FOUNDRY MECHANIZATION

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Professor Joseph S. Newell  
Secretary of the Faculty  
Massachusetts Institute of Technology  
Cambridge, 39, Massachusetts  

Dear Sir:

In accordance with the requirements for the degree of Bachelor of Science in the Department of Business and Engineering Administration, we herewith submit a thesis entitled, "Foundry Mechanization".

Acknowledgements are made to various men and organizations within the Foundry Industry, whose cooperation made this thesis possible. We also wish to express our sincere appreciation to Professor Howard F. Taylor and Mr. William E. Ritchie of the Institute for their advice and guidance.

Very truly yours,

James Veras

Stanley Kuryla
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We wish to acknowledge the cooperation extended by the following men and organizations in connection with this thesis. Through their assistance and through visits to the following plants, most of the information presented in this thesis was acquired.


PURPOSE

It was the original purpose of this thesis "to determine the underlying and limiting factors involved in the mechanization of foundries in general." Through the study of several foundries it was our expectation to find a "formula" which on the basis of such factors as volume and type of product, would indicate whether or not a foundry should be mechanized. A series of plant visits, however, convinced us that this purpose could not be realized. There were a few factors generally common to foundries, but in every case investigated the final decision rested on an entirely different reason. Therefore, we concluded that there was no "formula" solution to the problem. Nevertheless, we believe that the impossibility of applying a formula was a significant discovery at the outset.

It is now the purpose of this thesis to thoroughly analyze specific conditions and factors which led the companies investigated to either mechanize completely, partially, or not at all. It is also our purpose to make comparisons on such fields as production, finance, market, methods, and personnel, and to determine factors which affect specific types of foundries in the issue of mechanization. Moreover, it will be attempted to evaluate the economic worth of each particular mechanization program.
METHOD

Other than the detailed study of several foundries, our approach will include data gathered from consultations with various men in the industry and information disclosed in recent magazine articles. No standard presentation was considered advisable because each case demanded a different type of write-up to fit the circumstances prevailing in the particular company.

Theses have been written on the applicability of specific machinery such as sand-handlers, conveyors, etc., in foundries. Magazine articles have appeared explaining the type of mechanization installed in certain foundries. The scope of this thesis lies further from what is already known. We will attempt to reach conclusions which will permit any foundry executive to evaluate the necessity of mechanization in his plant and to forecast the problems as well as advantages expected.
SUMMARY OF CONCLUSIONS

The following conclusions have been reached as a result of our investigation.

Any foundry considering mechanization must weigh certain basic factors and evaluate them before making the initial outlay. Each foundry is a different case and has to be handled individually. The factors for consideration are listed briefly below and are explained fully at the end of the case studies.

1. **Volume**
   
   Sufficient volume of production is necessary to insure continuous operation, profit, and amortization of the investment.

2. **Cost**
   
   The expense for mechanization is high, not only in the initial outlay but in future maintenance.

3. **Flexibility**
   
   Mechanization curtails flexibility. Jobbing foundries rely on flexibility a great deal. Captive foundries can sacrifice flexibility more easily.

4. **Market**
   
   Size and location of market limit expansion. Limited expansion make mechanization economically unsound. Jobbing foundries have a market advantage because of flexibility.

5. **Labor**
   
   Good working conditions and availability of labor are closely related. Locations affect the labor market.

6. **General Economic Conditions**
   
   Where investment costs are high, as in
6. **General Economic Conditions** (cont.)

mechanization, it is unwise to proceed unless general business conditions warrant it.
CURRENT HISTORICAL BACKGROUND

There is a current movement in parts of the foundry business that is meant to modernize an industry that has been in sore need of development for many years. This movement is not limited to the industry only but includes such affiliations as foundry publications, foundry organizations, and foundry courses in colleges. However, the interest to bring the industry on a level with more highly regarded industries, is spotty. Great effort is shown in certain circles while the status quo continues to prevail in others. In other words, the movement is not yet universal, but is now in the encouraging stage and might pay dividends several years hence if the promising beginning is followed through promptly.

One of the biggest motivating forces behind this progressive approach has been the need for mechanization in foundries where every operation until now has been manually performed. The old type foundryman who used to make his own molds and pour them 10-12 hours a day, six days a week, is fast disappearing. Labor available from the streams of immigrants who came to this country around the turn of the century, no longer exists. Moreover, the children of such men have been exposed to the American environment, with its endless opportunities arousing their ambition for success in more fertile fields than those offered by old, dirty foundries. Thus, a critical situation has become imminent.
and drastic steps have to be taken. Mechanization offers the best but most expensive solution.

This "foundry awakening" has received strong support from important sources other than the industry directly. Such organizations as the Foundryman's Society and the Foundry Educational Foundation have devoted particular attention to the foundry student while maintaining continuous activity with the industry. They have attempted to arouse the interest of young metallurgists and engineers in the direction of foundry work because they realize that without new, energetic sources of mental activity toward foundry progress, the industry will remain at the bottom of the industrial pyramid. Such approaches as publications, lectures, and summer work related to foundry operations, and sponsored by these organizations, are proving to be effective weapons with which to combat existing lack of interest of young college graduates toward foundries.

Several big foundry magazines, such as "The Foundry" and "The American Foundryman", have expanded their activities and significance in foundry circles recently. Mechanization of plants is given big write-ups, data of even confidential nature is disclosed for the common benefit, reports of research workers are continuously featured and extensive advertising brings to light the many means by which plants can be improved. Moreover, some of the magazines, as "The Foundry" did with the authors, go so far as to make yearly complimentary offers to students who merely
show interest in foundry work. The support of the industry, by extending generous advertising contracts to the magazines, has been of mutual benefit since many companies use these publications as a helpful guide to many policy decisions.

Perhaps the pioneer of this new exploration into foundry possibilities is the old college professor. He is the man who knows what can be done scientifically to help put the industry on top (both financially and in attracting good labor and supervisors) but to whom little attention is paid, until the crude, old ways are no longer profitable. Even then, his suggestions are questioned and many times remain untested. In short, the taboos developed in the past decades are still the biggest hurdle to be overcome. The typical case can be represented by the old-timer who claims he can give accurate fluidity figures most of the time by just looking into a heat. When you suggest a fluidity spiral test, which is elementary and simple, he objects violently even though it will provide correct figures every time.

The role of the scientist, however, does not stop with his knowledge and consultation value. It plays its biggest part in the classroom where he is faced with the task of convincing potential scientists that there is a definite need for them in the industry. In addition, he must be dynamic enough to convince college authorities as well as industry of the need for foundry laboratories in which the student can learn by seeing and doing. Such men
are the industry's greatest asset, yet the industry fails to appreciate their great worth.

It is becoming increasingly evident to foundrymen that a dollar can be saved in the foundry as well as anywhere else. It is this economic viewpoint, more than other arguments, that appears to interest foundries in investing in such means and methods which will be money-saving in the long run. Mechanization is the natural initial step. Since considerable confusion and uncertainty prevails on specific factors, it is the broad purpose of this thesis to throw some light on those factors which must be considered before plunging into mechanization.
INTRODUCTION

Mechanization of a foundry involves many of the same basic business principles and is limited by many of the same factors that apply to the installation of an improvement in any manufacturing organization. As obvious as some of these factors may seem, they will be discussed here, because it is evident that in some cases foundries have been mechanized before the importance of all related economic factors has been properly evaluated.

The first consideration in mechanizing a foundry is that the investment should yield a profit. Not only must the cost of castings in dollars per pound be reduced, but the additional return on the investment must be enough to equal at least the interest which that investment would draw if it remained in the form of cash. In addition, the increased profits resulting from mechanization should be sufficient to pay for the installation within a reasonable length of time. The maximum time over which this repayment should take place is the normal depreciation cycle of the equipment. From a sound business viewpoint, however, five years should be sufficient time for the improvements to pay for themselves. Though it may seem strange in our present day of strong competition, many foundries have been disastrously mechanized without due regard to the above factors.

A second basic idea is that doubled output is of no value unless the additional production can be sold. Thus,
even though an installation has been studied in the light of all of its financial aspects, its economic success still depends on the existence of a demand great enough to justify the increased output. There are several reasons why foundrymen have been led to believe that the market for their castings was high enough to justify expensive mechanization programs.

The demand for castings during the war was far in excess of the normal demand. This demand existed long enough during the war to accumulate surpluses in many organizations. In addition, backlogs of orders existed long enough after the war tended to give many foundrymen a false estimation of the true market for their castings. On this basis, some foundries were mechanized in a manner which was entirely dependent upon a volume of business far in excess of normal.

Other foundries have thought that they could maintain a volume in excess of normal by improving their competitive position enough to take business away from foundries whose prices were based on much more expensive methods. Unfortunately, in many instances, even a greatly improved competitive position has not maintained a large enough market to pay for mechanization. The reasons for this apply to many businesses, but in some cases are particularly applicable to the foundry industry.

Much of the price of a casting is in the form of the transportation cost from the foundry to the place of use. Thus, even though a foundry through mechanization might
produce a certain casting at a cheaper price than any other foundry in the country, it will not by any means take away the trade from other foundries. Thus, a mechanized foundry in Worcester, for example, would not be in a position to compete for a customer in Chicago against even the most antiquated foundry in Chicago.

