central boiler house was examined. There were four boilers 2 capable of steaming at 50 tonnes/hr and 2 on standby 25 tonnes/hr. Efficiencies were 85 to 90% and loading was said to generally be 70% with some variation $\pm 10\%$. Steam was delivered to turbines at 40 at and to processes at 7 at. The turbines were rated 2 at 9 MW and two standby units at 4.5 MW. A new 20 MW installation is planned with 120 tonne/hr capacity boilers.

Condensate return from turbines is at the ratio of 3 to 5 tonnes per hr and is supplemented by a small amount from processes (0.4 tonnes/hr). The possibilities for increasing condensate return were discussed. This would be a major energy saving item. At present the 5 tonnes/hr return represents a small fraction of the total steam use (70 tonnes/hr).

Space heating is only required in spinning mills in the winter months and represents about 20% extra steam raising.

The major process steam use is in sizing where live steam is used in the sizing kettles. During heating there is a volume increase from 450 to 650C. Consideration should be given to using indirect heating as an energy saving measure. Additional steam is used in drying sized yarn.

In No. 5 spinning mill the air conditioning system which is being installed was examined. This will employ refrigeration during the main summer months. Control of operation of this plant is extremely important from the energy viewpoint. The effects of the plant operations are of course felt in the work rooms where any deviation from expected conditions of temperature are immediately noted. However incorrect operation of the plant can occur with the correct temperature/humidity conditions being obtained. This lies in the control of the fresh air/recirculated and valve and incorrect setting admitting too much external and at high temperature will be cooled by the refrigeration unit to give correct working conditions, but with excessive energy usage. The 'out of the way' siting of this plant and its control room mean that unobserved errors of setting of the valve could go unnoticed for long periods with consequential wastage of energy.

VISIT TO MISR BEIDA DYERS CO. ON THURSDAY,
3rd FEBRUARY, AND MONDAY, 7th FEBRUARY, 1983.

JOHN G. ROBERTS
UNIDO ADVISER ON ENERGY CONSERVATION

SUMMARY

A survey of this factory shows the need for a detailed audit. Some preliminary analysis of energy use was made but further detailed data was required. Opportunities for major energy savings exist.

PERSONNEL

The visit made on 3rd February, 1983, was in the company of Mrs Yoser Allam when we met Mr Ebrahim Hefny (Secretary), Mr Anwad Ahmed (Head, engineering section), Mr Sayed Hegazy (Project General Manager). On 7th February, 1983, the visit was made with Dr Hosney M.M. Hassanin and Mrs Yoser Allam when we met Mr Omar Ishmel Mohamed (Chairman) and Mr Rashdy Yasser (Director, Planning and Production Control).

DISCUSSIONS

The visits to this major dyeing and finishing factory had two general aims. One was to examine the plant in the course of a tour through the major facilities to gain an impression of the main areas where energy conservation possibilities existed. Two, was to quantify aspects of energy use in the plant to enable detailed quantitative estimates of energy conservation possibilities.

In the event, the more detailed study would require considerably more time than was available to obtain data, make estimates and measure aspects of energy use to enable a detailed audit of energy use in this plant. This is seen as an urgent, major requirement to provide the basis for major energy saving at this factory.

In the course of examination of the , the following was determined.

Energy inputs were heavy oil (mazoot) - 64,000 tonnes in 1981/2; at the same time 2,204,124 kWh of electricity was taken from the network.

Energy use is summarized in the following Table.

		<u>GJ energy</u>	<u>% of Total energy</u>
<u>Mazoot</u>	64,000 tonnes	2,726,400	99.7
Steam delivered	792,600 tonnes	2,377,800	(87.0)
To No.1 Mill	201,600 t)		
No.2 Mill	204,000 t)	1,728,000	(63.2)
No.3 Mill	170,400 t)		
Total	576,000 t		
To Wool top	58,800	176,400	
Power plant auxiliaries	98,400	393,600	(14.4)
<u>Electricity</u>			
Generated	33,122,300 kWh	119,240	(4.4)
Network	2,204,124 kWh	7,935	0.3

Production in dyeing and finishing fabric amounted to 150 million m in 1981/2. With average weight of 1,409/m² and width of one metre this represents an approximate production of 21,000 tonnes. Yarn dyeing provides an additional 1,170 tonnes and wool tops 7,010 tonnes.

As steam is the major use of energy in the processing, as a first approximation we have

Energy requirement per tonne dyeing and finishing yarn and fabric of 77.9 GJ/tonne (i.e. 1,728,000 GJ for 22,170 tonnes production), and for wool tops 25.2 GJ/tonne (i.e. 176,400 GJ for 7,010 tonnes production). However, there must be apportioned to these values additional energy from the steam and electricity generating overheads. Insufficient data was available to enable this calculation to be made.

In the course of examining the factory major opportunities for energy conservation were discussed. Perhaps the most important was the complete lack of return of condensate to the boilerhouse. In normal Western European practise at least 50% of steam would be returned as condensate. Current plans are to harness a part of

the otherwise wasted hot condensate for further use as a hot water supply to the dye house. This is better than it being wasted but does not represent as high a potential return as would be achieved by returning maximum amounts of condensate to the boilers.

Hot water washers which are major energy users require attention; to minimise water, and hence energy use; to determine the potential for recovery of heat from effluent by heat exchanger for reuse in the incoming cold water.

Examination was also made of drying cylinders. Many units were designed for multiple strand drying and were seriously under-used, i.e. missing strands. Work scheduling can improve the utilization of such driers. The state of many mangles at the ingoing end of drying cylinder ranges left much to be desired. The water level remaining on fabrics was excessive. Measurements made showed 106, 92, 54 and 82% at four different machines. Similar measurements made by BEIDA staff showed similar high values occurred at more than 50% of the machines. Mangles in a poor state were the source of this fault. Water levels of 60 to 65% can be achieved by good modern practise, even better water removal can be achieved using special bowls such as the Roberto. Major energy savings can be achieved by reducing the amount of water to be evaporated by as much as $\frac{1}{3}$.

The general state of repair of steam glands and valves was capable of improvement. Many leaking valves were noted and these add up to considerable quantities of lost steam.

A complete detailed audit of this plant should be made and it is probable that this would reveal possibilities for energy saving amounting to between 35 and 40% of the total energy used.

VISIT TO EL NASR WOOL AND SELECTED TEXTILE CO. "STIA"

ON THURSDAY 10th FEBRUARY 1983.

JOHN G. ROBERTS

UNIDO ADVISER ON ENERGY CONSERVATION

Summary

This visit was made to introduce the "Request for Data" on energy and production to assess possible energy conservation measures.

PERSONNEL

The visit was made in the company of Dr Hosney M. M. Hassanin Mrs Yoser Allam and Mr Salah Saber. We met Mr Ahmed Abuel Whafa General director and five engineers.

DISCUSSION

The main purpose of the visit was to introduce the "Request for Data" on energy use and production. The importance of energy conservation for Egypt as a whole was contrasted with the low price of oil and power. The survey data was required to assess the size of opportunities for energy conservation. Mr Ahmed Abu El Whafa kindly agreed to provide data from STIA and called a meeting of engineers to discuss our requirements.

STIA consists of nine mills distributed over several sites.

They include:-

- I. Cotton mill with spinning and weaving.
- I Worsted mill with spinning weaving and finishing
- 3 Woollen mills
- 2 Factories producing under wear.
- I. Factory producing ready made garments.
- I. Dyeing and Finishing mill.

The plant visited was the cotton mill, the dyeing and finishing mill was at another site close by.

Total production for all mills based on yarn in 6600 tonnes/yv

Full co-operation in providing data was promised and the questionnaire would be completed by Tuesday 15th February 1983.

VISIT TO EL-NASR CLOTHING AND TEXTILES CO (KABO) ALEXANDRIA
ON THURSDAY 10TH FEBRUARY 1983.

JOHN G. ROBERTS
UNIDO ADVISER ON ENERGY CONSERVATION

Summary

This visit was made mainly to introduce the "Request for Data" on energy use and production. At this factory no condensate steam is returned to the boilers where as a 50% return should be normal practice. Solar energy water heating is a possibility.

PERSONNEL

Accompanied by Dr Hosney M. M. Hassanin, Mrs Yoser Allam and Mr Salah Saber, we met Mr Hassan Yassin Technical Director.

Discussion

The main purpose of our visit was to introduce the "Request for Data" which is being used to gather basic energy and production information on which to establish total energy consumption, specific energy consumption and to identify the main areas of energy use. The data will be used to indicate possible areas to which energy conservation measures might be applied.

This factory is engaged in knitting, garments making as well as dyeing and finishing which includes transfer printing. About 7000 workers are employed. All yarn is bought in and consists primarily of 100% cotton (90% of total currently) the remaining 4% consists either of polyester (for transfer printing) or polyester/cotton.

Current production is about 10,000 Doz garments (of all types) per day which consumes 20 tonne of yarn per day.

Yarn is rewound, waxed and knitted. Approximately 30-40% of production is dyed, some 60% is bleached for white and 10% goes out raw. Steam is supplied from boilers with an output of 10t/hr, two operate at any one time and have an efficiency of 85%. There is little or no condensate return. Main steam users are dye house and calanders. The dyehouse contains jigs, high pressure jigs, a continuous bleaching range, jet dyers, a caustification unit and also yarn bleaching and dyeing equipment.

In discussion on energy conservation measures the lack of condensate return was noted. This important item not only saves energy but saves the need for processing water for the

boilers. It is normal for at least 50% of steam to be returned as condensate in such a dye house. It was commented that there was no financial incentive as the cost of the necessary pipe work would not be recovered for several years as fuel oil (mazoot) is of low cost L.E 7.5/tonne. The saving would however benefit the country as a whole as the Government subsidy on oil is high for comparison the western european oil price is about L.E 120/tonne.

The possibility of using solar energy to heat water was discussed. This type of dye house largely requires hot water and the use of solar energy to provide this is a real possibility. This subject had been earlier discussed at the Textile Development Centre. Mr Yassin would clearly support a programme of work to establish the feasibility of using this solar of energy.

Mr Yassin kindly agreed to participate in providing the data on energy and production requested and his co-operation is gratefully appreciated. The completed data sheet will be available on 13th February 1983.

VISIT TO NATIONAL SPINNING AND WEAVING CO. ALEXANDRIA
ON SATURDAY 12TH FEBRUARY 1983

JOHN G. ROBERTS
UNIDO Adviser on energy conservation

Summary

This visit was made to introduce the "Request for Data" on energy and production to assess possible energy conservation measures. The dyeing and finishing mill was examined and recommendations were made for conservation actions. It is estimated that energy use could be cut by 50% at this mill.

PERSONNEL

The visit was made in the company of Dr Hosney M. M. Hassanin and Mr Salah Saber, we met Mr Esmael Zidan Manager of planning and projects and

DISCUSSION

The visit was made to introduce the "Request for Data" Initial discussions were with Mr Zidan. After explaining the range of questions asked in the "Request" and explaining how the confidential data would be used to calculate energy required per unit of production, Mr Zidan readily agreed to complete the questionnaire. Seperate returns would be made for the spinning, weaving and dyeing and finishing mills.

MILL VISIT

A tour was made of the dyeing and finishing mill. preparation processes were first, scouring in kiers of which there were eight of 4 tonne capacity. They operated on 8 hr cycle at 80⁰C. Bleaching was either by cold hyprochlorite in J-boxes in rope form or by hydrogen peroxide in a Bruggman J box range at 70 to 90⁰C, This later equipment was well lagged and in reasonable condition.

Washing was entirely in rope form. Water levels on fabrics passing to the driers was high, often greater than 90%. On at least two ranges of drying cylinders the ingoing squeeze mangles were broken and not operating so that fabrics were very wet. This wastes a lot of energy. Two horizontal drying ranges were leaking steam at almost every joint. Some leaks were massive with 1 to 2 meter jets of steam. The losses here must have been very high (possibly amounting on the two machines to 1 tonne of steam per hour).

Printing was by roller (six machines), rotary screen (one new stork unit) or by flat screen. Prints were fixed in a roller steamer or a loop steamer at about 100⁰C.

Printed fabric was then washed in rope form in a four unit open washer. These units were at 70⁰C and the final one cold. Major savings of energy could be made here by:-

1. Enclosing the washers with lids to prevent evaporation losses.
2. By counter flowing the hot wash liquors between the three hot units saving 66% of the total energy.
3. By fitting a heat exchanger 70% of the waste heat in the effluent could be reused by heating the incoming cold water.

In this way the total energy would be reduced from 100% to 20% of the current requirement.

It should be noted that this washing should be in open width to maintain the quality of the fabric.

No condensate return is made in the mill at all.

Total production is 47mm/y^v at 100g/lin m 4700 tonnes/y^z.

CONCLUSIONS

In general at this mill housekeeping is very poor. Much fabric is being spoilt by contamination by dragging on the dirty floor.

Maintenance of steam valves and joints is particularly bad and must be costing large sums of money in wasted steam.

I believe savings amounting to 50% of the current oil usage could be made in this mill.

VISIT TO ORIENT LINEN AND COTTON CO. SIDI GABER

ON SUNDAY 13TH FEBRUARY 1983

JOHN G. ROBERTS

UNIDO Adviser on energy conservation

Summary

A "Request for Data" was explained and agreement obtained for its completion. Operations in the dyeing and finishing plant were reviewed and advice given on possible energy conservation opportunities.

PERSONNEL

The visit was made in the company of Dr Hosney M. M. Hassanin and Mrs Yoser Allam. We met Mr Rashad Abdo Saleh, commercial director and Dr Mahmoud El Meniallawy, manager dyeing and finishing who's help is gratefully acknowledged.

DISCUSSION

The "Request for Data" was explained and the background to the importance of energy conservation discussed. The value will mainly be to the country as a whole as the price of heavy oil is subsidised heavily. Mr Rashad Abdo Saleh agreed to provide data which would be ready on Wednesday 16th February 1983.

Orient mills consists of separate units for spinning (production 5500 t/yr), flax spinning (1200 t/yr), weaving (16 m m²/yr), dyeing and finishing (of which 60% is bed sheets and about 10% terry), and making up. These activities are spread over several sites. The visit was at the weaving, dyeing and finishing units.

VISIT TO DYEING AND FINISHING PLANT

Steam for the plant is raised in two boilers of 15t/hr capacity for under the time one boiler is sufficient. Apart from dyeing and finishing the only other major use of steam is in sizing. No condensate is returned to the boiler.

Scouring and bleaching are both carried out by pad-steam with continuous operation into caravans. In both systems the fabric is reached for 1 hour at 70 to 80⁰C. Fabrics were dried on steam cylinders. Fabric water contents at these driers was higher than it should be (about 80% instead of 65 - 70% with best practice).

