

Relationship of Quick Die Change to EOQ and JIT

The grim science of economics cannot be ignored when wondering why production scheduling seems to be mass confusion resulting in misdirected resources. What may seem like a diesetting problem may be lack of good management and training. Increasingly the job of press operator and diesetter is being combined. Fortunately, good procedures such as standardized clamping and locating methods have simplified diesetting. Die handling improvements and die storage at the point of use have made exchanging dies much faster and safer. Quick Die Change is the key to making Just in Time (JIT) manufacturing possible while keeping the economic order quantities (EOQ) small.

Pitfalls of Excessive Run-Ahead

Simple logic says it would be wise to run enough parts to satisfy production or shipping requirements for a long time in the future once good parts are produced. This plan would be true particularly when an extremely difficult setup followed by trial and error adjustments is involved. There are however, many good reasons why this is not wise.

A better plan is to reduce the difficulty of the setup by adopting quick die change techniques and hardware. This will also greatly reduce the trial-and-error adjustments. The root causes of poor setup repeatability that are not corrected by quick die change (such as stock variation) should also be addressed.

Planning Amount and Frequency of Production

Many factors influence the exact amount of production. For example, there is a cost associated with rebanding partial coils of stock and returning them to inventory. For this reason, the savings realized by running integral numbers of coils should be factored into the decision process on the amount of production to run. Economics of coil sizes is also a factor. Large coils are often less costly on a per pound basis and produce more parts per coil change.

Customer relationships have a very big influence on the frequency of production. Some customers insist on a certain number of days inventory being on hand at the vendor's shop as a safety stock. However, many factors also dictate production scheduling that go beyond classic economic theory.

For example, the Michigan firearms deer-hunting season has serious implications for stamping production. The number of hunters in the field typically exceeds the number soldiers that make up the United States' standing army. There are only two solutions. Run production ahead at least one week starting in early October or shut down the pressroom for the first week of deer hunting season.

Working toward an Economic Order Quantity of One

Much has been written about Just in Time (JIT) in the past few years. The purpose of JIT is to deliver parts to a production line *just in time* and to keep the line running without a large bank of parts as a “safety stock”. Without some other considerations, a crisis is built in at the end of every batch. The production line needs the necessary parts to keep running. If there were any glitches in the delivery of the parts to the line, it may be necessary to either shut the line down, or spend an inordinate amount of effort and money to get the parts to the line.

What is Economic Order Quantity?

Economic Order Quantity (EOQ) is the quantity of parts, either purchased or manufactured, that results in the lowest part cost while considering:

For a purchased part:

1. The purchase price
2. The cost for issuing and processing a purchase order
3. The cost for holding the part in stock, if all of the order is not used immediately

For a manufactured part, the considerations are:

1. The cost to manufacture the part
2. The cost for setup of the equipment
3. The cost for holding the part in stock, if all of the parts are not used immediately

Factors That Influence Economic Order Quantity

To determine the Economic Order Quantity (EOQ), it is required to know not only the part cost and setup cost, but also the manufacturing rate, annual demand for the part, and the cost for holding the part in stock on an annual basis.

Manufactured part cost consists of the material cost, labor per part, rent or amortization of the space used to manufacture the part, equipment and tool amortization, scrap from damage while storing or while in storage, scrap from obsolescence, loss of parts while in storage, fixed burden, variable burden, and freight costs involved. If one part is produced and used immediately, (and not consider the cost for changeover), the cost is that of the part. Nevertheless, if any quantity of parts requires keeping some of them in stock for any time, there is an associated cost of keeping the part.

Part Storage Cost Factors

The cost for keeping the part is not just interest paid on the money tied up in the parts stored. It includes:

1. Warehouse rent or amortization
2. Damage for handling the parts to and from storage
3. Loss of parts while in storage due to information system problems

4. Danger of part obsolescence
5. The cost of warehouse equipment
6. The cost of labor to put the parts in storage and to remove them
7. Labor to maintain the inventory of the parts in stock
8. Insurance on the parts while in storage

The American Production and Inventory Control Society has estimated a typical average cost for keeping parts in stock is 38% per year—this is a reasonable starting point for metal stampings held in inventory.

