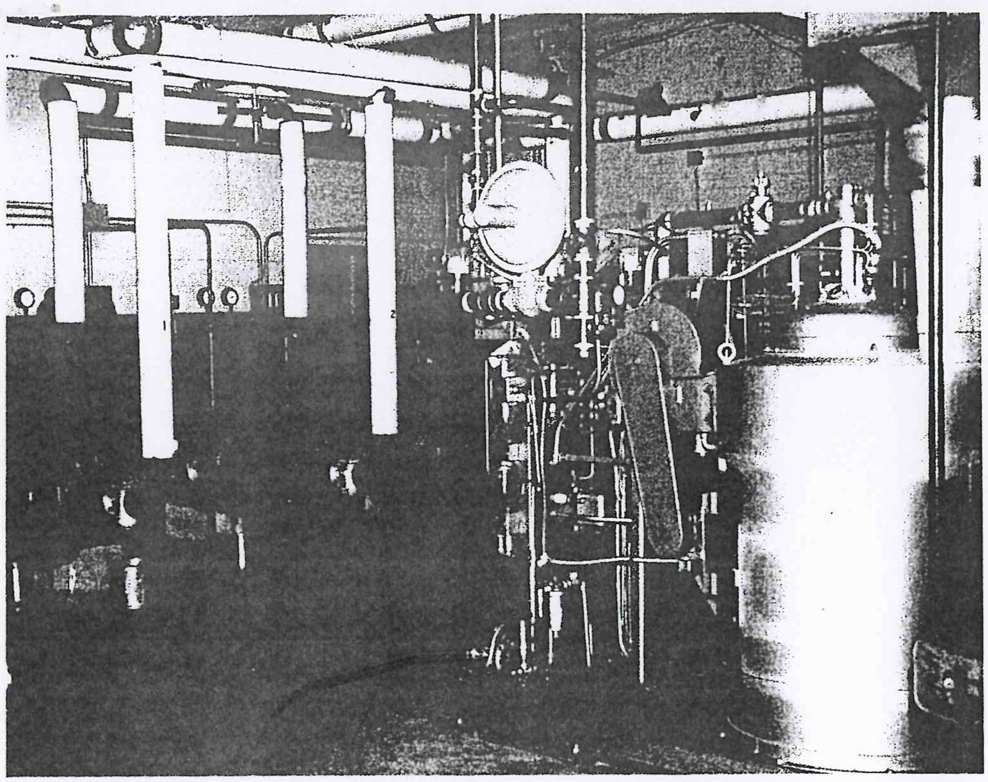


New hot oil system.

Distributed vs. centralized heating

Process and space heating decentralization can be energy efficient and cost effective

By **PREM MEHROTRA,**
Senior Vice President,
and **PAUL SOOD,** President,
Energy Resources & Planning, Inc.,
Chicago, Ill.

Historically, in an industrial plant, energy required for plant process heating and winter heating is provided by a centralized steam supply system with a battery of high pressure steam boilers located in one common equipment room and steam supply and condensate return lines running to all near and distant users. This approach is proving wasteful of energy in many instances. Some reasons for this are:

- Excessive transmission heat losses through complex steam distribution and condensate return piping, which is aggravated by deteriorated and damaged insulation.
- Waste of condensate as it becomes difficult to return condensate from all the odd places. In many cases, breakdown of local condensate return pumps results in permanent wastage of condensate to sewers.
- Leakage of steam through vents and malfunctioning traps.
- Inefficient operation of the boilers at low load factor.

In the present energy environment, this waste can be very costly.

An approach based on decentralization of the steam system has proved very successful in reducing energy consumption dramatically. A case study is presented here to illustrate this fact. The following features form important parts of this approach:

- Utilize high pressure gas piping to properly selected and located heat sources such as fluid heaters, boilers, or ovens.
- Replace steam with a high temperature fluid heat transfer medium and/or hot water.
- Provide a high pressure or low pressure steam source near the users where steam cannot be replaced.

Plant description

The plant under consideration is located in Chicago and is housed in a 50 year old building. The plant covers approximately 390,000 sq ft under the roof. Plant growth apparently was not a well planned activity as evidenced by poor utilization of constructed space and lack of records on buildings and systems.

Operations are divided into two activities:

- The Felt Div., which occupies the buildings west of the boiler house, manufactures felt and felt products.
- The Elastomer Div., which occupies the buildings east of the boiler house, produces rubber products.

Both divisions house operations starting from basic raw materials through final products. Processes in both divisions are shown in Fig. 1.