In addition to tangible economic factors, such as the final actual cost of a casting to a consumer, there are other reasons that prevent an improved competitive position from creating a larger market. Reciprocity is one of these reasons. Another is natural resistance to change on the part of a consumer, plus the inherent suspicion that anyone has of a bargain. An additional consideration common to all businesses is the effect that mechanization will have on flexibility, and the effect that the breakdown of one part of a producing unit might have on the entire production. Specialized equipment unfortunately gives rise to problems which require specially-trained maintenance men. Similarly line production always poses the breakdown problem illustrated by the fact that a 1% breakdown time for each unit in a process in which there are ten units means a total of 10% down time. Specific illustrations of these factors will be given later on in connection with various installations. But it is mentioned here, because loss of flexibility is one of the basic limitations on foundry mechanization as it is in any other business.

Now that some of the general considerations which apply
to foundry mechanization have been discussed, some of the problems which are common only to foundry mechanization will be taken up. Again, within the classification of foundries in general, there exist various types of foundries in which these problems occur to a greater or lesser degree. To begin with, only those problems which apply to all foundries will be discussed.

In the first place, a foundry deals with molten metal, a fact which gives rise to some special difficulties. The temperature of the metal can seldom fall more than 100°F from the time it is taken from the furnace to the time it is poured in the mold without seriously hampering the quality of the casting. Where light castings are involved, this means that the molten metal must be taken to the molds in small quantities and poured before it becomes too cold. Since there is no means of "piping" molten metal to the molds, the pouring operation requires considerable manpower in an amount that is virtually independent of the degree of mechanization.

Another difficulty arises by virtue of the dangerously high temperature of the molten metal and its liquidity. Aside from the safety precautions which the temperature makes necessary, spilling of the metal during pouring may freeze a roller conveyor or mold train. In the few instances where rubber conveyors for molds have been tried they were quickly discarded when a slight spillage of metal burned the conveyors apart.

A second problem which is common to the foundry is the presence of sand as a hazard to moving parts of machinery.
Though the dust content of the air is kept remarkably low in some modern foundries, thus reducing the hazards to workers, there is no way of preventing sand from getting into the bearings of a roller conveyor or the moving parts of a molding machine. Many foundry machine breakdowns have their origin in the prevalence of sand.

A third problem is to be found in the fragile nature of the molds themselves. Molds must be handled gently while they are being made, and their transportation from the molding station to the pouring station must be a smooth one. Where highly automatic molding machinery is used, extra strength must be imparted to the molds by using sand of a high bond strength. Extra thicknesses of sand and a higher bond strength have adverse effects on the permeability of the mold, thus often creating problems in connection with the quality of the casting.

The transportation of the molds must be controlled. In other words, a mold cannot be placed on a roller conveyor and allowed to roll by gravity until it is stopped by bumping into another mold or an obstruction. To meet this problem, molds are either conveyed on trains, or remain in permanent flasks, and are pushed, mechanically or by gravity, along a roller conveyor. Where permanent flasks are used, an additional transportation is necessary to return the flasks to the molder.

An overall problem in foundry mechanization lies in the fact that mechanization must often be on a large scale, since the derivation of all the potential benefits of one improvement depends upon the existence of an additional installation.
The installation of a sand-handling system is a good illustration of this.

Assume that a system of handling sand were installed with its objective being automatic delivery of sand to the molding machines and transportation of the sand from the pouring station to the conditioning plant. Keeping in mind the sand alone, such a system would make it unnecessary for the molder to shovel sand into his mold, since it would now come to him from an overhead chute. In addition it would be no longer necessary for that sand to be handled manually in order to bring it back to the molding machine, since this would be done by a conveyor belt. As a result of such a sand-handling system, the molder's job would become easier and more productive, and the amount of workers involved in a sand conditioning would be less.

Unfortunately, however, the above improvements would be impossible without the existence of the following changes in addition to the sand-handling system. First, the molds must be shaken out in a manner that will allow the sand to be transported back to the conditioning plant on the conveyor belt. Without going into the various methods by which this might be accomplished, it suffices to say that the molds can no longer be shaken out on the molding floor, but must be transported to a central shakeout station. Increased productivity, resulting in lack of floor space, requires that some form of continuous, or at least intermittent pouring be used. This kind of pouring then calls for additional furnace equipment, some instances of which will be described
further on. Furthermore, the cost of continuous pouring becomes prohibitively high below a tonnage which most foundrymen accede to be 5 tons poured per hour.

This brief illustration shows, then, that the economical mechanization of a foundry cannot proceed along a piece-meal basis. The benefits of mechanization can be derived only after a radical change has been made in the entire production of the casting.

In the past 6 pages, it has been attempted to show that despite the wide prevalence recently of foundry mechanization programs, mechanization is by no means a foundryman's panacea. By the very nature of economic considerations and the foundry process itself, mechanization must be thoroughly investigated before being put into effect. In addition, the user must expect to face many new problems as the complexity of his process is increased. In the following text, illustrations of mechanization programs in specific foundries will be discussed with special attention to the motives which led to, and the problems which arose from mechanization.
THE WESTINGHOUSE FOUNDRY
EAST SPRINGFIELD, MASS.
Introduction

The Westinghouse Electric Corporation at East Springfield, Massachusetts, has just completed the mechanization of its gray iron foundry in that location at the cost of $1,250,000. This expensive proposition has reduced manual handling an amazing 80% and has created conditions which are considered unique among mechanized, high production shops.

The captive foundry is only a small part of the East Springfield works, employing 75 of the 5000 persons who work in this location. Nevertheless, nearly every appliance made in the plant makes use of some of the gray iron castings coming from the foundry. These castings include fan bases, housings for motors, compressor parts etc., and become a part of such items as commercial refrigerators, soft drink dispensers, garbage disposers, vacuum cleaners and domestic automatic washing machines which are manufactured in the works. Most of the foundry's output is used at the East Springfield Works but some castings are furnished to the Company's Ohio plants.

The foundry superintendent is Mr. Elliot who has used his engineering experience to advantage by designing several machines and labor-saving devices now in use in the plant. This young superintendent instigated the movement which led to the mechanization and helped in the design of many components. One of his biggest selling points, other than the
practical need for the drastic changes, was a unique report to management which had more pictures, graphs and tables, than it did words. According to Mr. Elliot, his superiors were sold on the idea after examining this report.

**Why Westinghouse Mechanized**

In his report to management the foundry superintendent outlined several reasons which demanded immediate mechanization of facilities. Following is an analysis of the more important factors.

1. The former type of labor was no longer available. The company faced a severe labor problem at the end of the recent war. It could no longer employ the type of worker needed for an unmechanized foundry and had to either take drastic steps or face a shut-down. The old-timer labor-market had been exhausted.

2. The increased amount of manual handling was increasing costs as well as discouraging younger men from getting into the foundry game. Thus, labor would drift in other industry in the area where it could get similar pay for easier jobs. Besides, the sons of the old foundrymen did not want to follow the footsteps of their fathers after comparing opportunities in industries and learning trades which promised a better future economically as well as physically.

3. Production requirements had increased beyond the capacity of the old foundry and it was certain that they would remain high. This was upheld by the nature of the foundry
which, being captive, did not have to face the limits imposed by competition. A captive foundry produces standard products for another company rather than compete with other foundries in the open market. To this extent its production is guaranteed.

4. Need to maintain pre-war costs. It was Mr. Elliot's contention that despite increased production there was definite need to watch costs which would be a big factor in the competition which company products would face after the war. If the company could maintain its pre-war cost-level, it was believed that competition would not be a problem.

5. The need to improve quality would follow the desire to meet competition. Westinghouse reputation for quality had to be upheld by improving it at all times.

6. Competitors were mechanizing. Many of the foundries in the Springfield area had mechanized and increased the effect of the aforementioned problems.

When these factors were brought to management's attention it was clearly pointed out that no promise was made for cost reductions below those of pre-war level. Thus, the foundry had to be mechanized regardless of cost considerations. However, the eventual return in terms of the factors analyzed, as well as financially, would make the big capital outlay more than worthwhile. Moreover, a company with a financial status as secure as that of Westinghouse could well afford to invest and wait longer for the return than could a small organization.

Westinghouse top management appraised the arguments
offered and approved immediately, thus upholding the foundry's contentions.

Effect of Mechanization

The amount of manual handling of the foundry's 75 employees shows the amazing reduction of 80%, as has been stated. This figure has been arrived upon on the basis of 1470 tons of material and equipment that it was estimated to have been required to handle daily in the pre-mechanized set-up. In certain cases even more remarkable savings of human effort have been accomplished. For example, in molding housings for small refrigerator motors the molder formerly lifted 1320 lbs. per mold of four housings. This figure included 65 lbs. for handling flasks; 290 lbs. for shoveling sand; 357 lbs. for conveying molds; 88 lbs. for shifting pouring weights, and 520 lbs. for shaking out molds, conditioning sand, etc. The new mechanical arrangement completely eliminates the manual part of these operations. Therefore, on the basis of 500 molds daily, approximately 335 fewer tons need be lifted by hand than formerly!

Other than the installation of modern equipment, an important factor in eliminating or reducing handling operations has been the company's development of new devices to do certain jobs. These, to be described in more detail later, include an air-operated system for placing and removing mold weights and an automatic mold shakeout. Empty flasks are returned automatically to gravity roller conveyors leading back to molding stations. Bottom boards
are dispensed with by use of barred drags. It was through
the initiative and insistence of Mr. Elliot that these improve-
ments were adopted because the company that eventually
installed them did not believe them mechanically possible
or secure at the outset. Results until now have been com-
pletely satisfactory.