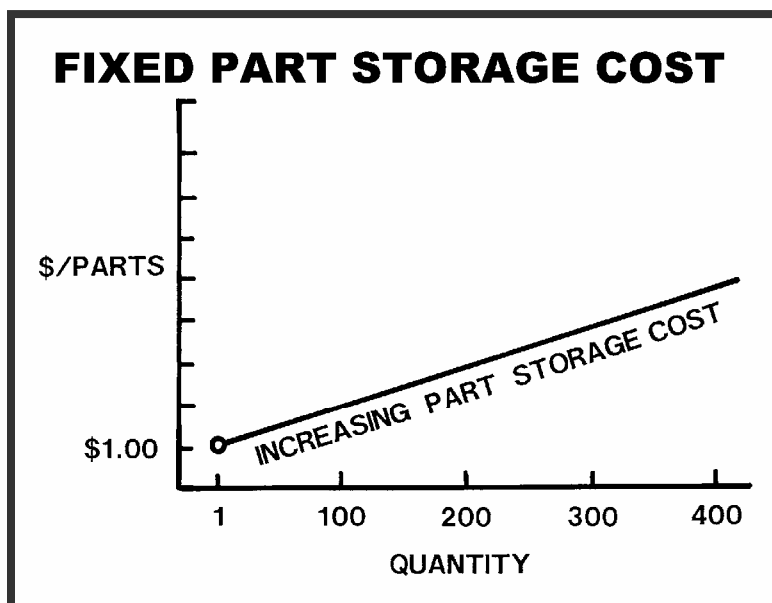


Figure 1. Warehouse space is expensive. Cost per part increases as a size of the production lot increases. *Smith & Associates*

To the cost of the part, add the cost for equipment changeover, or the cost for issuing and processing a purchase order. If there is only one part involved, the cost of that part is the total of the part cost plus the cost for changeover. If more than one part is made on a setup, the cost of that setup can be amortized over the quantity of parts made. The total cost of the part then depends on the total of the part cost, the amortized cost of the setup, and the amount put in the part for storage until its use.

The Economic Order Quantity

The EOQ model identifies the order size that will minimize the sum of the annual costs of holding inventory and the annual costs of ordering inventory. This model assumes that:

1. There is one product involved
2. Annual usage (demand) requirements are known

3. Usage is spread evenly throughout the year so that the usage rate is constant
4. Lead time does not vary
5. Each order is received in a single delivery
6. There are no quantity discounts

Determining Economic Order Quantity

Figure 1 illustrates how the costs of carrying parts in inventory are linearly related to the size of the part run. The formula defining this relationship is:

Annual Carrying Cost =

Where {Q} = Order quantity in units.

H = Carrying cost in dollars per unit per year.

Example:

Let {Q} = 100 units.

H = \$10.00 per unit per year carrying cost.

Carrying costs are therefore a linear function of **Q**, and increase or decrease in direct proportion to the order quantity **Q**, as illustrated in Figure 1.

Figure 2 illustrates how ordering costs are both inversely and non-linearly related to order size. The slope of the curve becomes flatter as the order size increases because the fixed setup cost is spread over an ever greater number of units. The slope of the curve is described by:

Annual Setup Cost =

{S} = Setup Cost

{Q} = Order quantity in units.

{D} = Demand in units per year.

Example:

Let {D} = 2000 demand units per year.

{Q} = 4000 order quantity units.

{S} = \$5000 in setup costs.

The total annual cost of carrying a part in inventory is given by

Annual carrying cost for one part =

{Q} = Order quantity in units.

{H} = Carrying costs in dollars per unit per year.