The driers were wide width (240 cm) and on at least one unit a single stand of fabric (90 cm) was being dried. This is wasteful of energy if it occurs frequently. There were many steam leaks at joint glands and a higher level of maintenance is recommended. Care should also be taken to ensure that over drying by operating the cylinders too slowly does not occur.

Washers were a mixture of counter flow and single box all future machine purchases should be of the counter flow type and heat exchangers should be fitted to recover waste heat from the effluent into the clean water inlet.

Printed fabric from rotary screen (stork) and flat screen (buser) machines was fixed in a start H.T steamer. This was well insulated and appeared to be operated efficiently. However checks should be made frequently on the exhaust control to avoid undue wastage.

Two Krantz stenters were applying fuel starch finish to fabrics. Exhaust settings should be checked frequently to ensure that they are not opened too wide and this wasting heat.

In future developments application of finishes from foams so that only 30% by weight of water is added to the fabric reducing every requirements for drying and increasing productivity.

Condensate return was reviewed. Where as the most beneficial action is to return all condensate to the boiler at highest possible temperature. This saves both energy and the cost of processing boiler feed water. Return in excess of 50% should be possible in this type of dye house. The next heat

opportunitiy is to use condensate as pure water supply for dyeing. In this context the yarn dyeing units should be considered for suitability for fitting a heat exchanger to boost the starting temperature in the dyeing cycle.

VISIT TO ALEXANDRIA SPINNING AND WEAVING CO. EL NOZHA

ON SUNDAY 13TH FEBRUARY 1983

JOHN G. ROBERTS

UNIDO Adviser on energy conservation

Summary

The "Request for Data" was introduced and the companies activities briefly reviewed.

PERSONNEL

This visit was made with Dr Hosney M. M. Hassanin and Mrs Yoser Allam, we met Mr Moustafa Osman Radi planning and production manager.

DISCUSSION

The "Request for Data" was described and questions answered on the scope of the survey. Mr Moustafa Osman Radi kindly agreed to supply the necessary details by Wednesday 16th February 1983.

The activities on the site visited was mainly spinning annual production being about 11000 tonnes. Weaving at another site (40 Mm/yr average weight 120g/linear m) and dyeing and finishing (12 Mm and 350 tonnes yarn per year) were the other main activities.

VISIT TO MODERN TEXTILES CO. ALEXANDRIA

ON SUNDAY 13TH FEBUARY 1983

JOHN G. ROBERTS

UNIDO Adviser on energy conservation

Summary

The "Request for Data" was introduced and the companies activities briefly recorded. General advice on energy conservation points in new machinery was given.

PERSONNEL

The visit was made in the company of Dr Hosney M. M. Hassanin and Mrs Yoser Allam. We met Mr Moh. Fadaly Chairman and Mr Ahemed Salem Technical Manager.

DISCUSSION

The questionnair requesting data on energy conservation and levels of production was introduced and it was agreed that it would not provide any problems in completion. Answers would be available on Tuesday 15th February 1983.

It is realized that this data will appply to a situation which will rapidly change as an extensive re equipment programme is in hand. Loom will be replaced air-jet and shuttleless and the current production of silk, viscose, polyester and blend fabrics will rise from 3.5Mm/yr to 7 Mm/yr .

In dyeing and finishing the importance of control of washing and water removal from fabrics before drying was emphasised. The choice of method of heating in heat setting and polymerizing stenters was discussed. The present technique of electrical heating to reach the temperatures required is the most expensive way. Direct firing methods with clean fuels (natural gas or sulphur free clean light fuel oil) was recommended particularly when used with recirculating air systems. The method so far favoured by Mr Ahmed Salem indirect fired hot oil circulation is very effective but requires at least 25% more fuel energy than the direct system.

VISIT TO EL-SIOUF SPINNING AND WEAVING CO. ALEXANDRIA
ON MONDAY 14TH FEBRUARY 1983

JOHN G. ROBERTS
UNIDO Adviser on energy conservation

Summary

This visit was made to introduce the "Request for Data" on energy and production. In a tour of part of the mill possibilities for energy conservation were identified and advice was given.

PERSONNEL

This visit was made in the company of Dr Hosney M. M. Hassanin and Mrs Yoser Allam. We met Mr Gaber Hassan El Dib the General Manager.

Discussion

This is a coarse count spinning mill which produces popular fabrics which are dyed finished and printed. The spinning sections comprise 230000 spindles and produce 100 tonnes of yarn per day (1982/82 - 50+/d). Not all yarn goes forward for weaving. Fabric is produced on 2200 looms at the rate of 220 kw per day (1981/82 - 172 km/d). The width is between 80 and 120 cm and average weight 150 g/lin. m. There are 12 looms producing 2m wide fabric. All fabric is dyed, printed and finished are in addition some fabric is processed on commission.

All power is drawn from the network. Water costs are rising and are causing concern. There is also a problem with discharge of effluent as the canals are becoming blocked. Reduction in water consumption is dyeing and finishing would thus provide benefit in three ways, saving energy lowering water payments and reducing effluent problems.

In a tour of the factory six new sample air-jet looms were examined with particular respect to the compressors. These were situated inside the buildings which are at a higher temperature than the outside. This problem will probably be greater during the summer months. All compressor inlets should be sited at the coolest possible

place outside on a north facing wall. For every 3 °C rise in air temperature efficiency at the compressor falls so that 1% more electrical energy is required. If water cooled compressors are used then cooling water can provide heat as hot water for other purposes

Power factor in the mill is largely uncorrected and is very low. Values quoted were:-

Spinning 0.75.

Weaving 0.5

Dyeing & finishing 0.8.

This suggests that there are considerable numbers of motors which are oversize and running below load. Correction condensers can be applied at the main supply points but it is better to fit correction condensers at each motor. This would reduce loads on supply circuits with in the factory, prevent overloading of transformers, reduce heating in circuits with consequent loss of energy and reduce the frequency of breakdowns.

In the dyeing and finishing section no condensate is collected and returned to the boilers. It is usual for 50% of steam used to be capable of collection as condensate and returned to the boiler. This saves energy in steam raising and halves the cost of processing make-up water for the boiler.

Drying cans should be preceded by good mechanical removal of water by squsezing to about to 5% water pick-up. This reduces energy requirements in drying. Overdrying of fabric must be avoided

Compressors sited in the dye house should be moved outside not only is the atmosphere hot it is also humid and the presence of moisture in air being compressed causes loss in efficiency and other unnecessary problems.

Six new smith jigs not operating were fitted with lids. When these machines are in use it is essential that they are operated with lids closed to minimise losses of energy. At or near 100 °C open lids double steam consumption as well as causing other problems such as condensation and corrosion.

The "Request for Data" was discussed and it was agreed that the information required would be provided.

VISIT TO EL NASR CLOTHING AND TEXTILES CO. (KABO)
ON MONDAY 14th FEBRUARY 1983 (SECOND VISIT)

JOHN G. ROBERTS

UNIDO Advisor on Energy Conservation

Summary

Information was provided in the completed 'Request for data'. Energy use in the dyehouse was examined and opportunities for reducing energy requirements identified in the use of winches and washing units.

PERSONNEL

This visit was made in the company of Dr Hosney M.M. Hassanin and Mrs Yoser Allam. We met Mr Hassan Yassin Technical Director, Mr Farouk Fathi Aglan Chemist and Mr Omar El Kadim Dyehouse Manager.

DISCUSSION

The visit was made to collect the completed request for data and the opportunity was taken to visit the dyehouse to examine energy use.

There were several areas in which energy conservation measures could be taken. Dye winches were being used for both dyeing and washing at the boil. There was a considerable escape of steam from these machines inspite of closed hoods. This suggests that the open-pipe delivery of steam to the bath was far too rapid and free steam was passing through the bath without giving up its heat. The steam rate should be examined with a view to reducing the flow. Baths need only be simmering at 100°C not boiling vigorously. It is estimated that 50% of the steam used could be saved.

On the continuous bleaching range the possibility for reducing the hot water use should be examined. This should be followed by an evaluation of the possible use of a heat-exchanger to recover heat from the waste water flow. Approximately 70% of this heat can be recovered and reused to heat the incoming cold water. Similarly the washers on the DORNIER mercerizing equipment should have heat exchangers fitted for optimum energy conservation.

VISIT TO ARAB AND UNITED SPINNING AND WEAVING CO.
SIDUF ALEXANDRIA ON TUESDAY 15th FEBRUARY 1983

JOHN G. ROBERTS

UNIDO Advisor on Energy Conservation

Summary

Energy conservation possibilities were found and discussed during a tour of part of this factory. Although many energy conservation features not found in other factories were already implemented there still exists scope for further reduction in the overall energy requirement.

PERSONNEL

Accompanied by Dr Hosney M.M. Hassanin and Mrs Yoser Allam we met Dr El Sayed Ahmed Dahmoush, Chairman.

DISCUSSION

Dr Dahmoush described briefly the activities at Arab and United, the factory contained spinning, weaving, knitting, dyeing, printing and finishing. It is divided into several separate units covering a complex site. Spinning is carried out by both ring frame and open end methods. The latter is mainly for waste spinning of coarse yarns. Total yarn production is about 22000 t/yr. Some yarn is sold this amounts to 8 to 9000 t/yr. Fabric is woven at the rate of 80 Mm per year at widths between 70 and 90 cm and at an average weight of 120 to 150 g/m². Of these fabrics some 60 Mm per year is bleached and printed.

Heavy fuel oil (mazoot) is used to raise steam and to heat oil which is circulated to heat equipment for print fixation, for baking and also to stenters.

The general background to energy conservation was discussed. The need for good maintenance and cleaning in spinning, weaving and knitting was stressed. The problem of power factor particularly arising from oversized motors and the lack of correction equipment led to discussion of the best point at which to apply correction. The current preference for small condenser correction units at individual motors was recommended. This not only applies correction at the point required but it also means that the correction is applied only at those times it is required i.e. when the particular piece of equipment is operated. Application of the correction means that losses in the power distribution network are minimised and the capacity of cables, switchgear and transformers can be reduced. Overall it is believed that many power failures can be attributed to lack of power factor correction causing overloading of circuits and hence break-down. A paper describing best practices was made available to Dr Dahmoush.

In the course of a tour of part of the factory attention was drawn to ways in which energy conservation could be usefully applied. On spinning frames, belt drives were oscillating badly on their pulleys at about 50% of the spindles. This increases friction and hence energy use. This was caused by worn, damaged or badly adjusted belts. A number of heavy belts on opening machinery were slack and clearly slippage was occurring. Tensioners should be fitted and correctly adjusted to minimise energy losses.

Modification to the building structure in the up-twisting section was raising concrete and brick dust in an area in very close proximity to new machinery which was not covered. It was stressed that abrasive dust of this nature could rapidly cause considerable wear on bearing surfaces and once in a bearing would be extremely difficult to remove.

In the boiler house heated oil storage tanks were not lagged, heat losses can be quite large but possible problems with lagging in relation to spillage and maintenance have to be considered. Usually the advantages of such lagging far out weigh any disadvantages. There were several quite large steam leaks which should be repaired. A leak at a valve spindle of 0.25 mm between spindle and packing is equivalent to a 2.5 mm hole and steam losses at 10 bar pressure would amount to 108 tonnes of steam in a year.

Drying fabrics on stenters and cans was preceded by good squeezing. This is noteworthy as at many factories this is not so. The maximum mechanical removal of water must always take place to maintain the highest drying speeds and hence to minimize energy losses.

In the area of the stenters a number of compressors were correctly sited outside the building. These units constitute a potential supply of free hot water, for if water cooled they would provide a steady stream of hot water from the cooling circuit.

Fabric preparation was effected in a Bruggman triple J-box range. This was fitted with coupled washers so that wash water was used twice halving water requirement. It also passed through heat exchangers to recover waste heat into the fresh water supply.

Drying cylinder condensate was used to provide hot final rinse water so that fabrics were mangled hot to maximize water removal before drying.

No condensate return was made to the boilers, in a dyeing and finishing plant of this type 50% return would be normal and would make a major contribution to reduced energy requirement as well as significantly reducing the processing costs for incoming water in the water treatment plant.

This factory incorporated energy conserving features, particularly in the dyeing and finishing area, which were not seen at other factories visited.

ANNEX 3
(QUESTIONNAIRE)

FACTORIES SELECTED FOR REQUEST FOR DATA

1. The Arab and United Spinning and Weaving Co.
2. El Siouf Spinning and Weaving Co.
3. National Spinning and Weaving Co.
4. Orient Linen and Cotton Co.
5. El Nasr Clothing and Textile Co., KABO.
6. Modern Textile Co.
7. Alexandria Spinning and Weaving Co.
8. El Nasr Wool and Selected Textile Co. "STIA".

REQUEST FOR DATA

NAME OF MILL

PERSON SUPPLYING DATA

INFORMATION IF POSSIBLE FOR 1981/82 PLEASE STATE IF OTHER YEAR HAS BEEN USED.

ENERGY INPUTS

MAZOOT TONNES.

ELECTRICITY KWH
(FROM NET WORK)

ANY OTHER? PLEASE STATE TYPE AND QUANTITY.

PRODUCTION

MAIN PRODUCTS ARE

	WEIGHT	AVERAGE COUNT
YARN		
DYED YARN		

LENGTH AVERAGE WIDTH AVERAGE WT/M²

FABRIC

WOVEN

KNITTED

WHITE

DYED

PRINTED

ARE FABRICS FINISHED RESIN? OTHER ? PLEASE STATE QUANTITY.

IS ALL YARN CONVERTED TO FABRIC YES/NO.

IF NO HOW MUCH IS SOLD

QUANTITY:

AV COUNT:

IS ANY YARN BOUGHT IN

QUANTITY:

AV COUNT:

TOTAL PRODUCTION

YARN	QUANTITY	FABRIC	QUANTITY
	AV COUNT		AV WIDTH.
			AV WEIGHT/M ²

WATER

QUANTITY FOR PROCESSES
FOR BOILERS.

QUANTITY OF STEAM TONNE/YEAR
EFFICIENCY %

HOW IS IT MEASURED.

BOILERS

NUMBER

TYPE

STEAM PRESSURE

TEMPERATURE

CONDENSATE RETURN

QUANTITY

TEMPERATURE

BLOWDOWN

CONTINUOUS/ INTERMITTENT

%

GENERATIONS

ELECTRICITY PRODUCTION.

CONDENSATE RETURN.

QUANTITY TEMPERATURE

STEAM USE

DOES ANY STEAM GO OUT OF THE MILL HOW MUCH?

USED FOR SPACE HEATING QUANTITY
FOR HOW MANY MONTHS?