Two boilers, each rated at 40,000 to 60,000 lb per hr, formed the core of the steam system. Steam was generated at 200 psig and distributed at about the same pressure to processes in both operations. While the high pressure steam was used primarily in manufacturing processes, several unit heaters had been tapped into high pressure lines. Steam at 15 psig was supplied to the plant heating system through a secondary steam system. Major steam users are listed in Table 1.

The steam system was operated year-round as one or more users required steam at any given time.

Distributed vs. centralized

Most operations in the rubber division were on three shifts, five days per week. Most operations in the fiber division were on two shifts, five days per week. Occasionally both the divisions worked on Saturdays and Sundays.

A study to determine the steam profile revealed that about *48 percent* of the energy supplied to the boiler was wasted through flue gases, steam leakage, condensate drain, and transmission heat losses; *42 percent* was used to provide ventilation preheat and transmission heat losses in winter; and *10 percent* was the process heat. This is illustrated in Fig. 2.

A decision was required on strategies to reduce energy consumption. The choices available were narrowed down to two:

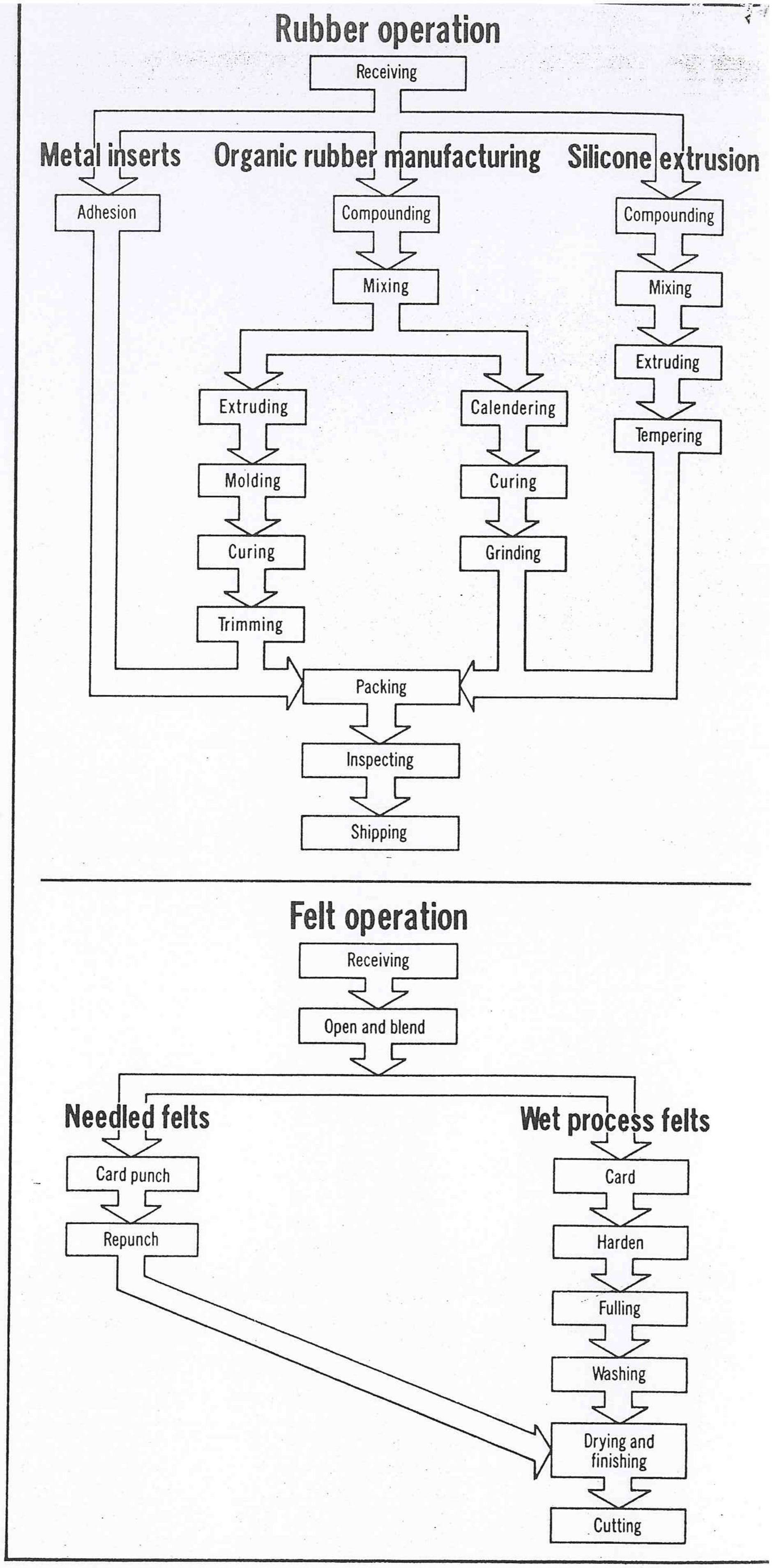
- Make system repairs and upgrade boiler plant with state-of-the-art technology.
- Abandon existing steam systems as well as the steam plant and provide for alternate means of supplying thermal energy to various users.