{S} = Setup cost.

Note: The annual carrying cost for one part is equal to the annual carrying cost plus the annual setup cost.

{Figure 6-3} illustrates the U-shaped curve that describes how the total cost of setup and storage varies as a function of the number of pieces produced. The U-shaped curve reaches its minimum value at the quantity where the setup and carrying costs are equal.

An expression for the optimal order quantity {Q_o} can be obtained through the use of calculus. The result is the formula:

Optimum Order Quantity =

{D} = Demand in units per year

{S} = Set up cost

{H} = Carrying costs in dollars per unit per year.

Example:

Let {D} = 2000 demand units per year.

{S} = \$5000 in setup costs.

{H} = \$10.00 per unit per year carrying cost.

The low point of the total part cost line is the Economic Order Quantity, the quantity that results in the lowest part cost. If the company buys or builds more or less than the Economic Order Quantity, then more will be paid for each of the parts.

Reducing the EOQ

There are only two ways to reduce the EOQ. Either the cost of storage or the cost of setup must be reduced.

There are not many opportunities for reducing the costs associated with holding parts in inventory. Little can be done to reduce the cost of building space, money, or the likelihood of part obsolescence. Fortunately, from the formula, if the cost of setup equals zero, the EOQ becomes one. Spectacular setup cost reductions are possible. Figure x4 illustrates how the EOQ curve changes as setup costs are reduced. If all setup costs are eliminated, the economic order quantity becomes one.

The Impact of JIT

Before JIT, a safety stock was kept for insurance against running out at the end of every batch. It was expensive insurance, and led to a certain amount of complacency in our manufacturing operations. As problems surfaced, a tendency arose to increase the safety stock, rather than cure the delivery problem.

This, of course, increased our average inventory, increased the risk of damage, loss, obsolescence, and the other means of increased cost caused by high inventories.

Figure 5 is a plot of inventory quantity on hand versus time. It indicates that there are 660 parts on hand today.

As time progresses, those parts were used at a rate indicated by the slope of the line in Figure 6. The “Never-Lie” inventory control system projects that the safety stock level will be reached at the end of day six. Everyone has a “Never-Lie” inventory control system, of course.

When the order point is reached as shown in Figure 7, “Never-Lie” will trigger an order for either the manufacture of the parts in the shop, or the delivery of parts from a vendor. This assumes that EOQ is checked on a periodic basis, and the Reorder Point and safety stock is modified if necessary.

Under normal conditions, a new lot is manufactured. Normal conditions are having the raw material, the tools in operating condition, and the personnel available to make the parts. Remember, this is before JIT.

If reordering isn't done on time, or if there are any of the factors (raw material, tools, personnel, etc.) that are not available, there is safety stock to protect against catastrophe on the production line. Production would receive the parts later, having maintained operations with the safety stock, and rebuild the safety stock when the next order arrives on time. The same usage pattern is true with a manufactured part.

The average inventory of a purchased part before JIT was the safety stock plus half of the Economic Order Quantity. Keep in mind, however, that enough warehouse space is needed to keep all parts in their Economic Order Quantity, or some fraction higher than half, because not all parts are used at the same rate.

Elimination of Safety Stock

JIT eliminated the safety stock, and in many cases did not consider that parts must be procured in their Economic Order Quantity. Only the average inventory by the amount of the safety stock was reduced. In many cases, this was very significant since safety stocks had become quite large.

With JIT, usage pattern remained the same, except that average inventory was reduced. The same is true of the manufactured parts—the average inventory was lower. Keep in mind that without doing something to reduce the EOQ, if the parts were made in less than

the Economic Order Quantity to further reduce the work in process inventory, the amount paid for the parts was increased.