USED FOR PROCESSES QUANTITY
PRESSURE
TEMPERATURE

WHAT ARE MAIN STEAM USING MACHINES ?

PLEASE LIST GIVING RATE OF STEAM USE PER HOUR .

ANNEX 4

(TECHNICAL REPORT ON ANALYSIS OF RETURNS)

ASSESSMENT OF ENERGY USE AT SELECTED TEXTILE MILLS

JOHN G. ROBERTS

UNIDO ADVISER ON ENERGY CONSERVATION

Summary

The energy use at twenty one textile mills has been examined and specific energy requirements for processing in knitting, spinning, weaving, non-woven manufacture and dyeing & finishing have been evaluated.

INTRODUCTION

Requests for information on energy use, production, and where possible details of boiler and machinery operation. The type of questionnaire is shown in Appendix 3. Completed returns are on file at the Textile Development Centre Alexandria.

HANDLING OF INFORMATION

The information received was used in calculations to determine the energy use at each main production stage for one tonne of product. To do this the following calculation steps were made.

Energy inputs to the site were brought to common units by multiplying quantities by the appropriate conversion factors. Using the following factors.

Heavy fuel oil (Mazoot) tonnes $\times 42.6 =$ GJ (giga joules 10^9 joules)
Kerosine litres $\times 0.0035 =$ GJ
Electricity kWh $\times 0.0036 =$ GJ

Where quantities of steam are known these are converted by tonnes $\times 2.7 =$ GJ at normal factory temperatures and pressures.

All converted energy inputs were then summed to give the total annual energy input to the site in giga joules. When more than one production step was carried out at a given site then the division of energy use in each production step has to be calculated where possible as otherwise estimated.

The next step is to convert production values into weights of production at each of the appropriate steps of spinning, weaving, finishing etc. In the 'request for data' the necessary questions were included to provide the necessary information at most of the sites covered.

Annual values for total energy input at each processing step were then divided by the total weight of production for that step. This gives the value of the Specific Energy Requirement which is the average value for the total energy requirement per tonne of production.

SUMMARY OF TOTAL ENERGY REQUIREMENT PER TONNE OF PRODUCTION
BASED ON INFORMATION GIVEN ON QUESTIONNAIRE

FACTORY	TOTAL ENERGY PER TONNE OF PRODUCTION			
	KNITTING	SPINNING	WEAVING	DYEING & FINISHING
KABO	3.7	-	-	58.7
STIA No. 1	-	11.1	40.6	118.7
STIA No. 6	-	-	2.4	24.3
STIA No. 7	-	4.0	3.2	79.3
STIA No. 5	-	-	3.7	131.0
STIA No. 9	-	4.4	15.4	53.1
STIA No. 3	No Production data given			
STIA No. 8	No Production data given			
EL SIOUF	-	4.5	14.7	65.6
ARAB and UNITED	-	3.2	28.3	31.6
ORIENT (FLAX)	-	15.0	-	-
" (COTTON)	-	9.3	20.3	82.3
MODERN	-	-	3.2	129.0
NATIONAL (KARMAZY)	-	13.1	-	-
" (MOHREM BAY)	-	-	20.0	144.0
EL GHARBIA	0.5	-	-	142.0
ALEXANDRIA	-	3.4	12.0	40.4
KAFR EL DAWAR No. 1	-	15.6	-	-
" No. 2	-	24.5	-	-
" No. 3A	-	7.6	-	-
" No. 3B	-	22.3	-	-
1+2+3	-	-	25.7	-
BEIDA YARN & FABRIC	-	-	-	77.9
" WOOL TOPS	-	-	-	25.2

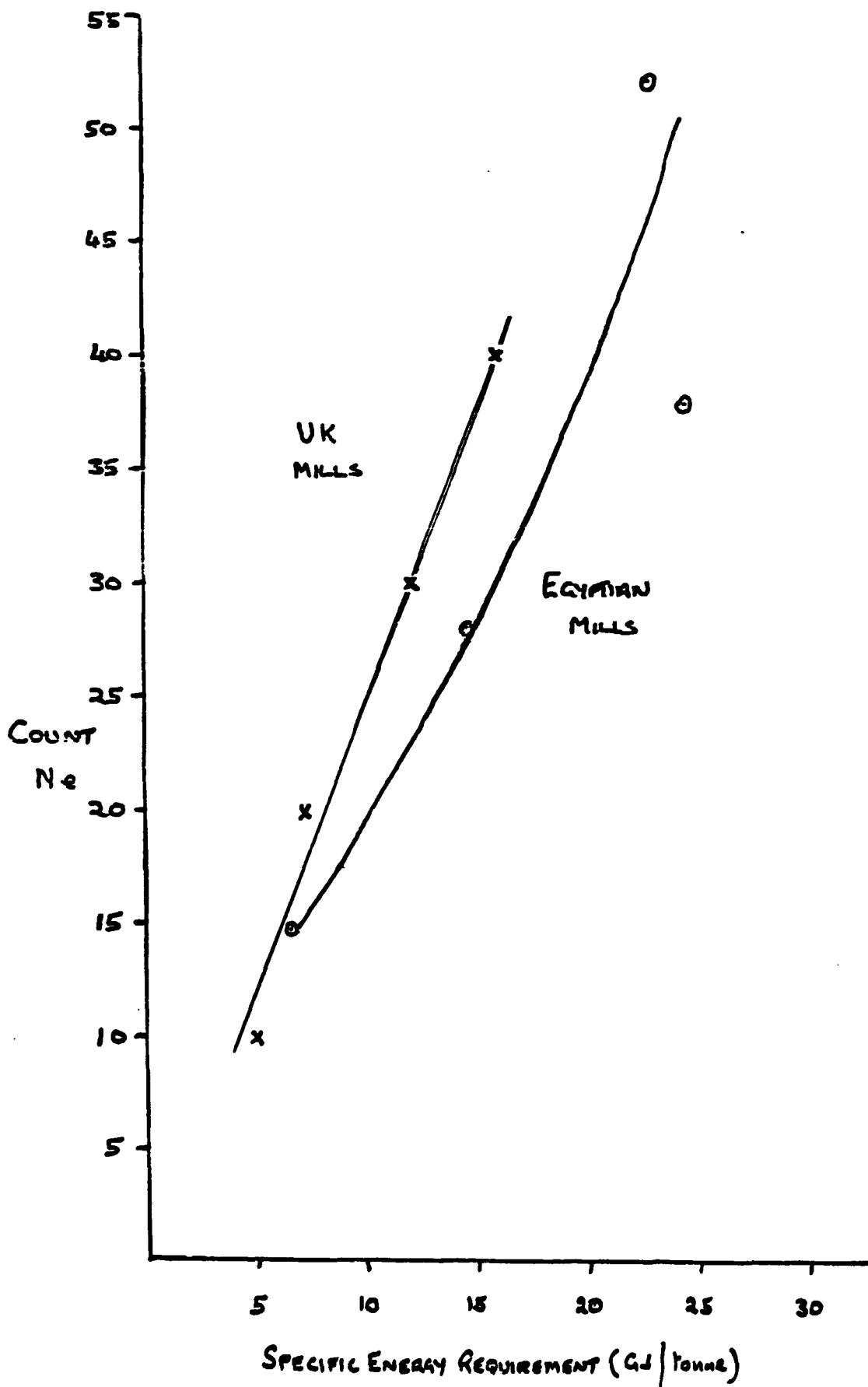
* Assuming Spinning and Weaving are in ratio 1:3.5
Non-woven production

RESULTS

The values obtained at each mill examined are shown in the accompanying table.

These results enable comparisons to be made between mills in the same sector (i.e. spinning, weaving etc.). However care should be taken in not taking these comparisons too far as there is considerable variation in the energy requirement for different products, for example, in different counts of yarn, different weights of fabric as in differing degrees of complexity in the dyeing and finishing process. The true value of the value of SER is in making on-going comparisons at a given mill, so that improvements in the efficiency of utilization of energy use can be monitored.

An excellent example of differing energy requirements for a given product can be seen in the case of yarn spinning. The count of the yarn determines the energy requirement. The finer the yarn the greater the number of revolutions required at the spinning frame for a given weight of yarn produced. The relation between count of yarn and energy requirement per tonne of product for several mills is seen in the accompanying figure. For comparison similar data from spinning mills in the UK is also plotted. The energy requirement per tonne of yarn is consistently higher in Egypt at all but the coarsest counts. From observations made during visits to spinning mills it is suggested that this is the direct consequence of at least two factors: one the low power factor in the Egyptian mills visited which leads to high energy losses in the distribution circuits and two, the high frictional losses at machines through dust and dirt contamination of bearings and poorly adjusted and worn belt drives to spindles.



CONCLUSIONS

Collection of data of this type to facilitate on-going monitoring of energy utilization is an essential feature of any energy conservation programme. It provides a means of assessing improvement and of maintaining improved standards. It also enables early identification of any fall-off in standards of energy utilization.

Hence data collection should continue and be expanded to cover the entire industry sector.

PAPER 1

ENERGY CONSERVATION - WHY ?

The fossile fuel resources of the world are limited. The rate at which they have been used in the last 100 years has been increasing rapidly as world population has grown and as industrialization has increased. These rates of growth have been so high that the rate of use of some fossile fuels will exhaust the world supply in the next 100 years.

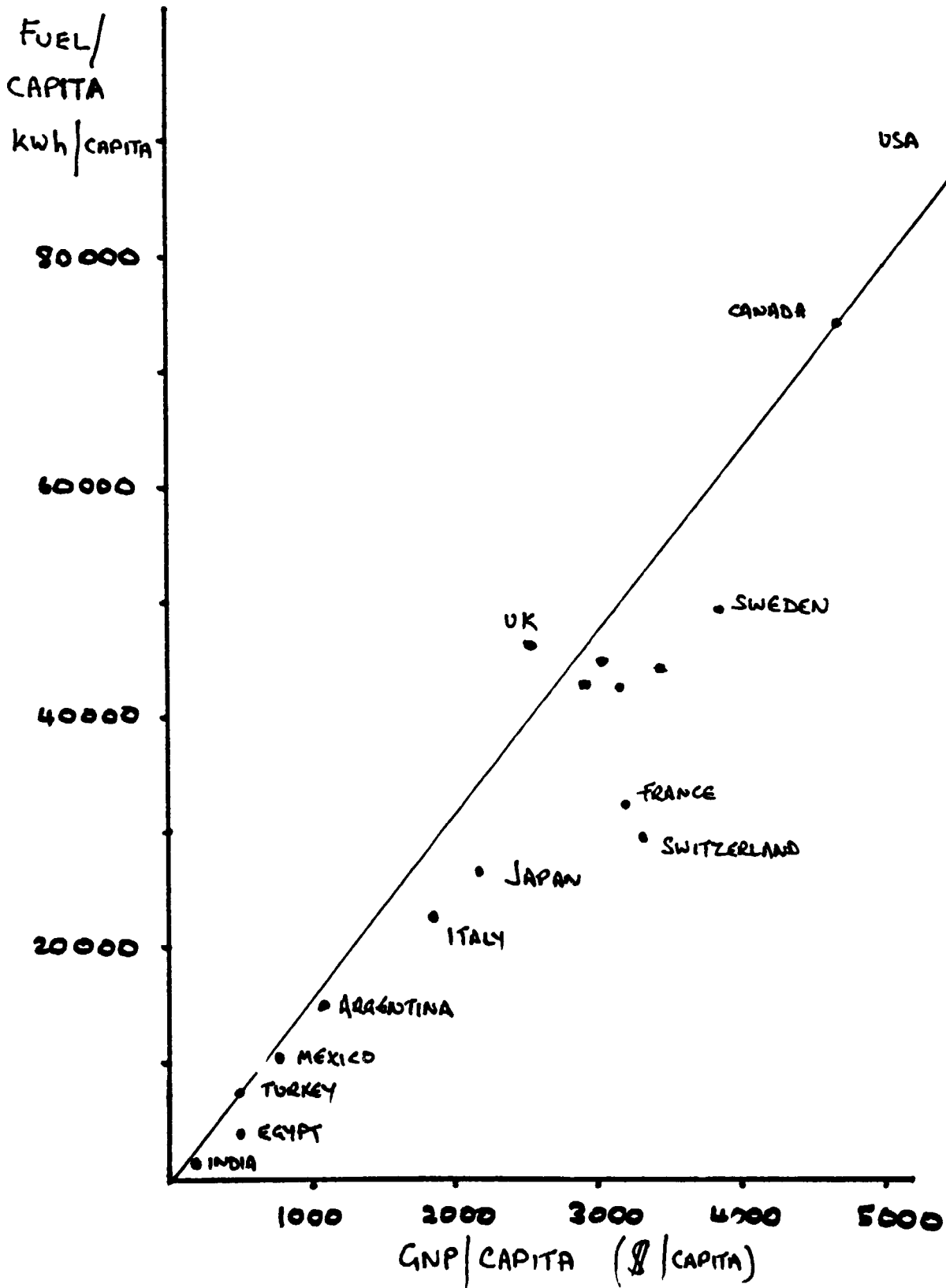
The level of fuel use in different countries varies greatly. for example from United Nations data for 1970 the wide distribution can be seen Fig.1. Many countries with growing industries have moved up the curve since 1970 but the west European countries and Japan have moved to lower energy use through energy conservation and economic recession (Figure 2.) The continuing upward growth of the rest of the world and Russia and China show how there is increasing demand for fossile fuels.

Figure 3.