Table 1—Steam users before retrofit implementation.

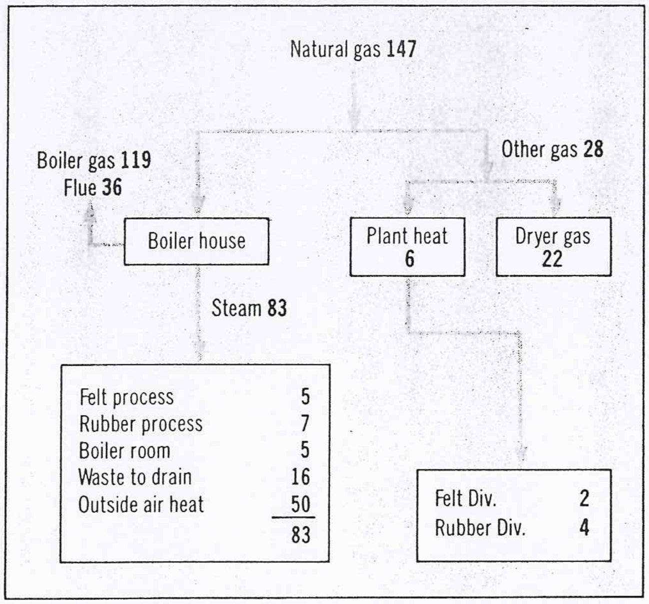
Description of users	Location	Steam pressure, psig
Elastomer presses (50)	Elastomer Div.	200
Extruders	Elastomer Div.	200
Ventilation	All plant	15
Domestic water	Elastomer Div.	200
Felt roll presses	Felt Div.	200
Felt wasters	Felt Div.	200
Plant heating	All plant	15
Office heating	Felt Div.	15

We made a decision to abandon the existing systems and decentralize the energy distribution in the plant. Our decision was reached through a careful consideration of several factors. Some of those factors are discussed here:

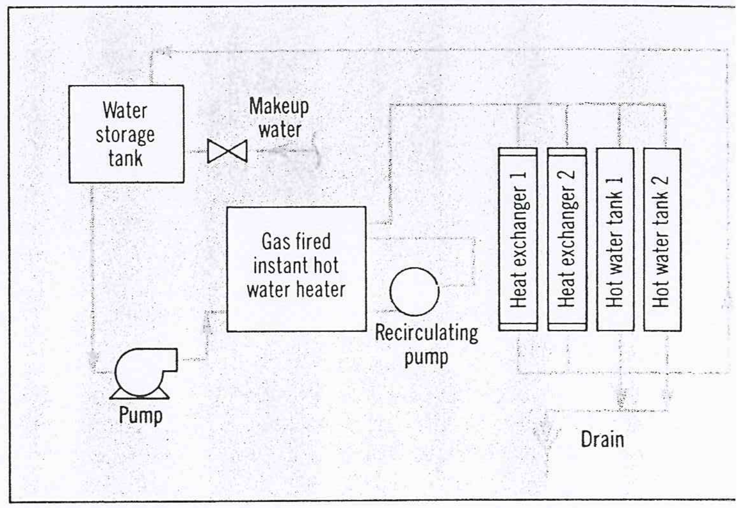
- *Age of existing plant.* In the consideration of a modification to an existing plant, the age of the plant is an important factor. To illustrate, consider two plants, aged



1 Plant process.



2 Plant heat balance (all quantities are in billions of Btu per year).



3 Felt washer hot water heater.

25 and two years respectively. Table 2 shows factors for both plants. We might quantify each of the factors in Table 2 in terms of dollars. A fully amortized plant has zero book value, hence no write-down cost. A newer plant entails a write-down cost. The technology scale can be translated, through efficiency considerations, into annual operating costs. Similarly, cost of repair can be annualized and quantified.