To reduce EOQ, the primary job is to reduce the cost of setup, or order cost (the cost to issue and process a purchase order), rather than the cost of the part. In fact, reducing the part cost increases the EOQ, resulting in more parts, not necessarily more dollars, with work in process. Without reducing the setup, reduction in part cost does not result in much of a reduction of the total part cost. The total part cost is relatively flat at the point of the EOQ, so reducing the part cost by even 50% would result in a real reduction of the part cost by as little as 10%.

Most of us have heard of setups that take eight hours or more. It is possible to reduce an eight-hour setup to 30 minutes or less.

Several points to decrease changeover cost should be kept in mind.

1. Be ready for a die change
2. Semi-Automatic die change
3. Automatic die change

We can reduce die change time to almost zero using:

1. Point of use manufacturing
2. Transfer presses with gaggable tooling.
3. Design for automation.

The necessity for the considerations for manufacturing during the product design phase cannot be emphasized too strongly. It is mandatory that Manufacturing Engineers be involved in the product design at the outset of a new program. They are the ones who can help with the design so that the part can be manufactured with little or no die change.

An EOQ of one can be attained, and that can make JIT work without the hassle now associated with it.

Quick Die Change

The term quick die change is relative. How quickly dies can be exchanged is not solely a quantifier of stamping efficiency. The ability to set the die safely, clamp it in the press securely, and stamp good parts with little or no trial-and-error adjustment is the goal. It is much more important to be able to consistently change over an operation in a reasonable amount of time and produce good parts, than to strive for speed alone if dangerous short-cuts result.

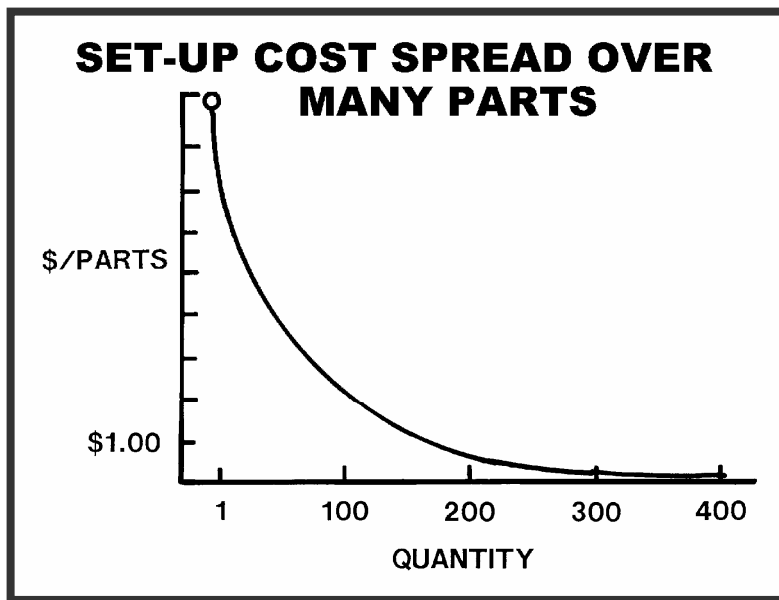


Figure 2. Long costly setup times may result in very large production runs. The cost of setup is lower per piece. However, this increases the per piece part storage cost.

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Small Lot Production

Making only the quantity of stampings that can be used in a short period to assemble products has many benefits. Large lot production requires expensive storage space and inventory control procedures. In addition, there is always the danger of part obsolescence, and deterioration due to corrosion. This increasing storage cost as lot sizes get bigger is illustrated in Figure 1. Long setup times often result in large lot sizes. The logic is to increase machine uptime by large lot production. Spreading the cost of setup over many parts does reduce cost of each part attributable to setup as shown in Figure 2.

In general, the lot size is based on the number of parts required for production in hourly, daily, weekly, biweekly, or monthly quantities. For example, an integrated automobile manufacturing facility may stamp all of the large body panels at the assembly plant in one or two day lot sizes. The small stampings typically are produced by contract stamping shops that deliver the required parts in similar small lot sizes. Only the required number of parts are produced and delivered on schedule as needed. A common term for this type of low-inventory system is just in time or (JIT) manufacturing.