WORLD DEMAND FOR ENERGY 1928-1978

	Million Tonnes Oil Equivalent	<u>Coal</u>	<u>Oil</u>	<u>Natural Gas</u>	<u>Others</u>	<u>Total</u>
1928	1160	74	16	3	7	100
1938	1275	68	21	6	6	100
1948	1730	57	27	8	8	100
1958	2800	47	33	11	9	100
1968	4590	34	42	18	6	100
1978	6685	27	46	19	6	100

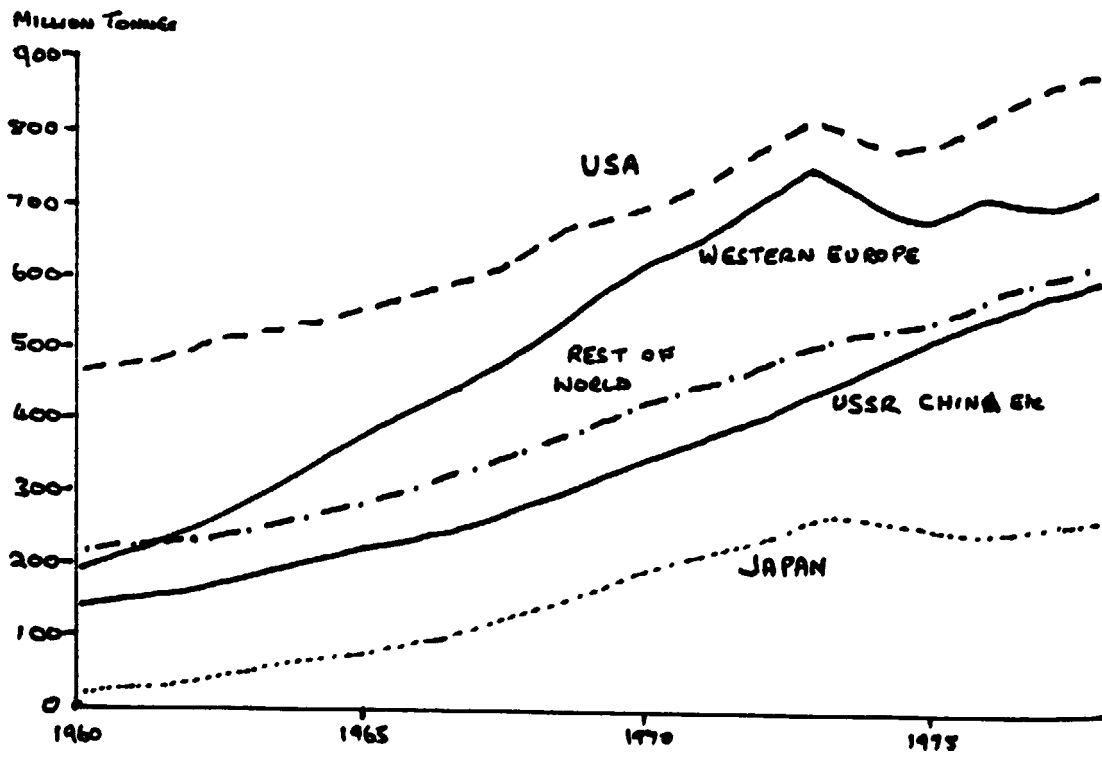
FIGURE 1.



(SOURCE: UN Statistical Yearbook 1970)

FIGURE 2.

World Oil Consumption 1960-1979



The increase between 1928 and 1978 has been rapid and most marked by the increase for oil and natural gas (Fig.3) and the decline proportionately in the use of coal. This is related to the ease of abstraction and the ease of handling in use. The increase in total energy has taken place in the rest of the world reflecting the massive growth of new industry.

Oil reserves are located in various parts of the world. Here in the Middle East are located the largest reserves some 50000 million tonnes. The current rate of use World wide is about 2500 million tonnes per year. So at the present rate of use the Middle East could supply the world for about 20 years (Fig.4) of course there are supplies in other parts of the world but they would not double the expected supply. There will of course be other discoveries of oil fields but again geologists have now a very good understanding of the type of rock structure which contains oil and also of the location of such structures throughout the world. So we cannot expect to find suddenly completely new and unexpected oil fields. We have to accept that there is a limited supply and treat it accordingly.

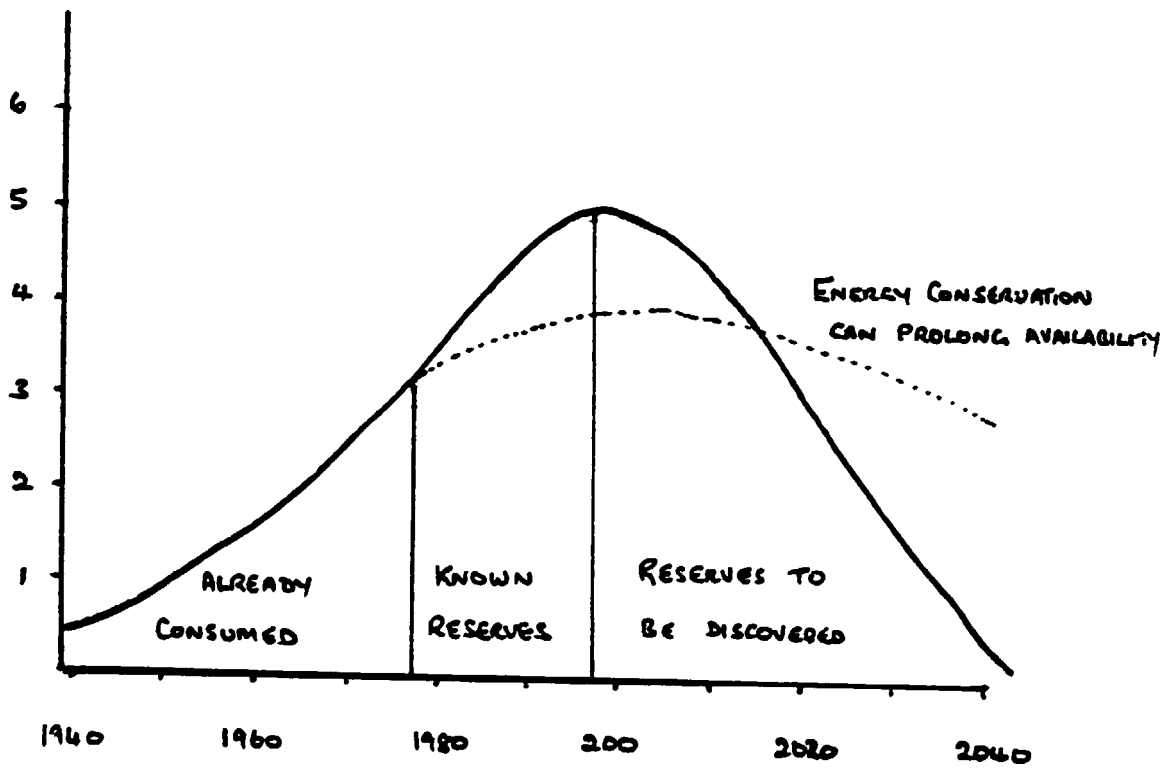
Many countries have set up a strategy to cope with this situation. Substitution of coal for oil in raising steam is occurring widely. Hydroelectric and nuclear power generation is being invested in. Alternative sources of energy are being experimented with such as solar, wind and wave power and ultimately plasma power.

Of other fuels natural gas closely follows oil and is of similar limited supplies.

Coal however exists in far greater, but not unlimited, quantities. It is notoriously difficult to mine and not all sources are currently economical to mine.

FIGURE 4.

CONSUMPTION
billion tonnes
per year



One major source of energy has not yet been mentioned. It is energy conservation. You will say it is not a source of energy but if equivalent production can be achieved with a reduction in energy use then it is every bit as good as a source of energy.

So this is the reason for my presence here as an adviser for UNIDO. You can all play a part in establishing energy conservation as an essential part of your industry.

In many countries Energy conservation is well established. It is true to say that an important part is played by the cost of energy. In many countries the true market price of oil, coal, gas and electricity applies. From my experience in Egypt I find that there are major subsidies provided by your Government amounting I believe to L.E. 2.7 billion per year. So that you enjoy a price of L.E 7.5/tonne for heavy fuel oil and less than 1 piastre/Kwh for electricity. This means that there are not the same financial incentives for energy conservation. I detect in Egypt a feeling of concern that makes energy conservation something that every one must take seriously in the future.

PAPER 2

ENERGY CONSERVATION - HOW ?

The first requirement for energy conservation in a factory is to establish the following:-

- Top management support for energy conservation.
- A person who has as part (or all) of his duties. specific responsibility for energy.
- Good communications.

In most factories a 10% saving in total energy use can be made easily by attention to detail - good housekeeping with some moderate capital expenditure 20% can easily be achieved.

What should be done first ? A simple audit of the factory site should be made. However in complicated large factories it is better to start at individual mills.

Measurements or estimates must be made of the following:-

Energy in comprising

Heavy oil (Mazoot)	Tonnes/year.
Electricity	Kwh/year.
Any other fuel	/year.

Using conversion factors these are then converted to common units.

Heavy oil	Tonnes X 42.6 =	GJ	%
Electricity	Kwh X 0.0036 =	GJ	%

Factors for other fuels are available

Total energy	<hr style="width: 100px; margin: 0 auto;"/> GJ =====
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Now each fuel can be converted to a % of total. The next step is to establish the total annual production for the mill. Spinning = tonnes yarn. Weaving = length fabric X average width X average weight/M² hence tonnes fabric. For dyeing and printing the total weight of production can be found.

How take total energy/total production to give a value for energy (GJ) per tonne of production.

Spinning in Western Europe is in the range 7 to 38% GJ/tonne but at least half this is required in heating mills in cold weather which is not necessary in Egypt. So the expected range should be 4 to 10 GJ/tonne. If special cooling is required this could be higher.

For weaving the expected value for Egypt could be of the order of 10 - 40 GJ/tonne. For knitting the values would be likely to be in the range 5 to 60 GJ/tonne and for dyeing and finishing 10 to 200 GJ/tonne depending on the complexity of processing. In the woollen and worsted industries it is difficult to quote meaningful values as there is such a wide variety of processing methods. In my experience in the UK values as far apart as 10 and 400 GJ/tonne have been found through the average is about 90 GJ/tonne.

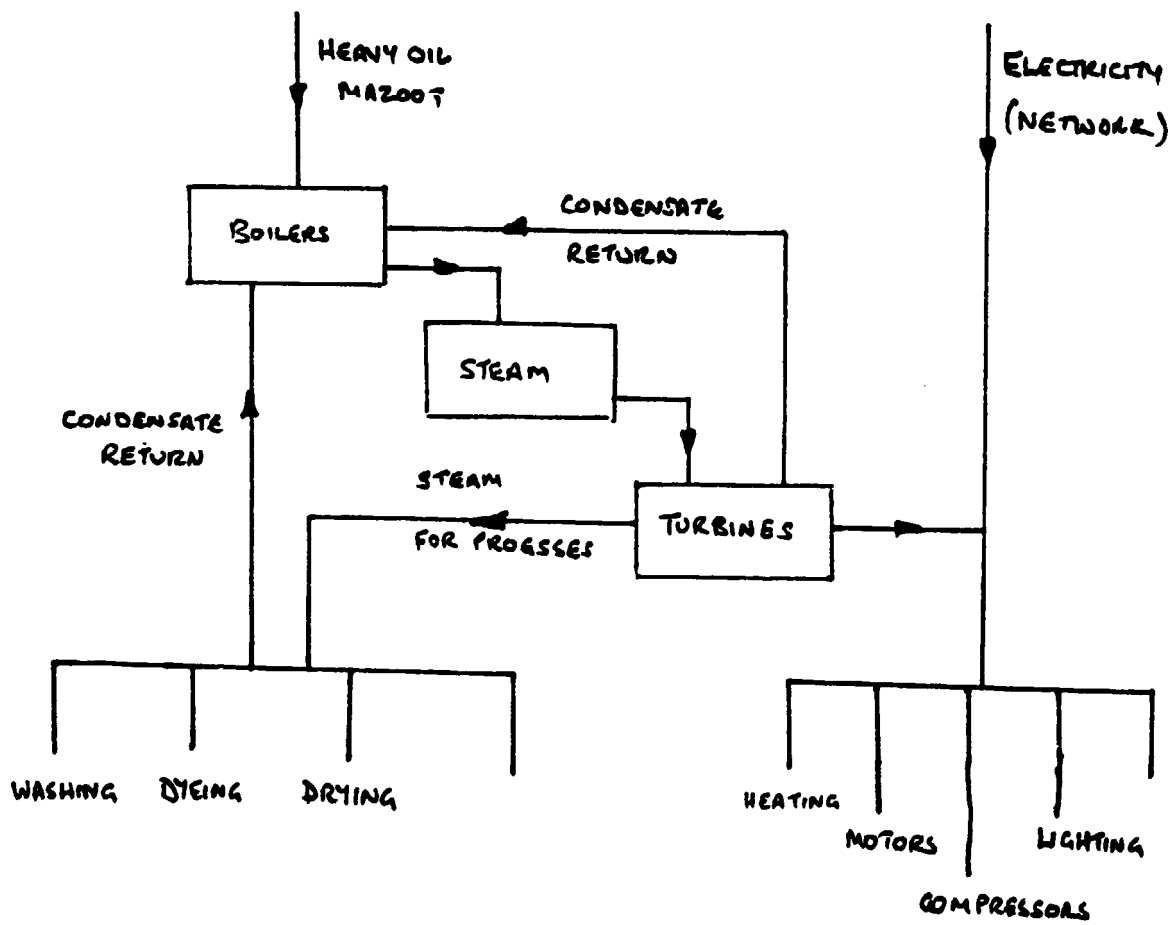
Having established the overall value for energy per unit of production it should be determined at regular intervals and changes found related to changes in processing in the factory. This is extremely important as much can be learnt from this factors which influence the value may be

- Production changes
- Changes in product mix.
- The difference between summer and winter temperatures.
- Faults which occur such as undetected leaks of steam or hot water.
- A damaged exhaust damper on a hot air machine such as a stenter or steamer-baker.

The next stage which should be undertaken is an audit of individual units, operations and machines in the factory. A balance of energy flows is made and the ultimate destination of energy determined. (Fig 1). This then enables the major energy using areas to be identified and will be of major assistance in determining priorities of every conservation.

Whilst this is in progress all parts of the factory will be needed to be visited and this will provide the opportunity for all "good housekeeping" requirements to be identified and actions implemented so that energy saving at little or no cost can begin immediately.

FIGURE 1 ENERGY FLOW



In an energy audit the amount of energy at each stage should be measured or estimated so that an energy balance is made.

Energy Conservation

Steam Distribution

(Utilisation of steam for process and heating. Dept. of Energy)

Let us start at the end of the steam run, i.e. at the surface of any process plant, because an understanding of the principle of heat transfer and the various resistances to that flow and the factors entailed are of fundamental importance to any steam user.