• *Load factor and diversity of use.* An analysis of load factor yields important tangibles as far as efficiency of operation is concerned. Ideally, every plant should have 100 percent load factor. Any deviation shows up as additional fuel costs resulting from deviation of boiler operation from optimum efficiency. A low load factor lends support to decentralization.

• *Complexity of distribution systems.* The cost, as well as effectiveness, of housekeeping is dependent on the complexity of the steam distribution system. The more complex the existing system is, the more justification there is to decentralize. A good means to quantify this factor may be cost of housekeeping and pipe heat losses.

• *Production uncertainties.* Uncertainties in the levels of production are reflected in the central plant load factor. The greater the uncertainties in production volumes, the more reasons there are to decentralize.

• *Intangible reasons.* The ability of a company to form strategies is greatly enhanced if it has more options available. A decentralized plant presents many more options than a centralized one. Consider a company that has several manufacturing locations. A situation could arise when it might be more advantageous to move a certain manufacturing process from one plant to another because of changes in market conditions. With a central system, the decision would cause pain at both the leaving end as well as the receiving end. On the leaving end, the move would degrade performance of the central plant. At the receiving end, the central plant might not be able to accommodate capacity without extensive changes in the existing central system. With a decentralized plant, the move would be much easier to accomplish.

Based on a consideration of the above factors, we made a firm recommendation to abandon the existing steam plant and distribution system.

Table 2—Age factors to consider before retrofit.

25-year-old plant	2-year-old plant
Fully amortized; no write-down if abandoned	Partly amortized; substantial write-down if abandoned
At low end of technology scale	At high end of technology scale
Needs more extensive repair more frequently	Needs less extensive repair

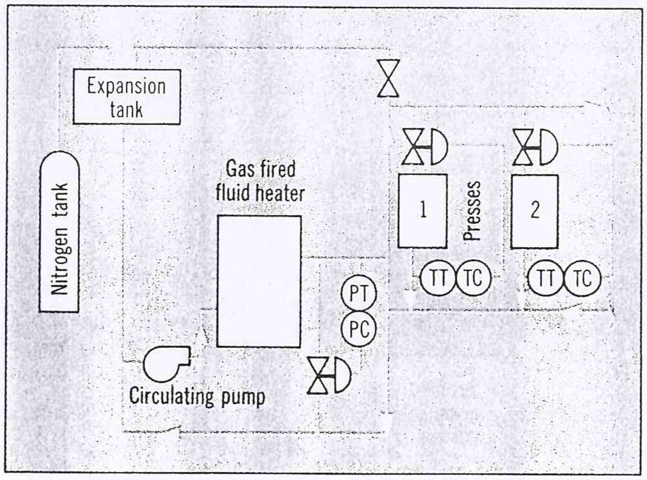
System decentralization

Below is how the system was decentralized in the various production areas:

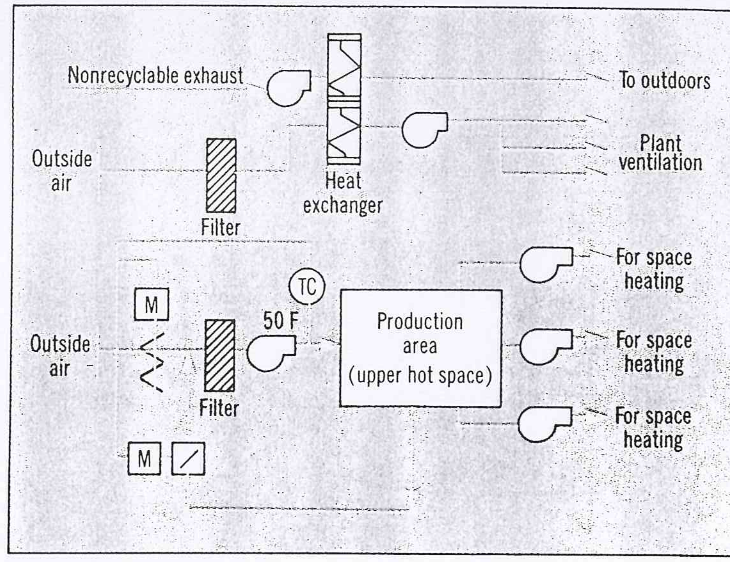
• *Hot water for felt washers.* A 800,000 Btuh instant hot water heater was provided to supply hot water to two felt washers and two tanks. A schematic diagram of the system is shown in Fig. 3. These washers are required to operate 8 to 12 hr per day.