Just In Time Manufacturing Requirements

The JIT system requires that all aspects of the stamping process are in control. The stock must be on hand in the correct quantity and material specification. The dies and presses must be capable of high-quality production, which requires good maintenance procedures. The time required for diesetting should be low in order to maximize stamping flexibility and press up time.

The goal of every activity must be to deliver high quality stampings to the assembly operation in time for assembly while avoiding large past queues or safety stocks. Of course, it is essential that the production operation never be shut down due to a lack of parts.

Economic Order Quantities

In simple terms, the economic order quantity (EOQ) is defined as the amount of parts to produce in order for the setup cost and storage cost to be equal. This amount of production reflects the lowest total part cost. Figure 3 is a graphical representation of these three factors.

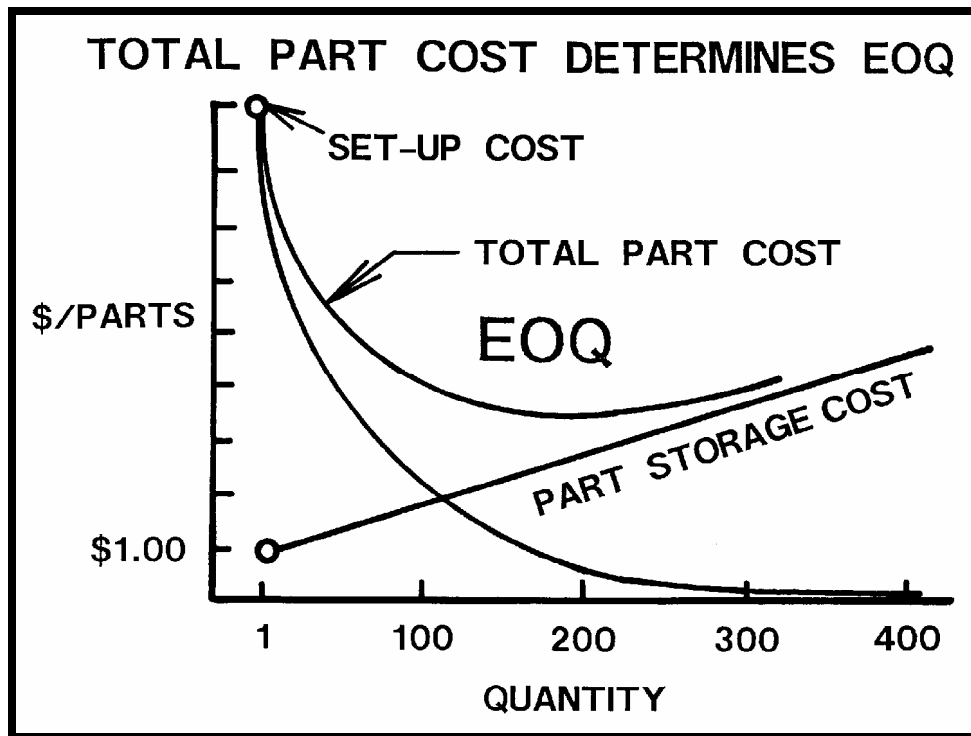


Figure 3. The U-shaped curve that describes how the total cost of setup and storage varies a function of the number of pieces produced. *Smith & Associates*

The part cost alone has a straight upward slope, reflecting the cost of storing the parts increasing with time. The setup cost has a curved downward slope that reflects spreading the setup expense over an increasing lot size. The EOQ curve reaches its minimum value where the combined storage and setup costs are the lowest on a per part basis. ¹

¹ This is based upon a paper presented by Phillip A. Gibson, Regional Manager, Atlas Technologies, and Atlanta, Georgia. The paper was presented at The SME Die and Pressroom Tooling clinic held in Chicago, August 29-30, 1989. Gibson's paper has instructions for setting the EOQ formula up in a spreadsheet.