FIG.6

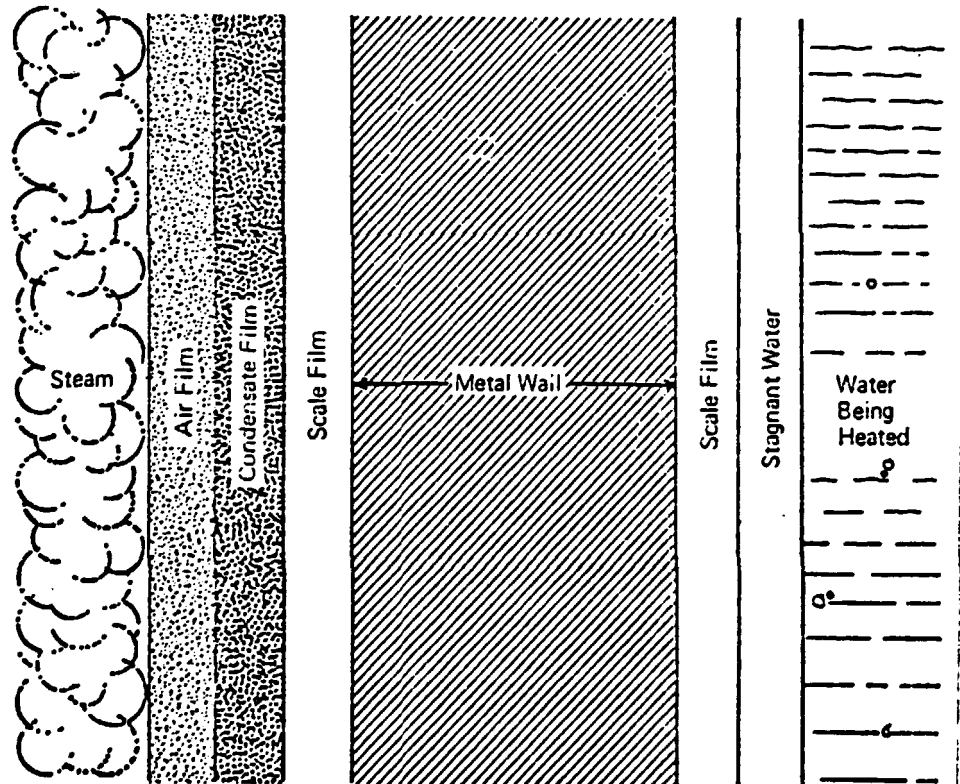


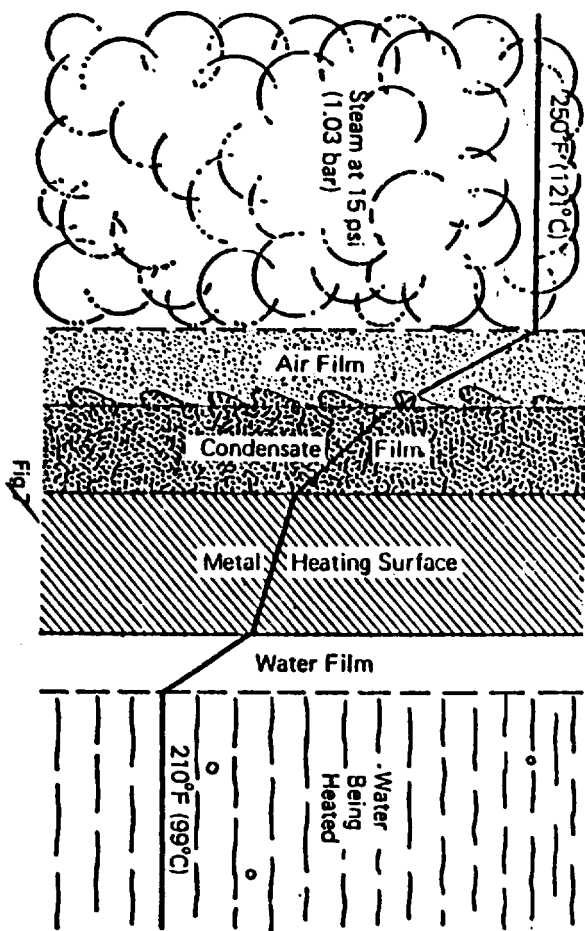
Fig 6 Films of air, water and scale film on the condensing surfaces seriously reduce heat transfer efficiency

Fig.6 shows succinctly the reason for the use of steam as a medium and the total aim of the expensive Boiler plant and the whole distribution system. The behaviour of the steam and the heat transfer at this interface decides in the final analysis the efficiency of production. The centre section of figure 6 is heating surface of any process steam plant in which the steam does not come into direct contact with process material. At the right is a stagnant film of the product and possibly a scale film of caked on product. These films put up considerable resistance to the flow of heat to the product.

It is necessary, where it is practical, to cleanse this surface; you will be repaid always for this type of maintenance.

We must now look at the left-hand side of the heat exchanger wall which, of course, is the steam side. This film is generally made up of rust and dirt from the pipework and of impurities associated with carry over from the boiler due to possibly priming as a result of peak loads, also feedwater treatment that is not controlled satisfactorily. If at all possible, clean out the heat exchanger as regularly as you can - the heating efficiency will improve dramatically. Investigate the use of foaming Amines in the feed-water treatment; this could reduce scale formation, particularly in wrought iron pipes and heat exchanges.

Secondly, between the steam and the heating surface is a water film and an air film. Air must be removed as efficiently and as quickly as possible; it is by far the best insulator and the most benefit will accrue when it disappears. The water must be removed also, as this is a bad conductor of heat.



FIGS. 7 & 8

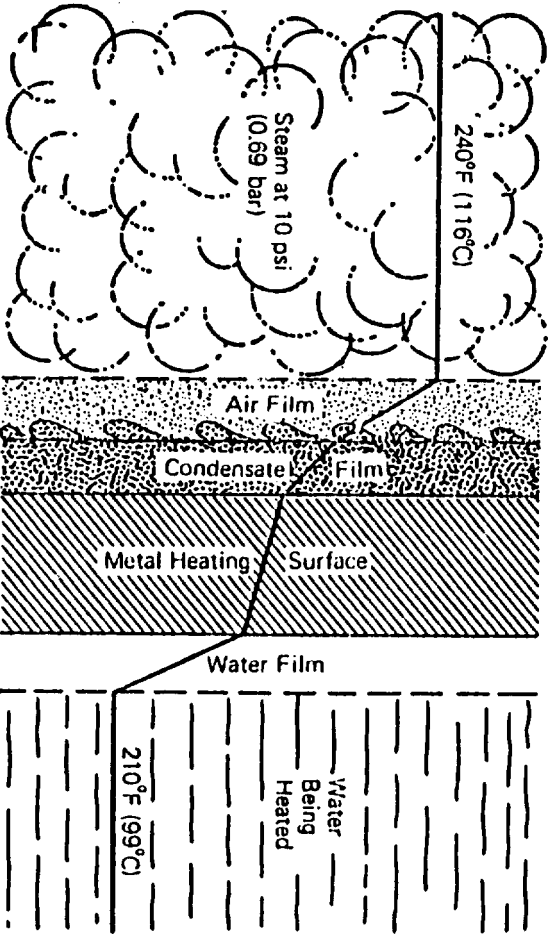


FIG.7&8 Examining figures 7 and 8 we observe that these give an even closer view of what happens at the process heating surface. The water film is between 60 and 70 times more resistant to heat transfer than the iron or steel wall of the heating surface, and 500 to 600 times more resistant than copper.

The film of air is dramatically more resistant to heat transfer, and of course is used as an insulator in fibrous matts where the non-conducting fibres enclose minute cells of air to produce insulation properties of superior qualities.

AIR is in fact 1500 times more resistant to heat transfer than iron or steel and 13000 times more resistant than copper. For example, a film of air of 1/1000 INCHES thick will resist heat transfer as much as a wall of copper 13 INCHES thick. Practically the effect of the air and water films on the process output are illustrated in the diagram shown. In figure 7 steam at 15 p.s.i. pressure is having to be used to give a process temperature of 210°F (99°C). In figure 8 the same effect is obtained from steam at only 10 p.s.i., because the thickness of the air and water films has been greatly reduced. Therefore at the original steam pressure of 15 p.s.i. it would now be possible to obtain, through accelerated heating, a much improved output.

FIG.8

Wherever possible these insulating films of air and water must be reduced.

The introduction of automatic air vents where air accumulates is essential and the type that will handle large quantities of air should be used. Air should be removed quickly because (a) the presence of air in the heat exchanger will, as we have previously shown, reduce the heat transfer significantly; and (b) when the steam eventually arrives at the heat exchange, very often turbulence occurs and any air remaining could intermittently mix with the steam, so rapid air removal is essential.

The quicker the removal of air then the more rapid will the steam space be filled with steam, and of course this enables the plant to reach production temperature.

To capitalise on the difference in temperature between steam and air we can use Thermostatic Air Vents or traps that will handle air as well as condensate by the use of installed thermostatic air vents. As previously mentioned, it is to our advantage to use high capacity air vents, and to this end a suitable air vent is the balanced pressure type as illustrated in FIG. 10.

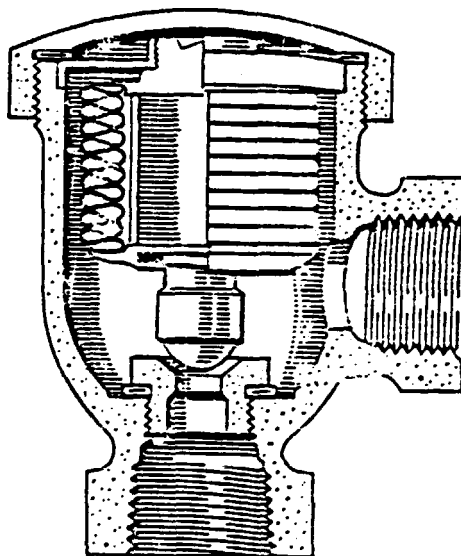


Fig 10 Balanced pressure air vent

Having talked about the requirements and in some detail problems associated with the end use of steam, we turn our attention to the beginning of the story - the boiler - and trace the passage of steam from that boiler to the end-use.

Why do we have a boiler? Being able to produce steam with the utmost efficiency is a laudable exercise but not an end in itself.

The purpose is really found in the metal heating surface of the heat exchanger which we have examined previously. Steam is produced for one purpose only - that is to condense and give up its heat through heat transfer to the production process.

In the laying out and the designing of the Boiler Plant, some of the following questions should be asked and answered.

1. In a multiple Boiler installation are the header pipes and connecting pipes laid out in the best arrangement?
2. Are the pipes of sufficient size to take the imposed loads?
3. Correct pressure for the process?
4. Correct quality?
5. Has sufficient thought been given to the layout of the steam and condense lines from the point of view of draining, trapping and insulating.
6. Condensate recovery, attention to falls in pipework to condensate collecting points, insulation.
7. Dryness of steam at point of use: Trapping, Air Venting, possibly the fitting of water separators.

Siting of the Boiler Plant

The Boiler should be sited as close to the process plant as possible. This will reduce the transmission loss, and loss from leakages.

Unless the steam main or pipe is run by the shortest possible route, then there will be needless radiation losses. Redundant pipework should always be removed immediately. For example, a 45ft length of unlagged 1-inch pipe carrying steam at 80 p.s.i.g. for 5 days a week and 50 weeks a year wastes in the order of 4 tons of coal, or 650 gallons (2955 litres) of fuel oil per year. This is equivalent to running a 2 kW electric motor on full load for a whole year just for the hell of it.

Design of the steam networks should take recognizance of the operation of the factory, so that in the event of one or more departments working different shifts then section turn offs can be facilitated.

(Recently we were asked to evaluate a steam network drawing which had been produced by a well-known Mechanical Services Contractor, and there was not one valve on the branches - all the valves that were planned were solely on the process plant.)

Lagging of the plant and pipework is extremely important, and experts should be brought in.

There is a vast amount of heat wasted through by-passes around trapping sets being left open.

By-passing is not normally necessary if the traps that are fitted are of the correct size and properly fitted. It can only be justified if it is of absolute importance to keep the plant running whilst repairs and maintenance are done.

Control of Temperature at point of use

The process should be controlled at the lowest possible temperature. Excess temperature wastes heat. Use Thermostatic Valves to control the heat.

Examine room temperature for excesses - remember that 1°F rise above 68°F can put 2 to 3% on your fuel bill.

Consider the heating of liquids by direct steam. (Brunel used a steam locomotive at a garden fete to produce the water for providing tea for a large crowd of people.) Provided the steam is under control, then this can be the most efficient way of heating a liquid. But direct steam injection can be very wasteful if too high a pressure is used, incorrect injection techniques are employed, or there is loss of control and the liquid allowed to boil.

Simplicity is the name of the game in types of temperature controls used.

Don't go for capital intensive equipment such as complicated proportioning controls when a simple inexpensive self-acting temperature control will do the job. Extreme accuracy costs money.

Don't let it slip away.

We assume that at this stage we have produced the steam efficiently and it is being distributed through a system that has reduced the losses to a minimum.

We now look at the uses the steam is being put to. Heating of the building is probably being done by the use of steam. The supply of the heat through the medium of the steam is to make good the heat losses from that building. Ingress of cool air and the combined effect of the losses through the structure have got to be made up from the heating system.

Therefore the total heat demand is controlled by the materials used in the construction of that building.

Because of the effect of poor materials, insulation building regulations have tightened so that a factory roof for example must now not exceed 1.42W/M^2 °C. Older buildings that are made of corrugated asbestos could have a U' value of $5/6\text{W/M}^2$ °C.

Mechanical drying of the process for cloth or paper is readily available and should be used wherever possible.

Better distribution of Steam

Process steam quality (its degree of dryness) depends, as we know, on the manner in which it has been generated and also how it has been distributed.

If you are generating saturated steam then the following should be checked.

Starting at Boiler stop valve, adequate collector for condensate with strainer and steam-trap - a steam separator at this point will pay dividends.

The steam main, no matter how well it is lagged, will collect condensate on its passage to the process plant. The condensate should be drained often and at every convenient low point using separators and trapping sets. Pipes too small cause steam starvation. Pipes too large cause excessive losses due to larger radiating surfaces.

Sagging or bellying mains due to bad design or too few supports cause water pockets to form and are often the cause of water hammer at warm up, and the steam picks up water reducing the quality of the steam.

Reducing Valves

Care should be taken in the installation of Reducing Valves makers' instructions should be adhered to. Wet steam is almost certainly the cause of malfunctioning of a large number of Reducing Valves and removal of condensate before the R. Valve is extremely important.

Steam trapping

The choice of trap and size, for the process in question, must be carefully considered. This decision can affect, amongst other things, the speed of process - whether the machine takes 15 minutes to come up to temperature or 40 to 60 minutes.

Common types of traps in use are:

1. Thermodynamic.
2. Thermostatic (Balanced pressure liquid-expansion, bimetallic-expansion).
3. Mechanical (ball float, open top bucket, inverted bucket).

T.D: - Very robust. Can be used outdoors

Balanced Press, Thermostatic:

Drawbacks: would be damaged by water hammer.

Advantages: automatically adjusts to steam pressure within its range, light and small large discharges also it discharges air freely.

Liquid Expansion Thermostatic Type

Advantages: they can be adjusted for temperature.

Can withstand water hammer.

It utilises the great power of hydraulic expansion.

Bimetallic Thermostatic type

They discharge condensate at a temperature below steam temperature therefore a cooling leg must be fitted. They are robust and resist damage from water hammer and frost.