• *Press conversion to fluid heating.* Approximately 50 presses, each having two or more platens and/or molds, were supplied with 320 F (200 psig) steam. A fluid heating system with 500 F fluid temperature and approximately 2.5×10^6 Btuh capacity was provided. A conceptual diagram is shown in Fig. 4.

• *High pressure steam for felt roll presses.* 1.5×10^6 Btuh high



4 Hot fluid press heating system.



5 Heat recovery system.

pressure steam at 350 F (250 psig) was provided for a cluster of three-roll presses as shown in Fig. 2. Long steam supply and condensate return piping and connected steam traps and condensate return pumps were eliminated.

- *Hot water for extruders.* A 350,000 Btuh instant hot water heater was supplied to provide heating for extruder heads in the beginning of the day for half an hour, which replaced high pressure steam.

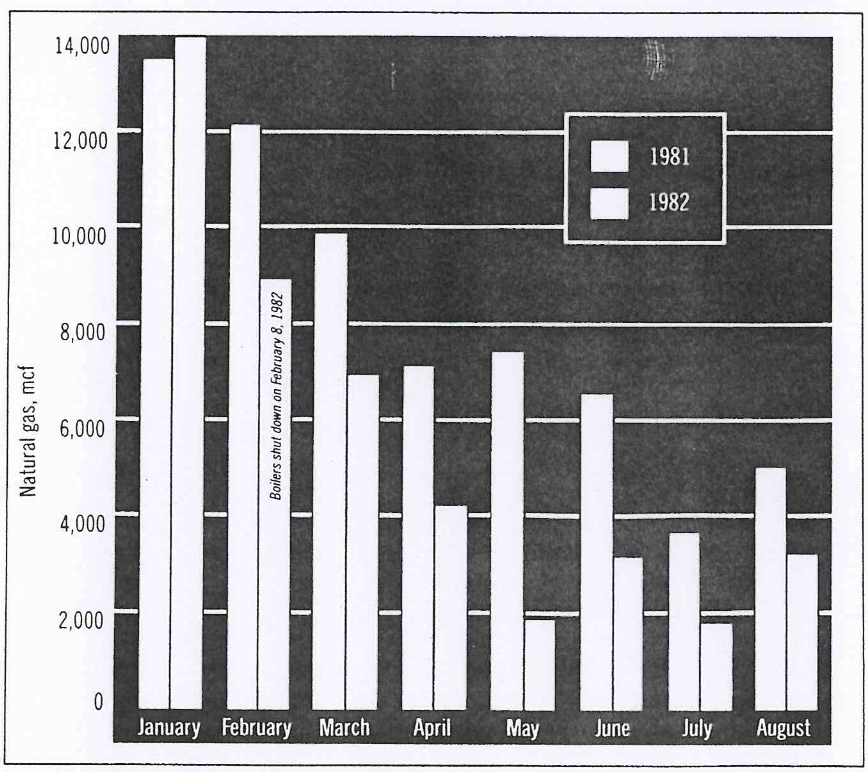
- *Domestic hot water supply.* The central steam heated hot water tank was replaced by a gas heated water tank to serve each of 10 washrooms. The bulk of hot water usage was from two or three washrooms for about one hr at the time of shift change.

- *Heat recovery system.* Six air-to-air heat exchangers were provided to recover heat from ventilation exhaust air. Four outside air supply and return air mixing fans were provided to take advantage of the warmer air temperature due to stratification in upper spaces in the plant areas. Fig. 5 shows conceptual design.

- *Plant perimeter gas heating.* New direct or indirect fired or infrared gas heaters with night and weekend setback controls were provided for the plant's perimeter.

- *Office heating by low pressure steam boiler.* A 2.5×10^6 Btuh gas fired steam boiler was provided to meet the office heating requirements. The boiler was provided with microprocessor based controls for night and weekend setbacks, load cycling, and optimum start.

The implementation of these retrofit projects and abandonment of the old steam supply system resulted in phenomenal savings in gas energy and energy costs. Fig. 6 shows a chart of annual energy usage before and after the retrofit project.



6 Comparison of gas use before and after retrofit.

Conclusion

Decentralization of process and winter heating systems can be very energy efficient and cost effective. There are no general conclusions that can be applied to every plant. The decision for decentralization should be made based on careful review of following factors:

- Age of plant.
- Diversity of use.
- Load factor.
- Operation variations of production sections.
- Uncertainty of production planning. Ω