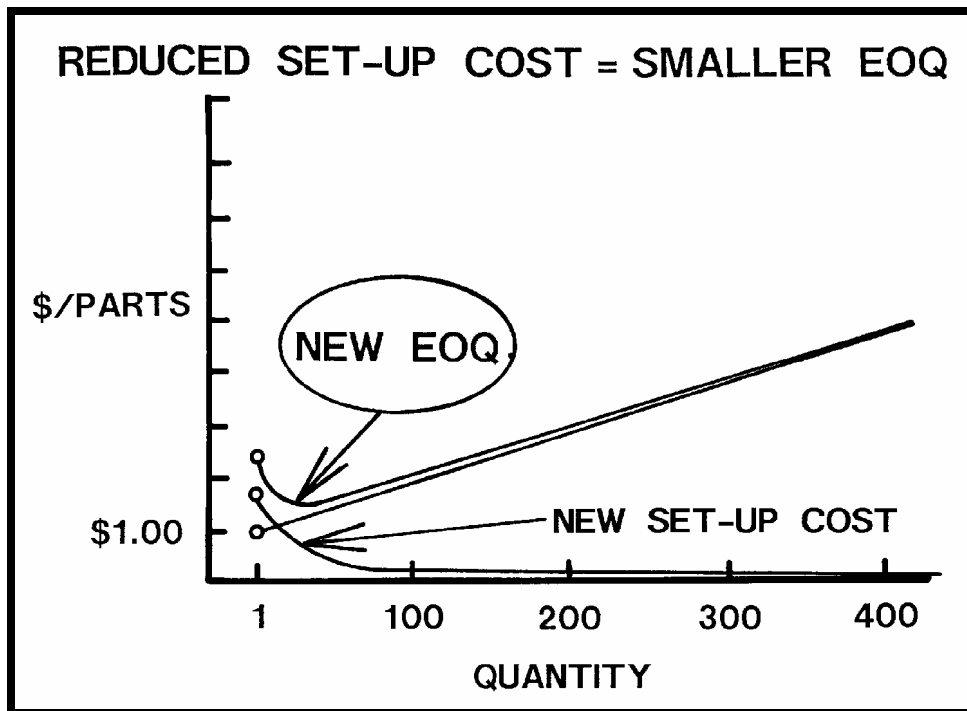


Figure 4. The EOQ curve changes as the setup costs are reduced. *Smith & Associates*

Storage costs are very difficult to reduce because they are the sum of all costs associated with keeping inventory. These include warehouse space, heat and light, taxes and the danger of part obsolescence.²

Setup time is nearly always a candidate for reduction. There are many case studies where die changeover times have been reduced from several hours to a few minutes. Figure 4 illustrates how a reduction in setup time and hence cost reduces the size of the EOQ.³

DEFINING AND REDUCING SETUP TIME

The actual time that elapses between producing the last old part until the press is again producing new good parts is the true setup time. It includes all delay factors such as finding the correct fasteners, trial-and-error adjustments; any needed die repair and obtaining quality control approval.

² William J, Stevenson, *Production Operations Management*, Richard D. Irwin, Inc., Homewood Ill., 1990. Chapter 10 describes the basic economic order quantity model and provides 15 examples on pages 507 to 537.

³ D. Smith, *Quick Die Change*, Chapter 6, *Relationship of Quick Die Change to EOQ and JIT*, The Society of Manufacturing Engineers, Dearborn, Michigan, 1991. The application of economic order quantities in metal stampings based on part and changeover costs are discussed in detail. The application of popular spreadsheets to analyze cost factors is presented including the required cell entries. Generally, EOQ is not advised as the sole driving factor used to determine the optimum amount of parts to run.

Reducing the Cost of Setup

Setup costs are candidates for reduction in many cases. It is common for the setup of a coil-fed progressive die to take two hours or longer. Tandem press line changeovers often involve a full shift.