Ball Float type

Ball float type traps are equally efficient at low and high levels of condensate discharge.

They discharge the condensate as it forms. Size for size they have a larger discharge capacity than most types of mechanical trap. Most of these traps have either an internal automatic air release or steam lock release. This removes the problem of air binding and steam locking.

Open Bucket type

Advantage: Robust, can stand up to the most difficult of conditions, they will stand up to water hammer. They last longer than most traps because they are made of heavier metal.

Disadvantage: They tend to be large. They vent air slowly. Because they retain water they can freeze.

Inverted Bucket type

Disadvantages: Tend to waste steam when lightly loaded. They can not air bind but release air slowly.

Advantage: Robust and simple.

Show slides illustrating some of the points in the text.

Finally a Note on Steam Leaks

Using steam values with conventional glands a leading valve manufacturer completed controlled experiments which revealed the following information: Using saturated steam @ 150 p.s.i. and with known gland clearances of 0.001", 0.0015" and 0.002" respectively there were losses of 24-516/hr, 58.8 16/hr and 71-316/hr. Taking steam @ £3 per 1000 lb of steam then gland with .002" clearance costs £36 a week, £144 per month or a massive £1 728 per year. **JUST ONE LEAKING VALVE.**

Energy Conservation

Practical approach in the boiler house

1. Boiler efficiency

Combustion is the chemical reaction between a fuel and oxygen, which releases, or liberates, heat.

We need to know the mechanics of combustion so that the realisation of the calorific value of the fuel being used can be attained.

The air supplied to the furnace for combustion contains, as we know, 21% by volume as oxygen and 79% by volume as nitrogen. The nitrogen takes no part in the combustion process and, in fact, it passes through the furnace unchanged, but as it does, it carries heat with it.

If we consider the case of pure carbon, then firstly, if there is enough air it burns to carbon dioxide (CO_2). Thus the air is replaced by CO_2 to the same volume, i.e. 21% CO_2 .

If the air supplied is less than required, some of the carbon burns to form carbon monoxide (CO). As a result the full value of the energy, or calorific value of the fuel, is not released, or attained.

In the fuels we use in boilers, of course, besides carbon we have present hydrogen and when hydrogen burns in air the product of this combustion is water (H_2O). Steam will be formed and on cooling will condense into water which, in fact, occupies an insignificant volume as compared with the original hydrogen.

Practical aspect of combustion

Carbon and hydrogen are present in the fuels we use and are burned together. If both the carbon and the hydrogen are burned completely then the hydrogen combines with some of the 21% of oxygen in the air to leave water and, of course, nitrogen. The carbon combines with the remainder of the oxygen to form CO_2 and nitrogen. It follows that if the exact amount of air was provided to burn the fuel completely then the exit gases would have less than 21% of CO_2 .

The water in the products of combustion could remain as steam, or it will condense. In both cases the percentage of CO_2 will be less than 21%, but, of course, if steam is present and not water then because of its higher volume the CO_2 will be at its lower value.

When analysing the flue gases, if steam is present then the analysis is on the wet basis. In most tests on flue gases the gases are cooled and hence the steam is condensed so, therefore, the dry basis is used.

Perhaps the tests for CO₂ and back end temperature is the most effective and easily performed tests that give an indication of combustion efficiency and excess air.

Explain test.

The percentage of CO₂ in the waste gases indicates the quantity of excess air used for combustion. Another instrument that can be used in place of the CO₂ recorder is the instrument that records the percentage of oxygen in the flue gases and hence the excess air. The oxygen percentage should be kept as low as possible, consistent with preventing CO and smoke. This method gives the quantity as a percentage of the amount of excess air present in the flue gases.

Listed below are theoretical % CO₂ and target CO₂ % all derived on the dry basis

	Theoretical % CO ₂	Target CO ₂ %
Fuel	18.6	12
Bituminous coal	19.2	13
Dry steam coal	19.5	13
Coke	19.5	13
Anthracite	19.5	13
Fuel oil	16.0	12

Even if we have the correct proportions of air and fuel it does not necessarily mean that there will be complete combustion.

1. The fuel may not have been heated enough to enable it to combine with the air to provide complete combustion.
2. Complete atomisation of the oil and mixing with the combustion air may not have taken place.
3. The velocity through the furnace may be too high, allowing the mixture to cool before completing combustion.

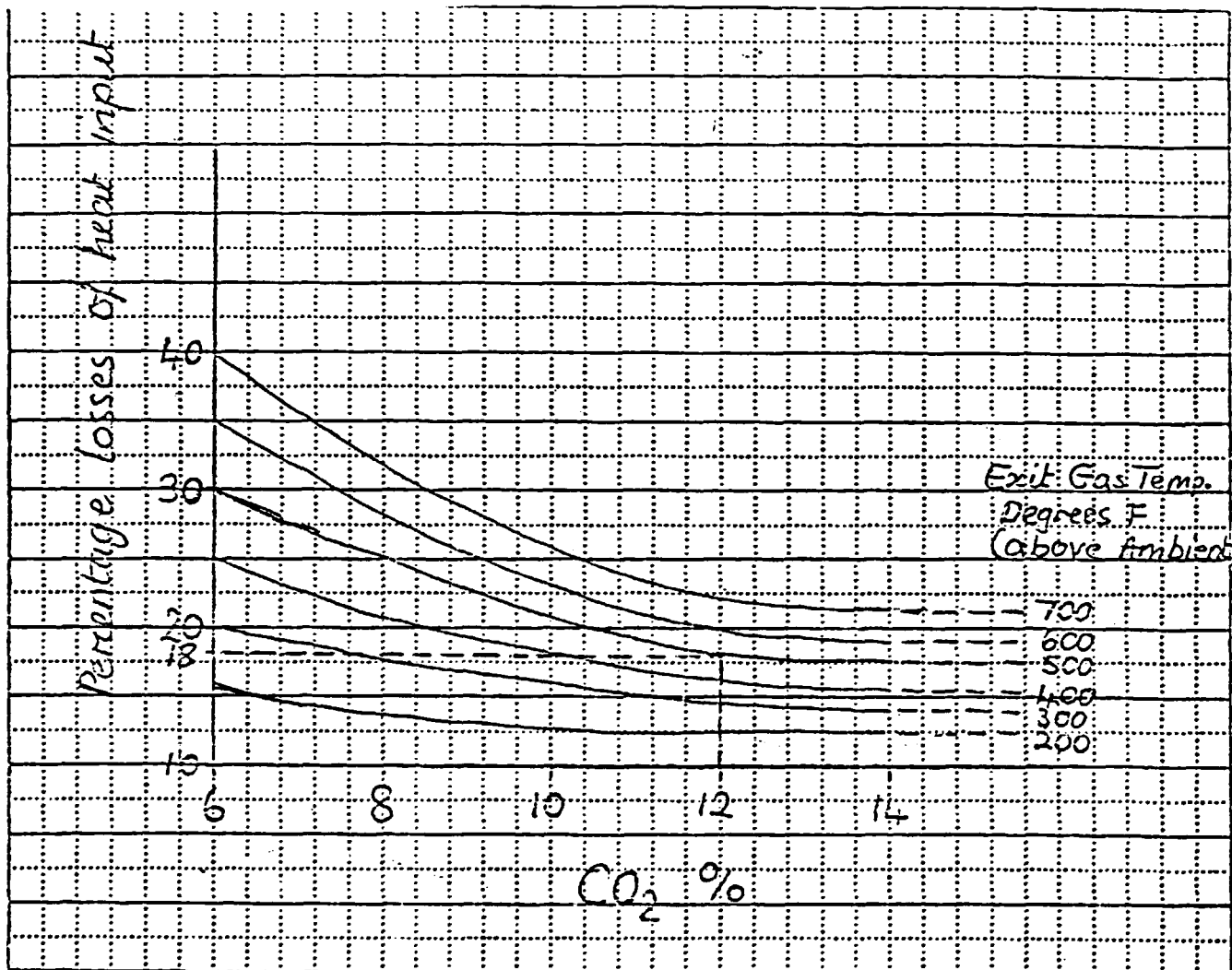
So it follows: get the three 'Ts' right, and we should have the first requirement: Complete combustion.

The three 'Ts'.

1. Turbulent mixing of fuel and air.
2. Temperature of fuel sufficiently high to enable it to burn.
3. Time for the fuel to combust within the furnace

A simple graph can be drawn to illustrate the percentage loss of heat input in relation to exit gas temperatures and percentage CO₂ present in the flue gases.

Viz:



So if we look at the graph and we attain a reading of 12% CO₂ and a back end temperature of, say 500°F, then the stack losses are in the order of 18%; add 2 or 3 percent for surface heat loss then the losses are in the order of 20%, making an efficiency of 80%. The addition of an economiser can give a further increase in efficiency of approximately 5 to 10%. If the efficiency is raised from 80% to 87% then there is a corresponding fuel saving of 8%.

Obviously, reducing the exit temperature by the use of economisers must be controlled. If reduced to, say, below 260°F then neutralisation of the sulphuric acid would have to be contemplated. The use of magnesia in this context has been made, but problems with this method do arise, i.e. dewpoint, that is, acid dewpoint, affecting the chimney lining.

The reduction in temperature of the exit gases will affect the chimney performance and, therefore, could introduce unacceptable pollution problems. So, as always, there has to be compromise between the requirements of the environmentalists and the need for economy.

Under project EEC laws it will be compulsory to burn low-sulphur oil in densely populated suburbia.

The water and steam space

It may be all that is necessary is to listen to D.C. Gunn of Thompson Cochrane, the Glasgow boiler makers, who says:

Water and Steam :

No untreated boilers should be in operation anywhere in the world. (Give Syrian experience, i.e. salts calcium bicarbonate in heavy deposits on waterways, including furnace- result furnace end blown out, killing one man and maiming another.)

Depending on the substances present in the boiler feed water, the modern high-efficiency boiler can be destroyed in a short span of time by excessive over-heating, due to scale growth, or by dissolved gases, causing corrosion, in my experience free oxygen, being the main cause, although not necessarily exclusively.

It is normal to feed suitable chemicals to the boiler feed water; the chemicals that have been added reacting with the undesirable constituents within the boiler.

Without the addition of these chemicals the scale-forming salts such as calcium bicarbonate would precipitate on contact with any heated surface to form a hard carbonate scale, which will reduce the rate of heat transfer, resulting in reduced efficiency, and if allowed to increase unchecked, become a danger to the boiler plant, and itself may be over-heating the furnace, and in extreme cases causing over-heating and ultimately the collapse of the furnace.

Salts such as sodium carbonate added to the feed water cause the hardness salts to precipitate, not as hard scale, but as sludge. Some of these remain in suspension in the water, the remainder falling as a soft sludge to the bottom of the boiler, which in most cases will be removed by the blowdown.

Dissolved oxygen is dealt with by the addition of sodium sulphite at a level of approximately 50 to 150 ppm. As the boiler continues to steam then the dissolved solids are concentrated and also the precipitated salts thereby increase the density. If this is allowed to continue then foaming and carry-over can occur, resulting in the production of wet steam at the best, and at the worst, dangerous conditions within the water space, i.e. surging towards the steam take-off point and in extreme conditions, exposing internal surfaces that would normally be surrounded by water. Water level and safety controls may lock out.

Manual or automatic blowdown is used to control the conditions in the boiler. Where excessive blowdown is necessary, for example, in hard water areas, then the recovery of some of the heat from the blowdown should be considered.

Should the pressure in a boiler be suddenly reduced by a peak load which cannot be matched by increased firing rate, then this can create the condition of carry over with the subsequent operation of the safety controls. It follows that water conditions in the boiler and the load imposed on the boiler should be controlled.

Because of the above statements and because the burner will be more efficient at full load, when sizing a boiler plant it should be sized for full load. This calls for careful additions of all the steam users before committing your company to a particular size of boiler plant.

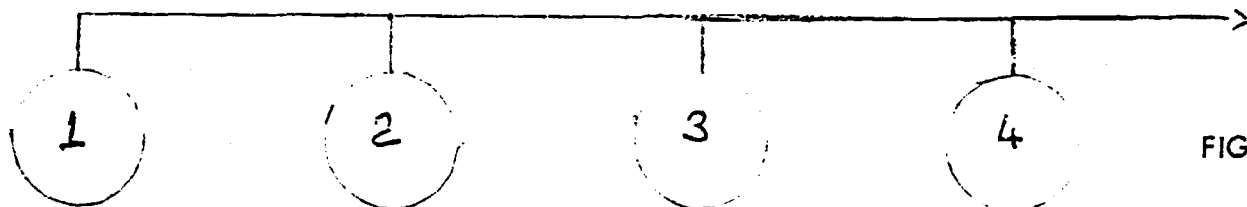


FIG 1

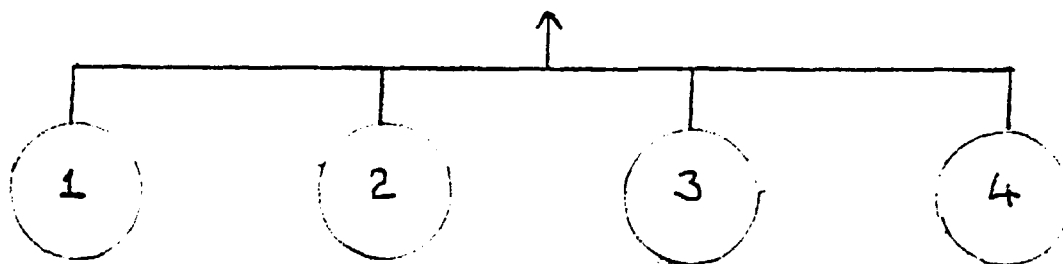


FIG 2

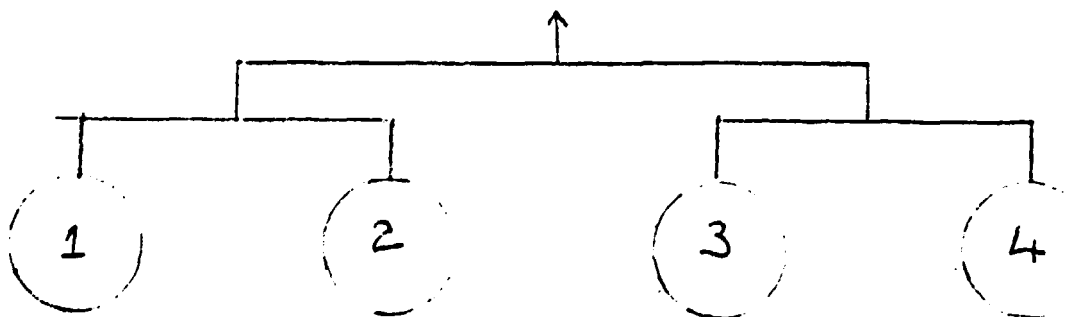


FIG 3

Fig. 1 shows the steam being discharged from one end of the header.