Layout and Production

The foundry building is a steel, brick, and sash con-
struction. Measuring approximately 180 x 250 ft., it has
47,000 sq. ft. of useable floor space. In addition, there
are three 50-ft. high bays and five 24-ft. low bays for a
grand total of approximately 1,470,000 cu. ft. of space.

There is a very extensive tunnel system which houses
more than 400 ft. of under-floor conveyors. These convey-
ors handle hot castings and used sand.

Seventy per cent of the side of the walls consists of
windows. The floor is laid out in parallel bays 140 ft. long,
with two cupolas located at one end of the center bay. One
side bay comprises the casting cleaning department, the
center bay is used for large volume production of motor
 housings, and the third bay for high activity castings of
small sizes. At one end of this last bay a few molding
 machines and single deck roller conveyor pouring lines are
provided to handle short orders on miscellaneous parts.
A total of 17 molding machines are used in the entire plant.

Castings range in size from \( \frac{1}{2} \)-lb. to 40 lbs. and in
thickness from 1/8" to more than 2". However, the average
casting weighs approximately only 5 lbs. The large quantities of castings required,--nearly 12,000 daily--permit long runs on individual patterns and a highly mechanized setup. It is this tremendous volume, which has increased from 40,000 lbs. to 60,000 lbs. daily since mechanization was installed, that has more than justified the big investment made.

A considerable amount of ventilating apparatus has been installed in the foundry. Included are 18 fan-driven roof ventilators of 113,000 cfm. capacity and localized exhaustors at the principal dust producing points. Three bag type, dry dust collectors draw a 33,000 cfm. from tumbling barrels, grinders, blast barrels, and sand blast units, collecting about 1 cubic yard of dust daily. In addition, three wet type collectors serve the sand system, including shakeouts, and have a capacity of 60,000 cfm. Most of the dust collected by the latter is carried away with the waste water. Heavier particles, collected as sludge in a settling tank, represent a daily accumulation of about 1350 lbs. Total air withdrawal is 206,000 cfm. providing 8.4 complete changes of air in the foundry hourly.

Forced air unit heaters are located at strategic areas to draw in fresh air from the outside or recirculate air in the building. The 16 heaters have a capacity of 7.8 million BTU based on 5 lb steam at 60 F. temperature for the entering air. In addition, ten air curtain heaters with total capacity of 4.5 million Btu are placed at outside doorways and at entrances and exits of the trolley conveyor (to be referred to later). The unit and curtain type heaters
combined are capable of maintaining a temperature of 60°F.
inside the building with an outside temperature of zero and
15-mph wind.

It is clearly evident that little, if anything, has
been overlooked in the way of complete mechanization for the
benefit of making the surroundings as completely agreeable
to foundry work as possible.

**Mechanization Facilities**

The new facilities available in the foundry under
discussion, have been the talk of the industry recently.
Several magazines have just completed lengthy articles pre-
senting the new set-up. The description that follows here-
with is a combination of information recorded by the authors
upon visiting the plant and supplementary data provided by
the aforementioned magazine articles.

Conveyors and automatic molding machines are the two
basic apparatus which, after a complicated but efficient
layout, form the backbone of any foundry mechanization.
This company is typical of the general case.

An overhead conveyor is used in the sand-handling
system. After passing through the perforated shakeout the
sand runs over a magnetic pulley. It is then carried by
an elevator to a vibrating screen which removes cores, lumps,
etc. From this point the sand is carried by conveyor to a
250-ton hot sand storage bin. Two mixers, located directly
underneath the storage bin, mix the sand with new sand, clay
and water. Westinghouse uses synthetic sand, having found
it the only sand that could combine the correct consistency for molding purposes as well as being collapsible to a degree demanded by the automatic method employed in the emptying of flasks which will be described presently. Next, the mixed sand is discharged to a conveyor which carries it to a sand conditioner. From the conditioner the sand is carried by conveyors to hoppers (Figure 1) above the various molding stations.

Figure 1

The two motor-housing molding lines employ jolt-squeeze-rollover machines in molding the drags. Figures 2 and 3 show the molder placing a drag flask, which is picked up by hoist from the conveniently located gravity roll conveyor leading from the shakeout. Six castings are molded per flask. Sand is obtained from an overhead hopper equipped with air-operated gate, and excess sand drops through a floor grating.
to a spill conveyor belt below. After being rammed, rolled over, and the pattern drawn, the drag is pushed through the machine onto a roller conveyor.

Copes are handled from the return gravity conveyor by air hoist to the molding machine, operated on 80-lb. air pressure and supplied with sand from the overhead hopper. The machine jolts the cope, scrapes off excess sand, squeezes the sand down, vibrates and strips the pattern—all in one automatic sequenced cycle. The molder picks up the cope mold with an air hoist and places it on the drag mold. The flask is then pushed down the roller conveyor to an air operated transfer car which moves the mold to position in line with the outgoing roller conveyor to the pouring lines.

When the molds are ready for pouring, clamping plates, are quickly dropped on the copes by the turn of an air valve which controls the raising and lowering of the entire line
of weights simultaneously. Clamping action is obtained by the applied air pressure. Molds are poured from 1000-lb. capacity insulated geared ladles transported by hoists over a tramrail.

Poured molds are picked up at the shakeout, located at the end of the roller conveyor-line by a 1-ton capacity jib crane equipped with a specially designed lifting and rollover bail, as shown in Figure 4. This rollover operation is necessary because the barred drag requires the flask to be shaken out with the cope down. The vibrating shakeout, 3 x 6 ft., is effectively hooded to trap dust, and discharges both sand and castings to a conveyor below the floor. The empty flask is placed on a ramp leading to a gravity roll conveyor (Figure 5) and a pneumatic ram then takes over,
pushing the flask up the ramp to the conveyor which leads back to the molding stations.

Figure 5

In the sequence of operations just described it will be noted that the workers' duties have consisted of manipulating the controls of various types of equipment; no manual lifting whatever is required.

Sand and castings from the two housing-line shakeouts fall onto a 49-ft. long oscillating trough conveyor below the floor and are transferred to a main conveyor of similar type which also receives spill sand over belt conveyors from the molding machines, as well as sand and castings from the small automatic molding lines. This main
oscillating conveyor, 133 ft. long, leads to a 4 x 8-ft. shakeout screen from which the castings slide into a loading chute, while the sand drops through to a belt to start its return trip to the central sand system. Castings are fed automatically from the loading chute to 2 x 4-ft. trays suspended from a 600-ft. long trolley conveyor. The conveyor moves continuously at about 10 fpm.

From the loading point the tray conveyor moves outdoors, carrying the castings at a height of 22 ft. above the ground (Figure 6) and re-entering the foundry on the opposite side of the building. This conveyor serves three purposes. It gives the hot castings an opportunity to cool; it keeps the heat of the castings out of the building, and it conveys the castings to the sorting room.
Sorting is conducted on a mezzanine at the end of the cleaning department bay and adjacent to the cupolas. Gates and sprues are removed and weighed for delivery to the cupola charger by the half-ton capacity automatic monorail system, while the castings are automatically discharged upon sorting tables. Sorted castings are dispatched to the cleaning room on the floor below either through chutes or in containers lowered by hoists. The cleaning room, equipped with tumbling barrels, centrifugal blast units and grinders, also has heat treating furnaces for use in stress relieving of castings. On the tonnage basis, approximately one-half the foundry's production is given such treatment. Lift trucks haul castings to the nearby machine shop.

Molding practice equipment employed on a small casting line differ somewhat from those used on the motor housing line. The most striking difference is a triple-decked conveyor line which handles the molds. (See Figure 7, next page). The top deck is for flask return; the other two for outgoing molds. Individual air cylinders for each outgoing conveyor line push the molds away from the molder, relieving him of this operation. Simultaneously, they push a poured mold into the shakeout device located at the opposite end of the conveyor. (See Figure 8, next page.) Triple decking the conveyor line not only conserves floor space, but it also provides flexibility in molding and pouring schedules since it permits accumulating a relatively large number of molds if hot metal is not immediately available. Flasks are operated with an air-operated device and molds are
poured from 500-lb. capacity ladles suspended from a monorail and moved manually along the pouring line as shown in Figure 9.

Figure 9

The picture would not be complete if mention was not made of the coreroom and the two cupolas. Considering the volume of castings production, core requirements are relatively small. Cores are made largely on blowers and are baked in rack type ovens. The coreroom is also equipped to prepare chills, a considerable quantity of which is required for various castings. These chills are coated with a rubber compound and in some cases are sprayed with fine silica sand after application of the base coating.
Specially designed machines are employed to facilitate these operations.

The two cupolas, which are used in alternate days, are 72" in diameter but lined to 45". Located at the end of the pouring floor, the furnaces are tapped either directly into the pouring ladles or into a mixer for holding. Ladles are moved from the cupolas to the pouring line via the overhead monorail.

We have now a thorough picture of the sweeping changes made by mechanization. It must be pointed out that the set-up is tailored for use in this specific foundry. A great deal of the designing was performed by Westinghouse engineers and the foundry superintendent. The company believes that it overlooked nothing. Even the trained eye would have a very difficult time proving otherwise.