There are several reasons why diesetting can take hours. The usual cause is lack of planning, haphazard preparation and finally, poor execution of the changeover. Industrial and manufacturing engineers classify setup time into two categories. The first is the external or preparatory phase of the diesetting activity that consists of all of the work that can be done before the changeover begins. This get ready work is accomplished while production is running. The portion of the diesetting activity that must be done while production is stopped should be minimized. Figure 5 illustrates the difference between the two classes of diesetting tasks.

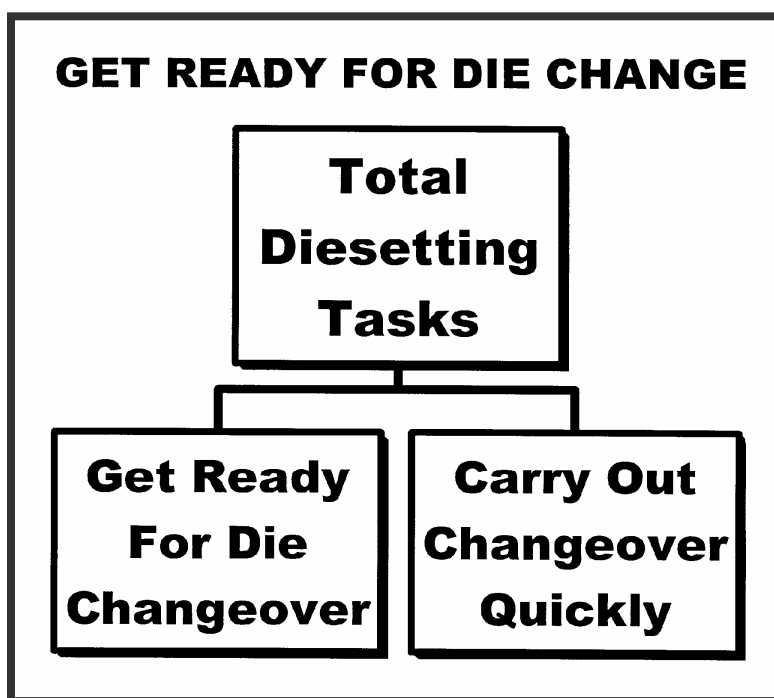


Figure 5. To improve diesetting efficiency, as many diesetting tasks as economically feasible should be done before production stops for die changeover. *Smith & Associates*

Keeping setup time as short as possible is very desirable. However, some tasks may require scheduling some press time during changeover. Examples are a quick style changeover by pulling a die section or necessary press maintenance.

Converting Internal to External Dieset

All of the tasks required to prepare for and carry out diesetting activities should be identified as discrete elements and the required times noted. An effective way to

accomplish this is with the use of low-cost home videotaping and playback equipment. It is best to have the persons that actually do the diesetting review the tape and work with engineering management to improve diesetting efficiency.

Employee Involvement

Improving pressroom efficiency was once mainly the duty of industrial and manufacturing engineers. Increasingly, this responsibility is being shared with the hourly workforce.⁴

Terms such as employee involvement and employee empowerment are applied to manufacturing management system in which all employees are encouraged and empowered to improve the functioning of all manufacturing activities. Of course, top management retains responsibility for the ultimate safety and efficiency of the workplace. However, it is a system where employees are given time to meet and jointly plan improvements with management.

An essential feature of this system is developing mutual trust. For this system to work, everyone must benefit. The rewards for such cooperation must be tangible, such as increased job satisfaction, employment security, and often a share of the increased profit.

NOTES: _____

⁴ Jerry Claunch and Philip Stang, "Setup Reduction; Saving Dollars With Common Sense", PT Publications, Inc., Palm Beach Gardens, Florida, 1990. This publication, especially chapters six through eight (PP 121-192) has comprehensive data on employee involvement techniques, internal Vs external methods and videotaping dieset activities.