The force driving the steam from the boiler into the header is the pressure difference between the boiler and the header, multiplied by the bore of the connecting pipe. The pressure difference is small, approximately $\frac{1}{4}$ lb/in² for No.1 boiler. There will be a similar force driving the steam along the header to where it connects with No.2 boiler. The pressure loss along the header will be in the order of $\frac{1}{4}$ lb/in² and will mean that No.2 boiler discharging into a $\frac{1}{4}$ lb/in² lower pressure in the header results in an increased driving force. Thus if boiler No.2 is at the same pressure as boiler No.1 it will discharge more steam.

Likewise for the other amount of steam between boiler Nos 2 and 3 than it was between boiler Nos.1 and 2 resulting in four times the pressure loss and three times more between boiler Nos 3 and 4, resulting in nine times the pressure loss. It is easy to see that boiler No.4 is likely to be over-loaded. The increased pressure difference between boiler No.2 and header results in an overload of about 5%, which is tolerable, so that a satisfactory solution is to discharge the steam from the middle of the steam header, as shown in Fig.2, rather than at the end. An even better arrangement is shown in Fig.3 and this should be used when more than four boilers are used. Connections into a header should not be so close together that the pressure drop due to discharge into the header can cause the flow from the adjacent boiler to increase, and not too far separated to incur too large a pressure drop.

The header bore should be generous.

Recourse to B.S.2486 water requirements for land boilers should be made and its requirements followed, including the tests outlined for water quality, including the frequency of testing.

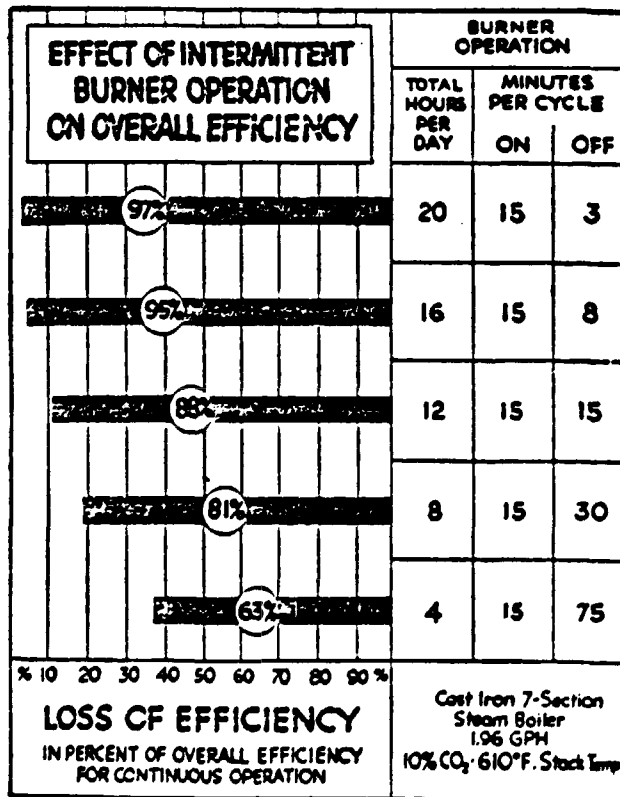
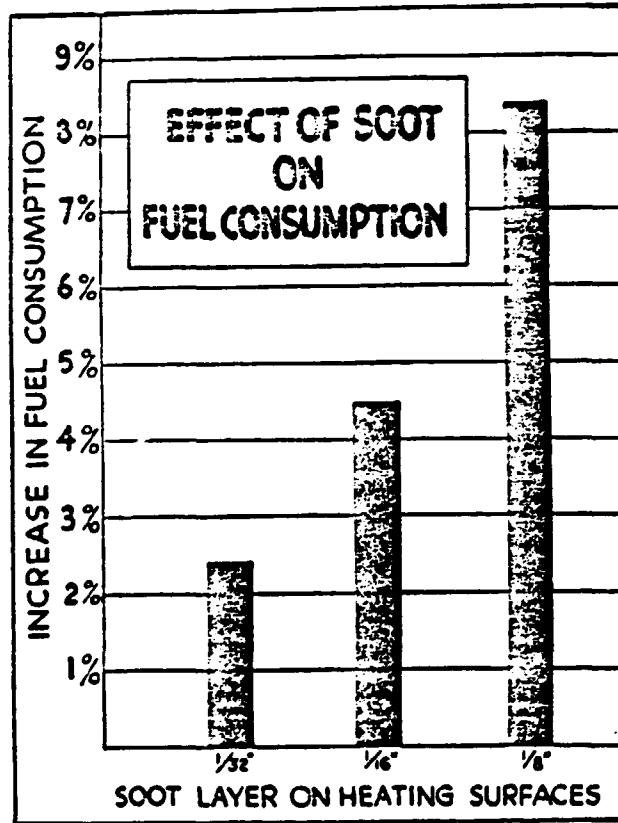
CO₂, EXCESS AIR AND STACK LOSS

% CO ₂	% Excess Air	Net Stack Temperature Degrees Fahrenheit				
		400	500	600	700	800
15	2	14.75	16.75	19.0	21.25	23.5
14	7	15.25	17.25	19.75	22.0	24.5
13	15	15.75	18.0	20.5	23.0	25.5
12	25	16.25	18.75	21.5	24.25	27.0
11	35	17.0	19.75	22.75	25.5	28.5
10	50	18.0	21.25	24.25	27.25	30.5
9	65	19.25	22.75	26.0	29.25	33.0
8	78	20.75	24.25	28.25	32.0	36.0
7	90	22.75	26.75	31.0	35.25	39.75
6	110	25.0	30.0	34.75	30.75	45.0
5	130	28.25	34.25	40.0	46.0	52.0

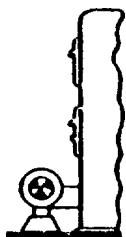
SAVINGS FOR EVERY \$100 FUEL COSTS BY INCREASE OF COMBUSTION EFFICIENCY

ASSUMING CONSTANT RADIATION AND OTHER UNACCOUNTED FOR LOSSES

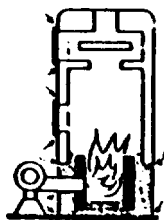
From an Original Efficiency of:	To an Increased Combustion Efficiency of:								
	55%	60%	65%	70%	75%	80%	85%	90%	95%
50%	\$9.10	\$16.70	\$23.10	\$28.60	\$33.30	\$37.50	\$41.20	\$44.40	\$47.40
55%	—	8.30	15.40	21.50	26.70	31.20	35.30	38.90	42.10
60%	—	—	7.70	14.30	20.00	25.00	29.40	33.30	37.80
65%	—	—	—	7.10	13.30	18.80	23.50	27.80	31.60
70%	—	—	—	—	6.70	12.50	17.60	22.20	26.30
75%	—	—	—	—	—	6.30	11.80	16.70	21.10
80%	—	—	—	—	—	—	5.90	11.10	15.80
85%	—	—	—	—	—	—	—	5.60	10.50
90%	—	—	—	—	—	—	—	—	5.30



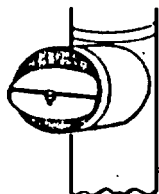
COMMON CAUSES OF LOW CO₂ AND SMOKY FIRE ON OIL BURNERS



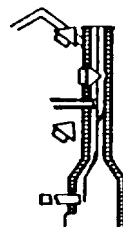
1. Improper fan delivery or incorrect air shutter opening.



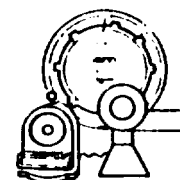
2. Furnace or boiler has excessive air leaks.



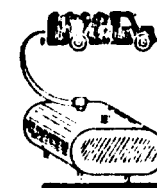
3. Draft regulator is improperly installed or sticking.



4. Draft is insufficient due to defective flue or insufficient height of chimney.



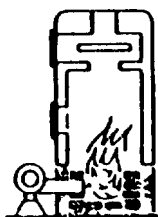
5. Burner "on" periods are too short.



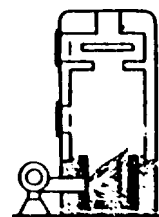
6. Oil does not conform to burner requirements.



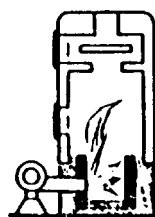
7. Air handling parts defective or incorrectly adjusted.



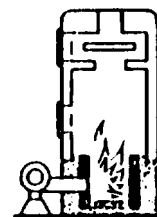
8. Firebox is cracked or of improper refractory material.



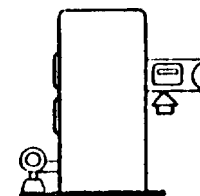
9. Spray angle of nozzle unsuited to air pattern of burner or shape of firebox.



10. Nozzle is worn, clogged or of incorrect type.



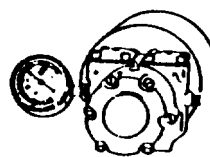
11. Gph. rate is too high for size of combustion chamber.



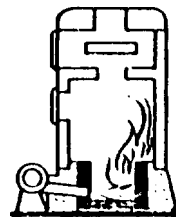
12. Ignition is delayed due to defective stack control.



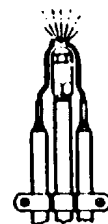
13. Nozzle spray or capacity unsuited to the particular type of burner being used.



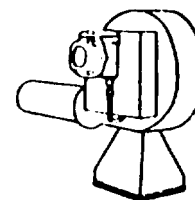
14. Oil pressure to nozzle improperly adjusted causing poor spray characteristics.



15. Nozzle is loose or not centered.



16. Electrodes are dirty, loose or incorrectly set.



17. Cut-off valve leaks, allowing after-drip of fuel oil.



18. Rotary burner motor is running underspeed.

OIL BURNER OPERATION DIAGNOSIS CHART

OVERFIRE DRAFT	SMOKE IN FLUE GAS	CO ₂ IN FLUE GAS	FLUE GAS TEMPERATURE				
<p>A Too low overfire draft, less than 0.01 inches water.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. Odors. 2. Pulsations, poor ignition. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. If stack draft also is low (less than 0.02-0.04 inches water). <ol style="list-style-type: none"> a. Defective or blocked chimney. b. Leaks in smoke pipe. c. Defective or improperly adjusted draft regulator. 2. If stack draft is high (0.05 or more inches water). <ol style="list-style-type: none"> a. Soot in heat exchanger—Unit needs cleaning. b. Poorly designed unit—might need even higher stack draft. 	<p>B Overfire Draft too high, greater than 0.02 inches water.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. High heat loss when unit is not firing. 2. Gas flow too high thru furnace—poor efficiency. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. Defective or improperly adjusted draft regulator. 2. No draft regulator present. 3. Draft inducer being used when not required. 	<p>A Smoke too high, greater than 2 spot.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. Soot deposits in furnace—causes high stack temperatures and poor efficiency. 2. Soot and smoke discharge from home chimney. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. If CO₂ is high, 10-12%. <ol style="list-style-type: none"> a. Overfiring of unit—oil rate too high. b. Too little excess air. c. Dirty fan or air handling parts. 2. If CO₂ is low, less than 8%: <ol style="list-style-type: none"> a. Check for faulty nozzle operation. b. Combustion chamber trouble—too large, poorly installed, broken, etc. 	<p>B Smoke too low, less than 1 spot or oil on smoke disc.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. Without oil on smoke disc: <ol style="list-style-type: none"> a. Low CO₂—Wasted heat. b. Excessive odors. 2. With oil on smoke disc: <ol style="list-style-type: none"> a. Lacquer and oil on furnace surfaces and controls. b. Strong odors in basement and outside home. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. Without oil on smoke disc: <ol style="list-style-type: none"> a. Air leaks into furnace. b. Air shutter open too much. c. Excessive draft. 2. With oil on smoke disc: <ol style="list-style-type: none"> a. Excess air set too high. b. Poor nozzle operation. 	<p>A CO₂ too low, less than 8%.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. Lost heat up chimney—poor efficiency. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. With low smoke: <ol style="list-style-type: none"> a. Underfiring combustion chamber. b. Nozzle is too small. c. Air leaks into furnace. d. Air gate open too wide. 2. With high smoke: <ol style="list-style-type: none"> a. Faulty nozzle operation. b. Poor combustion chamber. 	<p>B CO₂ too high. (See note below*).</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. Smoke may be too high—greater than 2 spot. 2. Pulsations and other noises may occur, particularly on cold starts. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. Not enough air—Air gate closed too far. 2. Dirty fan or air handling parts. 3. Not enough draft. 4. Burner being overfired. <p>*NOTE: Although some modern burners may be of excellent design and permit high CO₂ levels, it is possible to encounter smoke and pulsations. Check for causes shown above if necessary.</p>	<p>A Stack temperature too high, greater than 630°F. Net.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. High heat loss up chimney—excessive oil consumption. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. Dirty heat exchanger—possibly high smoke and high draft loss. 2. Overfiring furnace, high CO₂ would accompany. 3. Poor furnace design—Baffles needed. 4. Poor combustion chamber. 5. Excessive draft. 	<p>B Stack temperature too low, less than 380°F. Net.</p> <p>RESULT:</p> <ol style="list-style-type: none"> 1. Moisture condensation—rusting and deterioration of smoke pipe and chimney. 2. Poor draft. <p>CAUSED BY:</p> <ol style="list-style-type: none"> 1. Underfiring furnace.

This chart from "Service Makes The Difference" by Frank R. Dunn, Jr. Reproduced by permission of Fueloil and Oil Heat

COMBUSTION SERVICE RECORD

For Use with BACHARACH Combustion Testing Instruments

HIGH PRESSURE GUN-TYPE BURNERS

Owner John Doe
 Street 426 Maple Drive
 City Centerville Phone CE-5481-J
 If not home get key 428 Maple Drive
 Occupant Same
 Street _____
 City _____ Phone _____
 Work Authorized by Owner by Occupant John Doe
Signature of person authorizing work

Order No. 4244 Date 2-22-65
 Taken by Smith
Condition Reported
 No Fire Insufficient Heat
 Excessive Oil Consumption Odor
 Burner ignites, then Goes Out Noise
 Burner puffs . . . On Start; On Stop
 OTHER _____
When Service Wanted
 DATE 2-23-65 TIME Before Noon
 PHONE FOR APPOINTMENT _____
Job Assigned to:
 NAME Ryan DATE 2-23-65
Job Completed:
 DATE 2-23-65 TIME 10:35
 BY Tom Ryan
Signature of Service Man

I—Preparing for Combustion Test

1. Open main burner switch.
2. Inspect and clean out accumulated oil in combustion chamber.
3. Advance thermostat. (5-10° F.)
4. Close remote control burner switch.
5. Make 1/8" diameter hole in flue pipe and overflow.
6. Insert TEMPPOINT thermometer (200-1000° F. range) through 1/8" diameter hole in flue pipe.
7. Open inspection port or door.
8. Adjust flame mirror.
9. Close main burner switch. (Starting burner.)