Conclusion

In most other expenditures of this size, in other companies, it has been the need for increased production or lower operating costs that has initiated the decision to modernize. In the case of the Westinghouse foundry it was more the need to provide a better place in which to work, in order to attract the right kind of labor, that was the determining factor in approving the outlay. Yes, production was increased as desired and expected. But, if production had been the prevailing problem it could have been increased without mechanization and at a much smaller cost.
Westinghouse has effectively attacked those conditions which in the past have been most objectionable in foundry work. Molten metal still is unavoidably present, but heat has been reduced by prompt discharge of poured molds to under-floor conveyors. Manual handling of equipment and material has been reduced to an amazing extent, and in some cases even eliminated. The substantial improvement in ventilation, attested by dust counts, leaves little to be desired on this score.

It must be remembered that this is a captive foundry and it is only a small part of a huge, prosperous organization. As such, it enjoys advantages without which it could not hope to expect a good return on the big investment. These advantages will be analyzed as part of the conclusions arrived upon in the thesis.
THE CHAPMAN VALVE MANUFACTURING COMPANY

INDIAN ORCHARD, MASS.
Introduction

The Chapman Valve Manufacturing Company in Indian Orchard, Mass., is one of the foremost manufacturers of steel, alloy steel, bronze, and cast iron valves in the United States. Established in 1870, the Company has acquired a world-wide reputation and market for its product on the basis of sound design, good quality, and guaranteed performance.

Valves which the Company advertises in its catalogues vary in size from 1/4" to 24" face diameter. It is not uncommon for the Company to make valves as large as 48" in diameter, and the valves which were constructed for the power plant at Niagara Falls were so large that each one had to be cast in two parts, each part requiring an entire flat car for transportation. Virtually all valve patterns are made in the Company's own pattern shop, and the number of patterns now in storage is well over 3000.

Chapman's market is by no means restricted to the Eastern part of the United States. There are 18 sales branch offices spread throughout the country. In addition to a wide national sales coverage, Chapman products have been sent to all parts of Europe, including Russia, and to remote mining installations in Chile. In other words, while Chapman manufactures only valves, it has, nevertheless a tremendous variety of sizes and a very wide market. In 1948, its net sales were over 17 million dollars.
Mechanization

In August of 1948, the Company mechanized a part of its iron foundry at a cost of approximately $500,000. Aside from the sand-conditioning system which now serves all of the iron foundry, this mechanization has caused no changes to be made in the production methods employed in the rest of the foundry*. As a result, the foundry is now divided into three separate parts; the mechanized part, the part in which small valves or small orders are made on molding machines or by manual molding methods, and the part in which large valves are made and poured in place.

The mechanized section of the foundry at present accounts for about one-half of the total volume of the foundry on a tonnage basis, and for a larger proportion of the volume on a dollar basis. Sizes of valves made under mechanization vary from about 3" to a maximum of 12", this range being, presumably, the one in which the greatest number of orders fall.

Motives which induced the Company to mechanize part of the foundry hinged on the idea on greater volume and lower unit cost per casting. Elimination of physical effort was a particularly strong consideration, since the molds required for valves up to 12" in diameter were not poured in place, but had to be set up on the molder's floor.

*The word foundry as used from here on refers only to the iron foundry. The steel and bronze foundries are located in separate buildings and will not enter into this discussion.
Molds containing valves from about 6" up to 12" required at least two men to handle cope and drag sections. Since inconsistent sand conditions were hampering quality, despite the large number of men involved in the sand-conditioning operation, some central sand-conditioning method was contemplated even before mechanization. Thus, in a way, the partial mechanization of the foundry grew out of the need for better sand control.

Description Of Present Method

The essential elements of the mechanized foundry are pictured in Figure 10 below.
A turn-table, rotating behind the mold train in the foreground of Figure 10 contains six stations. At the first station, the drag is rammed with sand by the sand-slinger. Then the cope is filled by the sand-slinger. At the third station, cope and drag pass under a strike-off machine, (see white object in right foreground of Figure) which automatically strikes off all excess sand to make the mold flush with the steel cope or drag section. At the fourth and fifth stations, cope and drag are turned over, and the necessary cores are inserted. Then, as a final operation, the cope is lifted and placed on the drag to complete the mold, which is then placed on one of the "flat-cars" seen in the foreground of Figure 10. All of the operations in which the cope, drag, or entire mold is lifted are performed by means of an air hoist, thus eliminating all hard physical labor from the mold-making operation.

The moving mold train, with a capacity of 182 molds, size 36" X 28" X 28", moves the molds by the pouring platform in the right foreground of Figure 10. Molds are poured from a bull-ladle which is attached to an overhead monorail drive, moving at the same speed as the mold train. This permits continuous movement of the mold-train and, at the same time, insures good pouring. After the molds are poured, they pass under a hood, through which gases are removed, and then proceed to the shakeout, which is located directly behind the sand-slinger in Figure 10. Since the transportation from the pouring station to the shakeout takes at least one and one half hours, castings become
safely cooled by the time the molds are hoisted onto the vibrating shakeout. Castings fall off the shakeout into a palletized steel bin in which they are transported by lift-truck to the shot-blasting and other cleaning operations. From the shakeout operation on, there is no continuous movement of castings through subsequent operations as is the case in the Malleable Iron Fitting Co.

The maximum capacity of this system is calculated 450 molds per shift on the basis of one mold made every minute. It can be operated at a volume much lower than this, however, without interfering with the efficiency of continuous melting in the cupolas. For, when iron is not being used in the mechanized section, it can be poured in the other parts of the foundry. Molds which pass by the pouring station unpoured, however, must make the entire traverse of the molding-train loop to pass by the pouring station again.

Sand is supplied to the sand-slinger from an overhead hopper, which in turn is fed by a conveyor. Excess sand from the mold-making operation falls through gratings under the rotating table to be returned to the sand-conditioning unit. Similarly, sand from the shakeout is returned to the conditioning plant via an underground conveyor. When the mechanized part of the foundry is operating at a capacity of 450 molds per shift, at least 700 tons of sand must be handled to supply this part of the foundry alone.

At the present time, 23 men are engaged in operating the mechanized part of the foundry. Before the new installation was made, at least 35 men were employed making the
same kinds of molds, dumping them, and conditioning the sand. It is difficult to estimate the actual percentage increase in production, since the number of castings per mold is different than it used to be, and jobs from other parts of the foundry are constantly being adapted to the continuous system. In addition, sand from the conditioning unit is also supplied to the other parts of the foundry. A rough estimate by the foreman in charge of the mechanized unit, however, was that the productivity per man had probably increased by 100% as a result of the new installation.

Advantages Of The Present System

Many of the advantages of the new installation are, in a way, independent of the installation itself. Flexibility has not been lost, for example, because the other two parts of the iron foundry are capable of handling any job which cannot be made on the rotating table. The advantages and disadvantages which will be discussed here, then, will be only those which are associated with the mechanized process.

1. The sand-handling system and the use of synthetic sand, have markedly improved the quality of castings.

2. Use of standard-sized flasks has eliminated the necessity of storing a wide variety of flasks.

3. Elimination of strenuous physical effort from the molding operation has reduced labor turnover and improved the morale of the workers.

4. Use of a sand-slinger provides stronger molds, and packs the sand more smoothly around the pattern
than does a jolt-squeeze molding machine.

5. Elimination of at least 15 molding machines has reduced the amount of maintenance expense associated with the production of the continuous system.

Disadvantages Of Present System

1. While overall maintenance costs have been reduced, yet the present method of line production makes output much more vulnerable as the result of breakdowns. Any defect which causes the shut-down of the sand-slinger, conveyor train, or the shakeout, brings production to a complete stop. When the sand-slinger breaks down, and this is not an uncommon occurrence, at least 15 men become completely idle until it is repaired.

2. Cores, which are an important and fragile part of every mold, must still be inserted into the molds manually after being transported on pallets to the turn-table. Since some of the cores weigh as much as 200 lbs. the insertion of the cores remains as a strenuous operation.

3. The benefits of mechanization cease after the castings have left the shakeout. Thus, many of the advantages of the line-production set-up are dampened before they finally materialize as profits.

4. Use of standard-sized flasks has made it necessary, in many cases, to change the patterns to include as many castings as possible in each flask. This,
results in higher productivity, but, nevertheless, involves considerable additional expense.

Evaluation Of Mechanization

Insufficiently detailed cost information, plus the fact that the new installation still has some bugs that must be eliminated, makes it impossible to estimate accurately the savings that have been derived from this process. There is no doubt, however, that for operation at full capacity the new method improves the Company's competitive position through lower costs and higher productivity.

As in other cases of mechanization, however, it is equally obvious that the production of the continuous molding process must be high in order to cover the fixed charges of the investment. Fortunately, this process can be operated at partial capacity, either on the basis of a shift or a week, without causing loss of economy in melting and pouring. The fact remains, though, that if the volume of orders falls seriously, the profit margin is decreased by virtue of the new investment.

In the case of the Chapman Company, the following specific factors leading to, and permitting mechanization must be emphasized. First of all, the size of the Company and the variety of its operations aside from those carried on the mechanized process, are such that even if the new investment does not pay for itself rapidly, it is still justifiable on other grounds. The elimination of physical effort from the molding operation, and the existence of the
line as potentially capable of high production are advantages which might be too expensive for a smaller company to enjoy without a guaranteed return. Secondly, the size of the Company's market and the certainty of constant recorders of certain valves, makes it possible to produce castings for stock. An order from one of the large Oil Companies, for example, might call for deliveries over the entire period of a year.

It is not hard to visualize, then, that if the entire production of the Company consisted only of those valves which are now produced on the continuous line, it would have been economically impossible to have made the investment.
THE MALLEABLE IRON FITTINGS COMPANY
BRANFORD, CONN.
Introduction

The Malleable Iron Fittings Co. in Branford, Conn. contains one of the most highly mechanized foundries in the country. Although the Company incorporates a steel foundry, galvanizing plant, and machine shops for finished castings, discussion here will be limited to the mechanization of the malleable iron foundry.

Small malleable iron castings, principally pipe fittings, comprise the output of the iron foundry. The Company carries 1800 separate items of fittings in its line, 90% of which are considered stock items and are produced accordingly. Virtually all of the fittings are tapped in the Company's own machine-shops and equipment is available for whatever galvanizing is necessary.

While the greatest proportion of the production of the iron foundry is in the form of pipe fittings, it cannot be said that the foundry is producing a standard product. For, each of the 1800 items in the fitting line requires individual pattern equipment. This means that a separate metal pattern plate must be maintained in usable condition for each size of fitting. Furthermore, in an effort to keep balanced inventories, the Company cannot afford to run one size for an inordinately long time, unless it is manufacturing that particular item to order. Thus, from the standpoint of production, the Malleable Iron Fittings Co. may be compared to any similar jobbing foundry by virtue of its product variety and the relatively small length of run of any one item.
The foundry employs 55 molders when operating at an average capacity of 80 tons of iron poured each day. Its maximum melting capacity is 110 tons per day, and the feasible minimum under the present mechanized set-up is 50 tons per day. Iron is delivered from an air-furnace after passing through a cupola preheater in the usual manner employed for continuous pouring.

The present mechanized process was installed in 1942 at an approximate cost of $1,000,000. Increased productivity with the same labor force; elimination of physical drudgery, and continued quality were the goals of the improved installation. In addition, the Company installed extensive dust-collecting equipment and excellent sanitary facilities in an effort to increase employee morale through better working conditions.

Though productivity has been doubled with the same number of molders, and the unit cost of the casting has decreased considerably, no further information could be obtained as to the effect of mechanization on profits. Nor was there any accurate estimate on the manner in which maintenance costs may have risen since the introduction of the mechanized process. It seems safe to assume, however, that with at least six years of wartime and high post-war production, the Company has been able to pay for its investment with ease. Were this not the case, the poor present condition of the foundry business might make the burden of the installation great enough to outweigh any profits that the foundry might be making, operating only three days per
Financially, then, the foundry has probably passed its critical stage. Assuming that the investment has been written off, the Company is in no more vulnerable a financial position as a result of a decrease in business than it would be had there been no mechanization. Furthermore, for quantity production, it should have a definite competitive advantage over a non-mechanized competitor.
Description Of Facilities And Process

There are three lines of molding stations, two of which are illustrated below in Figure 11.

Figure 11

Each molding machine is supplied with sand by an overhead hopper. A grating under each molding machine allows excess sand to fall on an underground conveyor on which it is returned to the sand conditioning plant.

Snap-flasks and wooden bottom-boards are used. After the molder makes his mold, he lifts it from his bench, turns around, and places it on one of the flat cars of the mold train behind him. It is evident that all shovelling of sand and carrying of molds has been eliminated under this arrangement. The resulting saving in time and physical effort required has at least doubled the rate of production of each molder.
Each line of molding stations is serviced by a separate loop of mold trains (see Figure 12 below).

Figure 12

There are four trains of sixteen cars on each of the three loops. Movement of the trains is regulated by a series of automatic switches in such a manner that a train of molds arrives at the pouring station every four minutes. The interval between the time at which a full train leaves and the time at which an empty one arrives behind the molder's bench is sufficiently short so that the molder does not have to cease production in order to wait for a place to put his finished mold.
After the mold train has been filled, it moves on automatically to the pouring station (see Figure 13 below). Pouring is done continuously from small bull ladles with relatively little physical effort on the part of the men pouring.

Figure 13

When the molds have been poured, the train moves under hoods, through which gases are drawn off, to the shakeout station. At this point, the locomotive drive of the train is replaced by a slower chain drive underneath the cars. Molds are dumped manually into the shakeout, the bottom boards are left on the cars, and the train returns under the power of the locomotive to the molding lines.

Castings pass over a vibrating screen and are then conveyed to a self-clearing scrubbing cylinder. In this rotating cylinder, castings are tumbled for sprueing, and
sprayed with water so that they emerge from the process cool enough for inspection and transportation on a rubber belt. Since this method of sprueing is an important contribution to the increased production of the foundry, it will be briefly discussed here.

First of all, the effectiveness of this method of sprueing was dependent on the fact that as the castings were tumbled, the gates would break off from the castings without any subsequent damage to the casting itself. This necessitated redesigning the gates of practically all of the patterns so that the cross-section of the gate was decreased sufficiently to enable it to break off at that point without cracking the casting. Changing the patterns took place over a period of about one year. Needless to say, this would have been impossible were it not for the fact that the Company designs all of its fittings patterns and does its own grinding.

The scrubbing, or sprueing cylinders remove the gates from 90% of the casting which pass through the process. Since 90% of all castings can be subjected to this method of sprueing, (excessively large castings do not undergo this process, since they have been found to crack the smaller ones) it is evident that the savings in the labor usually required for this operation are substantial.

In addition to the complete automaticity of the sprueing and cleaning operations, there is another advantage to this process in the form of quality control. It takes less than an hour for a casting to proceed from the pouring
station to the inspection belt at the discharge end of the scrubbing cylinder. At this point a spot inspection by an experienced foundryman determines whether any defects that might appear in the castings are attributable to poor sand, faulty molds, or improper pouring. Defects arising from any of these three sources can be immediately remedied by changing the procedure of the faulty operator. Thus it is impossible for a whole day's production of a casting to be faulty, as can be the case when molds are poured off altogether at the end of a shift.

After this spot inspection, castings are conveyed past sorters, where they are classified and further inspected. Transportation to and from subsequent operations such as annealing, wheelabrating, grinding, and tapping is fully mechanized. The final step of the production cycle is the transportation to the storage and shipping room, where the castings are either stored in bins or packed for shipment.

Special Problems Arising From Mechanization

One of the principal current difficulties with the process revolves around the control of the moisture content of the sand. The reconditioned sand is discharged from an aerator onto a conveyor belt within thirty feet of the sand bin on top of the first molding station (see foreground, Figure 11). At this point, the sand is so hot that it can barely be held comfortably in the hand, and for this reason, the moisture can be seen steaming from the
sand quite profusely.

The sand travels on a conveyor belt over the molding lines and is plowed off into each bin as necessary by an operator. The temperature of the sand is such, though, that by the time a load of sand has traveled to the last bin in the molding line, (see background, Figure 11) its moisture content is at least 1% less than it would be had it been dumped into the first bin of the molding line. It is felt that this lack of consistent moisture content in the sand is partially responsible for casting defects.

If the uneven moisture content of the sand is, indeed, a source of poor quality, there seems to be no reason why this source of trouble could not be eliminated. Use of sand with more bond strength to lessen required moisture content, or additional sand storage capacity to enable the sand to cool might eliminate the moisture problem.

Advantages Of Present Method

Aside from such general advantages as higher productivity and improved working conditions, some of the advantages of this specific process are as follows.

1. A minimum amount of floor space and molding equipment is required, because of the speed in which each mold is made, poured, and shaken out.

2. The fact that the mold train moves intermittently, allows the molder to place his mold on the train, and permits the mold to be poured without any threat to quality. Under some arrangements, it is
necessary for the pourer to move along with the mold train while he is pouring. This means that a hand ladle must be used, thus introducing one of the most physically arduous methods into the pouring operation.

3. The division of the molding process into three separate lines makes it possible to vary production without using extra machinery necessarily. Similarly, breakdown of one mold train does not cripple the entire production of the foundry.

4. Rapid remedial quality control is possible because of the speed with which a finished casting results from a mold.

Disadvantages Of Present Method

1. Initial cost, power usage, and maintenance costs are higher than they would be for a continuous conveyor.

2. A breakdown of one mold train stops the production of one entire line of molders, since there is no other way in which the molds can be taken to the pouring and shakeout stations.

3. Inadequate method of cooling sand reduces quality of castings.

4. Flexibility of foundry volume-wise has been reduced considerably.
Evaluation Of Mechanization

Taking into consideration the advantages and disadvantages of the present process, there is no doubt that for high volume production the present set-up provides a more profitable method of production than the old arrangement of molding floors and single heat pouring. Whether or not the present method is the cheapest for that volume and type of casting, cannot be said, because it was not possible to make any foundryman divulge the cost of his product. Of more urgent interest, however, is the question of whether the Company is still in a better position than before, with its mechanized foundry, in the face of greatly curtailed production.

The primary limitation of reduced production lies in the melting and pouring method. If less than 50 tons of iron are poured per day, melting costs become prohibitively high, using the cupola and air furnace together. The alternative to continuous pouring, using the air furnace only for a single heat, poses the following difficulties.