II—Combustion Test Procedure and Inspection Data

STEP	Observe—and mark with ✓	TEST NO.			
		1	2	3	4
1 FLAME IGNITION	Instant	✓	✓		
	Delayed				
	Doesn't ignite				
2 FLAME COLOR <small>If flame shows two colors check both</small>	Orange		✓		
	Yellow	✓	✓		
	White	✓			
	Sparse				
3 FLAME SHAPE	Uniform	✓			
	Lop-sided				
4 FLAME IMPINGEMENT	At bottom				
	At sides				
	At rear				
5 ODOR <small>Near burner; observation door, draft regulator</small>	None	✓			
	Slight				
	Heavy				
6 NOISE <small>Mark (x) when Excessive Mark (v) if Moderate</small>	Rattle				
	Hum				
	Pulsation				
	Shout				
	Ringing				
7 SOOT DEPOSIT <small>Mark (x) if Heavy; (v) if Light; (o) if None</small>	Flue				
	Comb. Chamber				
	Furnace/Bolar				
STEP	Observe—and write in data	TEST NO.			
		1	2	3	4
8	<small>(Close observation door)</small> OVERFIRE DRAFT <small>in inches Water</small>	0.30	0.20		
9	TEMPPOINT READING FLUE GAS TEMP. °F. <small>When constant temp perature is reached</small>	710	610		

STEP	Observe—and write in data	TEST NO.			
		1	2	3	4
10	BASEMENT AIR TEMP. °F.	60	60		
11	NET STACK TEMP. °F. <small>Subtract basement temp. (step 10) from flue gas temp. (step 9)</small>	650	550		
12	FLUE DRAFT in inches water. <small>(Use same hole used for stack temp. test)</small>	0.35	0.25		
13	FYRITE READING % CO ₂ <small>(Use same hole used for stack temp. test)</small>	5 1/2	9 1/2		
14	TRUE-SPOT SMOKE READING <small>(Use same hole used for stack temp. test)</small>	1/2	1		
15	FIRE EFFICIENCY FINDER % COMBUSTION EFFICIENCY <small>(Open Main Burner Switch)</small>	60 1/2	76 1/2		
16	FLAME CUT-OFF (Seconds) <small>Estimate time required in seconds for flame to disappear after burner stops</small>	2	2		
17	<small>(Close Main Burner Switch)</small> OIL PRESSURE (psi) <small>Measured with oil gauge inserted on pump</small>				
18	FEED LINE SUCTION (inches) <small>Measured with vacuum gauge inserted in feed line</small>				
19	<small>(Open Main Burner Switch Remove Nozzle Assembly)</small> NOZZLE <small>(service if nec- essary, then reinstall)</small>	Size—Gph			
		Type—S/H			
		Spray Angle			
20	COMBUSTION CHAMBER SIZE	Depth "			
		Length "			
		Width "			
		Area sq. in.			

III—Adjustments and Repairs

Make adjustments, install replacements, and tune-up as required. Indicate, in spaces provided below, work done before repeating the tests listed under "I".
 Write in "A" for "Adjust", "C" for "Clean", "R" for "Replace". Mark "✓" for other work, and describe it on the back of this sheet, if necessary.

WORK PERFORMED	BEFORE TEST NO.			
	1	2	3	4
BURNER AIR SHUTTER		A		
SEAL AIR LEAKS				
BURNER AIR BLOWER		C		
TURBULATOR				
AIR COIL				
BAROMETRIC DAMPER		A		
BURNER IGNITION—SAFETY CONTROL				
LIMIT CONTROL				
ELECTRODES				
ELECTRODE CABLE				
TRANSFORMER				
AIR FILTERS		R		
NOZZLE				
NOZZLE STRAINER				
PUMP STRAINER				
PUMP				
OIL FILTER		R		
OIL PRESSURE				
PUMP CUT OFF				
COMBUSTION CHAMBER				
BURNER POSITION				
BELT-COUPING				
OIL LINE				
CHIMNEY REPAIRS				
FURNACE/BOLER CLEANED				

IV—Final Inspection

(a) Repeat the combustion check-ups listed under "I", and enter data in proper spaces.
 (b) Check each of the following for proper setting, operation, or condition.
 MAIN BURNER SWITCH THERMOSTAT
 BLOWER CONTROL LIMIT CONTROL
 PUMP CONTROL LUBRICATION
 LOW WATER CUT OFF OIL LEAKS
 CIRCULATING-AIR FAN AIR FILTERS
 CONDITION OF FUEL OIL good
 FLAME FAILURE CUT OFF TIME 120 SEC.
 IGNITION CUT OFF TIME 15 SEC.

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FIG. 3. Combustion Service Record, which details both the steps to be taken for a complete test and a means of recording the data obtained.

PAPER 3 (CONTINUED)

PRACTICAL ENERGY CONSERVATION

Boiler house check list

- Regular checks on boiler efficiency.
- Regular maintenance of burners.
- Good control of boilers.
- Maximum return of condensate to boiler.
- Heat recovery by econmiser.
- Insulation of heated fuel oil tanks.

Factory service check list

- Improve insulation of steam pipes.
- Improve insulation of condensate and hot water pipes.
- Recover condensate.
- Obtain maximum efficiency of compressed air system.
- Maintenance of steam supply repair leaks.

Manufacturing process check list

- Recover waste heat.
- improve control of processes.
- improve insulation.
- Modify processes.
- Replace plant.

Spinning

There are three main energy uses.

1. Motor drives.
2. Heating, cooling or air conditioning.
3. Compressors.

Maintenance of equipment driven by motors is important. There is a tendency to counter increased friction through wear and dirty bearings by increasing the size of motors. This is expensive and wasteful of energy. The loading of motors plays an important part in power factor. Under loading of motors creates a low power factor. I have found values 0.5. This means energy wastage through heating the conductor, the need for heavier cables which are more expensive and significantly higher ratings of transformer and switch gear. It can also lead to more frequent failure of power supplies.

Examine all bearing in routine preventative maintenance. Revise cleaning procedures on spinning frames where the build up of fly occurs on or near bearings, check all drives, slipping belts create high frictional losses.

Heating and air conditioning. Movement of air in large quantities is expensive. Fans must be frequently maintained in a clean efficiently operating condition. Heating is less frequently required than cooling but when deliberate heating is required it is necessary to ensure that the correct amount of fresh air is drawn in-excess cold air can very quickly raise the energy bill. Similarly with cooling hot air drawn in summer has the same energy using effect.

Knitting

This is inherently a low energy consuming process. The main factors using energy are similar to spinning and the same comments apply.

Weaving

A major energy use in the weaving mill is the warp preparation in sizing. The application of size materials from hot baths and the subsequent drying of the yarn consume considerable quantities of energy. The drying process must be controlled to give optimum drying conditions. Other major possibility here is a new technique where a low add-on of size solution is applied using a foam. In this way a water pick-up of 30% instead of typically 65% is possible hence halving the energy required in drying. The comments made under spinning also apply with equal force.

Dyeing and finishing

This is usually the most energy intensive part of textile processing.

Energy use is mainly fuel for boilers. Some 20% of use energy used in boilers goes up the chimney. The steam generated goes mainly to heating water (50%). The remainder is largely in drying and steaming of dyed fabric or prints.

Hence water plays an important part, the amount heated must be kept as low as possible. Check list for wet processes. Assuming total energy use 80 GJ/tonne (2 tonnes oil/tonne of fabrics).

For wet process

Avoid under loading	Saving propotional to load
Re-use hot rinses	1.8 GJ/tonne.
Use Counter flow in washing	7
Limit idling losses	1
Reduce rinsing water	1.5
Rduce water temperature	1.2
Recover heat from effluent	2.5
Total	15 GJ/tonne (19%)

For drying a heating processes

Maximise mechanical drying	0.3 GJ/tonne
Avoid over drying	0.5
Minimise setting and baking times	0.5
Reduce exhaust flows	1.5
Direct firing air stenters	1.0
Reduce idling losses	0.5
Recover heat from exhaust	1
Total	5.3 GJ/tonne (66%)

So you can see major savings are possible amounting to more than a quarter of the total energy use.

PAPER 4 HEAT RECOVERY

Introduction

Heat recovery is not new. Many of the techniques have been used for many years. It is only since the sharp rise in oil prices in 1973 that there has been a major increase in interest in heat recovery.

Before considering heat recovery it is important to note that every action to minimise wastage of heat has been taken. This means good housekeeping and optimization of processes because one can never recover 100% of waste heat.

Assuming that this has been done the points to consider are:-

- 1) What heat is available and is it of suitable grade (i.e high enough temperature).
- 2) What uses are there for the recovered heat. is storage or transfer of heat required.
- 3) The value of the recovered heat must be greater than the cost of recovery.
- 4) What is the best equipment to use.

In general the performance of heat recovery equipment depends on:-

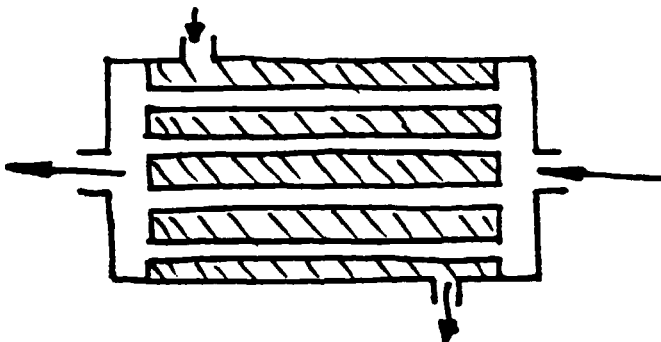
- 1) Temperature difference between heat source and heat sink.
- 2) Availability of latent heat.
- 3) Mass flow x specific heat of each source.
- 4) Efficiency of equipment.
- 5) Extra energy inputs required.

Equipment

1. Heat Exchangers or Recuperators.

These units allow heat exchange between two fluids without direct contact. There are many types.

SHELL and TUBE



This unit can withstand pressure. It is difficult to clean so can only be used with solutions with low solids contents. Fluid flow is counter current to give highest efficiency.

Energy efficiency $E = \frac{\text{Energy required into recovery stream}}{\text{Energy out of waste stream.}}$

Describes heat losses in unit

Heat recovery factor $F = \frac{\text{Energy recovered}}{\text{Energy recoverable from waste flow}}$

Describes effectiveness of recovery

- Applications
- Hot effluent stream (Boiler blowdown)
 - Solvent cooling recovery.
 - Processing liquids.

Plate type

Similar to shell and tube but thin passages and greater heat exchange surface area. Easier construction - bolt on - can be cleaned. Plates may be corrugated to promote heat transfer by turbulence. low cost. recoveries about 85%.

Applications Dye effluents.
 Flue gases.

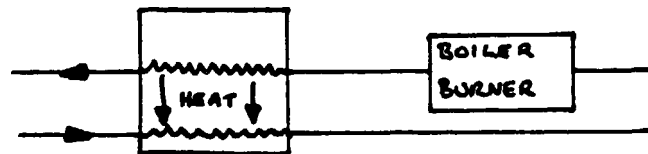
Run-Round Coil

Applicable for air or liquid streams separate in distance. They have an intermediate transfer medium (eg. water/glycol) which is pumped. Low cost 30 to 50% recovery on as two heat exchangers are involved.

Applications Drying.
 Heaters.
 Ventilation systems.

Recuperator

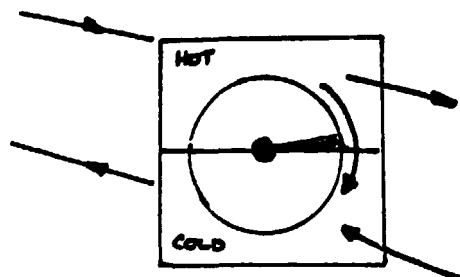
Used for preheating air for burners by use of flue gases.



Because of high temperature and high losses from radiation/convection recuperator must be close to boiler. Must be used with care because of possible problems with condensation.

Heat wheels

Have a high thermal inertia core rotated continuously from hot air stream to cold air stream. They can transfer sensible heat and latent heat when material has lithium chloride coating, usually they have filter to keep clean.

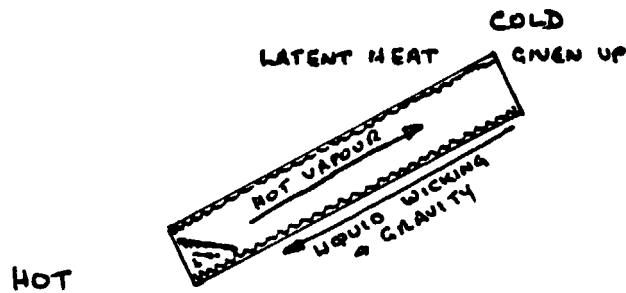


Efficiency 60 to 70% for sensible heat 20 to 60% for latent heat transfer.

Applications Process preheating.
Ventilation heating.

Heat pipes

Basically heat transfer devices using latent heat and wicking action.



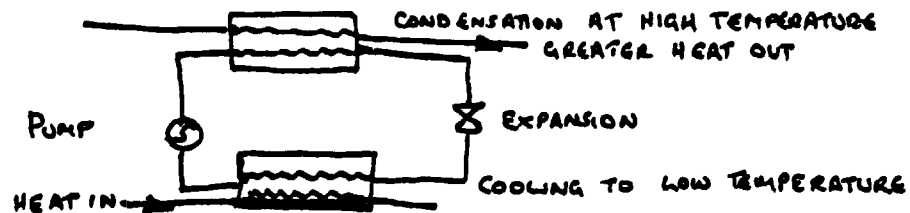
Wick - woven metal
Fluid - depends on operating temperature.

This device has a very high thermal conductivity 1000 X cooper low temperature drop - less than 5 cm/m can be used to cool or heat available for working - 250⁰C to 2000⁰C

Applications Dekers.
Flue gas heat recovery
Improving efficiency in heat exchangers.

Heat pumps

This is a refrigerator operating in reverse



Heat is upgraded in temperature at expense of some work input pump - electric; diesel or gas.

Important parameter Coefficient of performance COP.

$$\text{COP} = \frac{\text{Heat out put at condenser}}{\text{Work input at compressor}}$$

This value can be typically 3

Applications	Heat from air to water.
	Heat from water waste.
	Air heating.