On a single heat basis, none of the mold trains can be operated. This means that the old method of lining up the molds on the floor will have to be used, eliminating what economies have been derived from the present method of continuous, overhead sand delivery. Floor molding would probably not be feasible because of lack of floor space. For while there are even at present several molders making special orders on this basis, there is not sufficient additional space in the foundry to accommodate the molds which
would use one melt from the air furnace. (15-25 tons)

In summary, then, it can be said that it would not be economically possible for the foundry to operate at any rate of production less than that which would require continuous pouring.

In the case of the Malleable Iron Fittings Co., however, there exists a fact which might act to make its position less critical than that of the average mechanized jobbing foundry faced with greatly curtailed production. This factor is the nature of its principle product and its market.

Pipe fittings are purchased by a great many separate users. Thus, while the overall demand for the fittings may decrease greatly, it will remain continuous enough to enable the Company to produce for stock. In contrast to this, most jobbing foundries produce strictly for order; and repeat orders, particularly in bad economic times, are not certain enough to justify producing for stock. Furthermore, active competition makes it necessary for them to give rapid delivery. As such it is not always possible for a foundry to forestall the production of such an order until it has built up sufficient orders to run at economic capacity if only for a few days.

Since the Company is in a position to produce fittings for stock, it can run the foundry profitably at economic capacity if only long enough to build up its inventories. The profit or loss it makes on this basis will, of course, depend largely on the extent to which the mechanized
installations have been amortized. And below a certain rate of production there is the point where even fixed costs will not be met.

In conclusion, then, the Malleable Iron Fittings foundry is a typical example of a foundry which has been mechanized suitably for a high volume of production. Production at a level below 60% of capacity, however, gives rise to losses of efficiency which make it questionable, from an economic point of view, whether the foundry is in a better position as a result of mechanization.
THE WARWICK MALLEABLE IRON COMPANY
HILLSGROVE, R.I.
Introduction

The Warwick Malleable Company, located in Hills Grove, Rhode Island, is a jobbing foundry which in normal times employs 200 men and has a capacity of three hundred tons of finished castings per month. The company handles orders of various sizes and except for a few customers in the mid-west, concentrates in the New England market. It is owned by its two biggest customers but it is managed by a salaried manager, Mr. Harry K. Taylor. Mr. Taylor is comparatively young but, nevertheless, has had over twenty years of experience—principally in the machine tool industry. This specialized background has given Mr. Taylor the advantage of knowing a great deal about machining operations and costs. He has used his experience to advantage by offering free consultation to company customers on how they can economize by designing castings which require a minimum of machining. It is Mr. Taylor's contention that through proper design and foundry practices, great savings can be made while the quality of the casting is improved. His belief is reflected in company policy which calls for emphasis on quality and service rather than cost.

Outlook On Mechanization

Two years ago this company had plans for mechanization but abandoned them for reasons that will be explained in detail presently. It is Mr. Taylor's theory that mechanization as such is overrated, if not dangerous. He believes that there are cases where mechanization would pay but that
these are found once in ten. He claims that a modification, in his words, "modernization", is a more desirable procedure, and should be considered more seriously than complete mechanization. By modernization, Mr. Taylor means the addition of such equipment or methods which will reduce labor costs (which comprise 65% of his foundry expenses) while maintaining the existing flexibility. The danger in mechanization, claims the general manager, lies principally in financing it. There is no half-way approach to mechanization, because once you begin, you cannot afford to stop. That is, the installation of one machine will demand the addition of others if maximum use is to be made of the first one.

Why Warwick Did Not Mechanize

Although the management's outlook is obviously negative, it offers several valid reasons for not changing the plant's layout and methods. The main reasons in opposition to mechanization which Mr. Taylor presented are as follows:

1. Financially, the project did not appear to be feasible despite the contrary assurances of the engineering firm promoting the installation. First, great difficulty was anticipated in securing the capital necessary for the operation. Secondly, the investment of such a big sum in securities or real estate could yield a higher return than the risky mechanization project.

2. Loss of flexibility would have impaired Warwick's operational schemes very seriously, if not irreparably.

As a competitive jobbing foundry, this Company relies
on flexibility to handle even the smallest size of order. Since it has established its clientele on its ability to cast any of their small items the company felt that it could not jeopardize established business. Mechanization would make costly, and impossible in many cases, the casting of several items that the company produces now.

3. Higher scrap would result from mechanization. This is contrary to the theory prevailing in foundries which have mechanized and where it is claimed scrap losses have decreased appreciably. Warwick, nevertheless, supports its contention by emphasizing that pouring is the most critical part of making castings and that the careless pouring associated with mechanization would not yield the excellent results that hand-ladle pouring exhibits. The company backs up this statement with its own records on scrap losses which show a phenomenal low average of 5%-6%.

4. High maintenance costs would increase overhead appreciably. Mechanization would demand maintenance of a crew of skilled mechanics who would have to be available at all times for repair of possible breakdowns. The company believes that it would have been very difficult to find and keep such highly skilled men in competition with other industries in the area which have something more to offer them. Estimates had been made and indicated that with expectation of "normal" breakdowns one maintenance man per molding station would be required.

5. Frequency of breakdowns and their effect upon continued production was a serious factor which influenced
the company against mechanizing. It was felt that the time necessary to make repairs would seriously affect volume of production at great cost.

6. Continuous or semi-continuous pouring was deemed inadvisable for application to this plant because of the sacrifice in quality that might have resulted. Being a particularly quality-conscious organization, Warwick was not prepared to make sacrifices of this nature for the sake of increased volume.

Though these points defend the company's decision on mechanizing its foundry, experience of other foundries as well as economic developments since the company was considering this question, have brought out many other factors worthy of consideration. Some of these will be brought out as they have concerned Warwick in its recent operations.

Jobbing vs. Mass Production

A jobbing foundry differs radically from one that operates on a mass production schedule. In general, the first can undertake all custom orders while the latter must concentrate on standard products. Warwick's management believes that mechanization is easily applicable where nothing special is demanded of the product, as would be the case in the production of a standard item. A jobbing foundry, on the other hand, has to deal with varieties of patterns, sizes of castings, and sizes of orders. To do this, it must maintain complete flexibility so that adjust-
ment for the output of any special product will require a minimum of setting up and, more important, time. In addition, conditions must be such that every operation from setting of the flask to the final inspection of the casting will be closely followed so that all necessary control factors will be applied. To become more specific, Mr. Taylor offers some examples. Good jobbing work calls for particular attention to the sand used with each pattern. Variation in the sand in such properties as moisture, permeability etc., can make or break a good casting. A job foundry can give the attention necessary for sand control because it is manually handled to fit the job. A central sand-handling system on the other hand, makes control impossible because the sand is the same for all patterns used. Moreover, synthetic sand is used in most mechanized sand-handling systems and offers few of the desirable qualities for good pouring. Thus, artificial "quenching" of sand (cooling and aerating) subjects it to cracking during pouring.

Let us consider pouring as such. According to Warwick's standards, pouring is the most important operation in the process of casting. Obviously, it is claimed, if the metal is not poured correctly all previous attention given the mold goes to waste. They regard pouring as an art, not a science. Two things must be known before metal is poured into the mold. First, what is in the mold; secondly, how the mold was made. A worker who has made the molds he is to pour, meets both specifications. He knows whether it was a light or heavy job. He knows what sand he used. He knows
whether or not the job was peened by hand or shovel. All these factors determine how the metal is to be poured in order to obtain the results desirable. How could you possibly control so closely all these important factors under a system where one man makes the mold, another pours it, and neither knows what sand was used or how the mold was really made since a machine performed all the operations? You could not. In this respect mechanization does not offer the control demanded of a custom job.

These specific examples are intended to show that the basic nature of a jobbing foundry calls for attention to entirely different factors than does a mass production foundry.

Experience of Others

Warwick's management has kept a watchful eye on the progress of other companies which undertook mechanization. Several companies in the Providence area, encouraged by the heavy volume of war-time orders, decided to take the drastic step of converting to mechanization. At the outset the ventures appeared to be profitable because backlogs had to be filled and the war-time boom continued for a short time. Today, the story differs radically. Several of these companies have gone into receivership while others have shut down completely. There are, nevertheless, foundries which mechanized, prospered and are now making adjustments to meet changing conditions. These companies anticipated the change from a seller's to a buyer's market and established policies which are carrying them well through
the slow down in foundry business.

Influenced by the general reaction in its area, the Warwick Company believes to have adopted a wise policy when it decided to maintain its jobbing layout. The management finds it difficult to understand how other foundries are "plunging into mechanization" in a period when every effort has to be made to cut down overhead in order to continue in operation.

The Company and Labor Supply

One of the most serious considerations which have convinced companies of the urgent need for mechanization has been the rapid decrease of the old time molders. As has been pointed out in the introduction, the industry cannot find readily the type of labor that is needed to do the work in a foundry where all operations are performed manually. Warwick, for reasons that are somewhat indefinite, claims to have had no trouble finding workers within its area. According to Mr. Taylor, men with a strong back and a weak mind will always be available to do the type of molding in use today. This, he claims, is not the old type molding, which was an art, but a routine that any man can learn well enough in three weeks. Warwick's wage rates are high, as compared with those of other industry in the area, and provide an excellent incentive for workers who are not sure they would care to do that type of work.

Warwick has had the fortune of having a good union for
its workers and being able to reach mutually satisfactory
decisions in whatever differences have come up between
labor and management.

It is this company's attitude that there is a certain
fascination attached to the "foundry game" which, once
instilled in the worker, draws his interest forever. They
believe that the climax of one hour's pouring after six of
molding is something to which every molder looks forward to
day by day. Though this appears to be an idealistic atti-
tude, it helps explain why so many molders have been behind
a bench anywhere from twenty to forty years.

Foundry Market

One of the standard arguments presented by supporters
of mechanization is that it helps meet competition. Since
many foundries have mechanized, others are faced with even-
tual change to that method if they are to compete success-
fully with companies which can lower prices because of
greater volume. According to Warwick's management, however,
competition is not the only factor that controls the market.
Many of these companies have been in business for many
decades and in the years past have established interlocking
agreements and friendly ties which they will not break for
the sake of eliminating their competitors. Thus, the intent
is for all to do well because it is believed that the market
is not over-flooded with foundries. If a company fails it
is usually the result of its own policy rather than the
intent of its competitors.
There are other factors which Warwick feels help control the market. Resistance to change is an inherent weakness of many people, particularly the customers of a foundry. If a company is satisfied with the castings and the price offered by a foundry with which it has been doing business for many years, it is not likely that it will change to another which can offer a better price because of mechanization.

Another important consideration is reciprocity which exists in this industry as much as in any other. Many foundries help one another going so far as to recommend to one of their own customers that he give a certain job to another company which can do better work on the specific order. Such relations have been entrenched through the years and it would take more than a change in method to break them.

**Present Status**

Warwick is as seriously affected by the current drop of foundry business as any other similar company. It has been forced to lay off men, cut down the work week, and narrow its daily output in order to continue in operation. It has been able to lay off men without difficulty because of a clear-cut contract with the union which leaves it up to management to make lay-offs on a strict seniority basis. Moreover, many of the workers either find some sort of manual labor in the area--made possible by the extensive industry in the area--or spend the time in their homes
where they do odd jobs to keep busy. It appears that the latter is a favorite passtime at any time for those who have their own homes nearby. The company has yet to face a labor problem whenever jobs have been made available after a layoff.

Warwick's management attributes the present slowdown in business to nothing more unusual than the customary reasons that have resulted in slowdowns in the past. Nevertheless, it has sent out a salesman with the dual goal of drawing some new business and to encourage existing customers into making purchases which, for reasons that are difficult to analyze, they are not making.

It costs this company a minimum of $18,000 monthly to keep operating. All extra costs are variable and can be controlled. According to Mr. Taylor, if you lay off ten men it immediately means an appreciable reduction of the payroll in a foundry like this. If it was mechanized, on the other hand, the minute a machine was not operating you would have a running cost of depreciation and lack of production. What's more, concludes the general manager, how could you possibly operate a mechanized foundry if all the business you had was only 20% of capacity? You could not. Nevertheless, under its present setup that is just what the company is doing. It regards it as the most conclusive proof of its arguments against mechanization.
THE PRODUCTION PATTERN & FOUNDRY COMPANY
CHICOPEE, MASS.
Introduction

The Production Pattern & Foundry Company, in Chicopee, Mass., is an unusual example of foundry mechanization, because it embodies reasons which would make anyone but a foundry equipment salesman claim that it should not be mechanized. Yet the owner, a young, aggressive ex-pattern-maker, is proceeding to make some extensive installations to mechanize his foundry despite the fact that at the present time his Company is operating only three days per week.

A brief description of the foundry and its gray iron products should serve to indicate the reasons why mechanization may not be completely sound from an economic standpoint. There are a total of 75 employees in the foundry, 15 of whom are molders.

This foundry is a small job foundry in the strictest sense. All of its production is to order, and most of the orders which the Company handles are relatively small, 1000 pieces being the average size of an order. In addition, some 10% of the Company's customers supply their own patterns. Though most of the castings are of the size encountered in a malleable iron foundry, castings weighing up to 100 pounds are made by this organization. Established only 2 years ago, the Company has not had a very long opportunity to build up a wide trade of its own. Its steady customers number less than 25 at present. As such, it must compete for orders largely on the basis of price, quality, and delivery.

Mr. Jahn, the president of the Company, gained his foundry experience working in a large number of foundries
as a pattern-maker. There is no doubt as to the power of his initiative and perseverance. Yet it is not certain whether his experience has included training in financial matters sufficient to give him an accurate picture of the cost and investment aspects of mechanizing a foundry.

Motives Leading to Mechanization

The production Pattern & Foundry Co. was operating only three days a week when the president of the Company decided to mechanize. He was, nevertheless, sufficiently optimistic about the future to be willing to assume a large investment in order to be in a better competitive position to secure orders when business became more prosperous. In addition to improving his competitive position, Mr. Jahn was also prompted by the usual motive of elimination of physical effort from the making of castings.

In order to secure higher productivity at lower unit costs, it is necessary that the existing limited space in the foundry be used more fruitfully. As can be seen from the picture on the next page, (Figure 14) the space for setting molds after they have been made is very limited. With the molding machines placed along each side of the lower end of the building, each molder has space for only about 100 molds. Since it is not this Company's practice to place molds on top of one another prior to pouring, the only manner in which more floor space can be created to handle the higher production is to pour the molds continuously.
Description of Proposed Installation

The principle change which will be made in the existing process is the installation of a sand-handling system, which will deliver sand to the molding machines from overhead hoppers fed by a conveyor belt. Figure 15 is an illustration of the type of layout which the improvements will follow.

Figure 15
The conveyor will travel along the length of the molding stations, all of which will be moved to the right hand side of the foundry. Fortunately, there are 16" I-beams along the upper sides of the building. The supports for the conveyor will be attached to one of these I-beams, without any additional construction or reinforcement.

In addition to the sand delivery conveyor, there will be an underground conveyor running along the left side of the building, which will receive the used sand after the molds have been poured and shaken out. This conveyor will return the used sand to the conditioning unit, a Simpson muller and an aerator. There will be no conveyor under the molding machines to return sand that is spilled from the chutes while the molds are being made.

Each molding station will have a system of "flat-cars" mounted on rails, which will take the molds by gravity to the pouring stations and, in the same manner, return the cast iron bottom-boards to the molders. Though the mold conveying system is still in the process of being designed it will probably consist of separate flat-cars, which the molder will lift from the end of the return track to the head of the delivery track each time he sends a mold to be poured. At the end of each mold conveyor, there will be a grating, over which the molds will be shaken out manually. Iron will be delivered from the 42" Cupola continuously in bull ladles suspended from a monorail. Castings will slide down the gratings into palletized bins in which they will be transported to the cleaning operations.
At the present time, molding is done for the first six hours of the day, and when the heat is tapped, all of the molders and most of the employees from the cleaning and inspecting operations perform the pouring operation. It is estimated that continuous pouring will require the services of four men throughout the day. As these four men will presumably be the ones who are now engaged in handling sand, no additional labor will be required for the new process. With approximately the same labor force, then, Mr. Jahn estimates that production will increase by at least 50% as a result of the improvements.

Advantages of Proposed Improvements

In addition to the broad advantages related to the expected increase in productivity, some of the specific advantages of Mr. Jahn's proposed improvements are as follows:

1. No loss in flexibility will occur, since each molder will continue to be an independent unit. Similarly, the method of transporting molds to the pouring stations will permit the use of whatever size flasks are required.

2. Breakdown of one of the molding machines will not make the entire production cease.

Disadvantages of Proposed Improvements

Aside from the economic aspects of the proposed installation, there exist these disadvantages.

1. Failure to install a conveyor under the molding machines will mean that some of the speed of molding that
arises from the use of hoppers will be counteracted by the
necessity of having each molder occasionally shovel up the
sand which will spill and accumulate around his machine.

2. There are no provisions for drawing off gases
which will arise from the molds as they are poured. Unless
hoods are installed over the pouring stations, or ventila-
tion is provided in some other manner, working conditions
will be rather unpleasant because of the continuous presence
of gases.

3. The proposed method of conveying molds to the pour-
ing stations seems more expensive, complicated, and less
economical than would be a set of roller conveyors.

Evaluation of Mechanization Program

Mr. Jahn received an estimate for the installation
of the sand-handling equipment from the National Engineering
Co. The complete cost of the installation, including
labor and the digging of the ditches under the shakeouts
would have been about $150,000. By purchasing most of the
equipment as war surplus from a foundry in Bridgeport, and
using his own labor, Mr. Jahn estimates that he can make
the installation for half the price quoted by the National
Engineering Co. Perhaps the fact he can do the mechaniza-
tion so cheaply himself has influenced Mr. Jahn more than
other considerations, such as the true savings that will
result from the sand-handling system.

It appears quite certain that the present scale of
the operations of The Production Pattern & Foundry Co. does not merit the increase in productive capacity that will result from mechanization. In addition, it is a reasonable assumption that the financial situation of the Company is not so healthy that a non-productive investment of at least $75,000 will not be a source of trouble, if not insolvency. The success of the venture, then, seems to depend entirely on an improvement in business conditions such that capacity production can be achieved soon enough to counteract the interest that the investment is now drawing.

In fact, the only optimistic viewpoint that can be taken of Mr. Jahn's plans is that he obtained a bargain in the price of his equipment, and that he is making improvements during slack business conditions. Hopefully, such action will place him in a more secure competitive position when business improves, rather than prevent him from breaking even now that his volume has fallen off.
CONCLUSIONS

As has been stated, we do not believe that there is a "formula" solution to the problem of mechanization. Our conclusions, therefore, will emphasize the most important factors which predicate or prevent mechanization, by showing what effect each one of these factors might have under particular circumstances. The order in which the factors will be discussed is not necessarily indicative of their relative importance, since the importance of each factor varies with each application.

Volume

It is difficult to conceive of a foundry mechanizing unless there is sufficient volume to insure the economical operation of the machinery and an increase in profits great enough to amortize the investment. High volume can take the following three forms, in order of decreasing desirability.

The optimum kind of volume involves the production of relatively few different items for long runs. The Westinghouse foundry, for example, may keep the same pattern on a molding machine for as long as six months. In this manner, pattern equipment is rapidly amortized, interruptions for set-up changes are minimized, and quality becomes better as the molder and pourer become specialists in that one item.

The next most desirable type of volume is a high volume of one kind of product with many different size classifica-
tions. This situation exists in the case of the Malleable Iron Fittings Company and the Chapman Valve Company. In these cases, high volume is assured through a reasonably secure demand for pipe fittings and valves, and it is possible to produce for stock. Naturally, the great variety of sizes means that there is considerable cost in changing patterns and in storing them.

High volume, which involves great variation in size and type of product, and, at the same time, rather small orders, is seldom the basis for mechanization. A company in this category might have twice the sales of a company whose volume is of the most desirable type, and yet the former would be unable to mechanize fruitfully. In such a case, flexibility, which will be discussed further on, must be maintained, as each order may require different flasks, molding techniques, and pouring methods.

It is further to be emphasized that expectation of greater volume through mechanization is not a sound reason for making the investment. Orders must be in existence or in sight, for castings must usually be sold long before they are made.

Cost

Mechanization is expensive, because it must proceed a long way in order to be completely effective. Cost, therefore, is a very important consideration in the mechanization of any foundry.

There are varied considerations that must be made in
relation to the cost of installing a mechanized system. The initial outlay, in every case, is a large one, and cannot be justified unless it yields a return comparable to that provided by high-grade securities. That, however, is only a part of the cost consideration. The maintenance of a mechanized foundry is an expensive proposition. Furthermore, the high overhead has to be met whether or not machinery is in operation. It is this point which relates closely to high volumes of production, since the latter guarantees continued operation, meeting of overhead, and a profitable yield.

The financial status as well as the type of foundry are factors which must be considered in deciding whether or not the cost is justified. A company of the size of Westinghouse can well afford the delay of the return of a large cash outlay in the foundry, because the investment will amortize itself through other phases of the business. The Warwick Malleable Iron Company, on the other hand, has to be absolutely sure of a rapid return, or else jeopardize the continuation of its operations. A captive foundry does not have to cope with competition, and can proceed on a mass-production basis with greater ease than can a company which is manufacturing a variety of products in a competitive market.

No mechanization should be undertaken unless a company has made exhaustive investigation of all related factors mentioned above, and has found that it can afford the
risk involved. Westinghouse can take the risk because it can afford to lose. Warwick cannot afford to lose, and thus is unable to assume the risk. Mr. Jahn of the Production Pattern & Foundry Company seems to feel that the risk he is taking represents the only way in which he can meet competition.

**Flexibility**

It is indisputable that mechanization curtails flexibility. By flexibility is meant the ability to handle small, varied orders without sacrificing economy of operation. In addition, flexibility means the freedom of a process from complete shutdown in the event of the breakdown of one machine.

A completely mechanized foundry can handle small orders and a variety of castings only at the cost of time and money. Some companies, such as Warwick, have established a business which depends on the handling of a few small, profitless orders, of a certain customer in order to insure a large order from the same source. Such orders may not be profitable, but at least they do not disrupt the entire production of the foundry, as they would the production of the Westinghouse foundry. Thus, when business relies heavily on customer service, flexibility is sacrificed only in direct proportion to customers. Obviously, a company like the Warwick Malleable Iron Company, cannot suddenly change its policies with regard to orders, since most of its customers demand service.

In the comparison of a jobbing to a captive foundry
there lies the best illustration of how flexibility affects mechanization. Assuming other conditions to be equal, a jobbing foundry cannot sacrifice flexibility, while a captive foundry is scarcely concerned with it in the first place. Flexibility in a jobbing foundry can only be sacrificed to the degree in which what is lost in flexibility can be more than made up in greater volume through the manufacture of more standardized products. The Chapman Valve Manufacturing Company serves as an illustration of this degree.

Flexibility, then, is closely related to the type of market. If the market of a particular foundry calls for a variety of castings and numerous small orders, flexibility can well be the determining factor in mechanization considerations. In view of the certain existence for small orders of large and small castings, there is no doubt that foundries with complete flexibility will be needed, unless the costs of installing and operating a mechanized process become sharply reduced in the future.

Market

Aside from the relationship between flexibility and market, there are two other aspects of a market which must be considered—size and location.

A foundry is generally limited in size of the market that it can supply because of specialization, competition, or transportation costs. Thus, a company will most likely produce a certain type of castings and sell them in a region where competition is fairly limited. If it were to expand
its market into areas beyond a certain distance from its plant, transportation costs might become high enough to make purchases from that company uneconomical for certain customers. The Production Pattern & Foundry Company, and the Warwick Malleable Iron Company are good examples of the restrictions imposed by transportation on market considerations. These companies supply New England customers, and cannot hope to compete with similar plants in the Mid-West, for example.

There are companies, however, which have, through superior technological and managerial advancements, manufactured a product which has attained national or even international favor. The Chapman Valve Company is an example of this situation. Such companies are the exception, however, and sometimes owe their success to monopoly or long-established good will.

If a company wishes to expand, it must seek a greater market. Expansion will bring about a day when, cost-wise at least, it will pay to mechanize. A company must have a good picture of market potential before plunging into expansion through mechanization. If it is a jobbing foundry, its chances of expanding its market are good because it can offer variety through flexibility. But then it faces the problem of sacrificing this flexibility through mechanization. It is the enigma presented by this type of consideration which illustrates the impossibility of making a decision between mechanization and market through the application of a formula.
Labor

Whether mechanized or not, a foundry needs labor to keep running. The type of worker required, his availability, and what can be done to attract him into foundry work are some of the factors related to the question of labor and mechanization. Mr. Elliot, of Westinghouse, claimed that his Company spent $1,250,000 mechanizing largely because it was becoming increasingly difficult to find laborers for the foundry. In addition it was becoming increasingly difficult for the older workers in the plant to keep pace with the hard physical requirements. Mr. Taylor, of Warwick, expressed the opinion that men with strong backs and weak minds would never become extinct, and that the labor requirements of a non-mechanized foundry can always be met in normal business times.

If a company is faced with a labor shortage, however, it has to act quickly. Mechanization makes the work easier, healthier, and the surroundings more attractive. If a company finds that labor is its only problem, though, it must resort to every other solution possible before mechanizing only to alleviate that problem. Despite temporary labor shortages and altruistic feelings on the part of management, cost is, and should be, the justification for mechanization.

There have been companies, such as the Eastern Malleable Iron Company, of Naugatuck, Conn., which met a serious labor shortage by recruiting men from thickly-populated areas such as New York City. People out of work will accept even the worst foundry working conditions for a paycheck. When business is good, foundries usually offer to pay rates
higher than the community average to attract sufficient labor.

Location of a foundry is closely related to employment problems. In the South, for example, there is a plentiful supply of cheap labor willing to perform arduous foundry work. In the East and Mid-West, however, we notice the greatest concentration of mechanization, and might attribute it to the need of better working conditions to attract a higher type of laborer from a scarcer market. This reason may apply to a certain extent, but the reasons of costs and volume apply much more strongly.

It is true that for continuous high production, mechanization can reduce labor expenses. But it is not felt that labor conditions have reached the critical point where they overshadow other factors in importance.

General Economic Conditions

The foundry industry claims to be one of the first victims of any depression. If this is true, a foundry has to be particularly conscious of general economic conditions before taking a radical step like mechanization. Not only must a foundry's own business picture be satisfactory, but the future must also look bright for those industries which keep foundries in operation. A company must analyze its own problems, its competitive standing, and the condition of the industrial market which it serves.

The Production Pattern and Foundry Company is mechanizing today believing that it will spend a minimum by doing
so at this time. But business is poor, the plant operates only three days per week, and competition is becoming stronger by the day. Thus, this Company's timing is considered unsound, in view of the added costs it must assume without sufficient volume to bring about mass-production economies.

Regardless of the nature of a foundry, economic considerations are of basic importance in the consideration of any step, such as mechanization, which requires large cash outlays. No company should take this step unless it is convinced that general business conditions warrant the necessary investment.
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2. "How To Figure Where You're Going Before Mechanizing". Business Week, Dec. 11, 1948.


SOURCES OF ILLUSTRATIONS

Figures 1-9: See No. 3, above.


Figure 14: Useful Information, Production Pattern & Foundry Co., Chicopee, Mass.

Figure 15: See No. 1, above.