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ECONOMICS AND MANAGEMENT ASPECTS OF DIES AND JIGS PRODUCTION[1]

by

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PREFACE

Why Dies & Jigs?

Since the beginning of time, man has constantly pursued the development of implements to assist him to help himself and to help others. Each new implement has resulted in a new stepping stone to raise his standard of living. No other single factor has perhaps done more to benefit mankind, in his efforts to avoid hunger and the hazards of the elements, from the ancient stone hoe to the present day computer, than the knowledge for a useful application of a tool of some type. Whether a simple pencil, a hammer, a chisel or a valuable timepiece, it became a useful tool of immeasurable assistance.

This paper will not review further those historical details in the development of useful tools. It will rather deal with the specifics which apply to Dies, Jigs, (Tools) and Fixtures, also their needs to assist an undeveloped country to develop productively. The word "Tools", generally will be used wherever possible in the interest of reducing word volume within this, Dies & Jigs, subject matter.

The reference generally will be directed toward those special Dies & Jigs, usually made for quantity lot production. In other cases, however, oftentimes a tool of this type is critically needed for only limited quantities. These variables have been kept in mind.

Management of Dies & Jigs:

The first order of business needed for a successful tool making organization is for management to assign a qualified leader for the activity. This is a function requiring an individual with a combination of theoretical knowledge also a thorough practical background. With this type of leadership, the organization should develop into a strong and efficient unit. Management must of course provide the location, the means for necessary equipment and the guidelines. A plan for a strong training unit should be a part of the program. Good tools can be made without serious difficulty, however skills are required also good equipment, well cared for and properly maintained. When the work of tool making can begin, then management must initiate a plan to train a number of good potential toolmakers, on a continuing basis for a specified period (4000-8000 hours). Another factor of good management for tool making, is its insistence upon suitable quality raw material tool steel. The making of this raw material is an intricate process, it contains many variables. But the end result of securing good quality tools, cannot be expected without such raw material. In this matter management must set its policy early, concerning the quality of tools it desires. There should be room in this decision for change, when and if change is deemed necessary. Raw material tool steel, both the high carbon content as well as the alloy (high speed) steels, can be a serious problem for the undeveloped country. Normal procedure would call for a one to three month stock pile of commonly used types. The undeveloped country, remote probably from a supplier, will need to look

Management of Dies & Jigs:

carefully into its supply requirements and perhaps operate on a six month, or longer lead time, for tool steel material. Considerable caution needs to be exercised along the lines of product variety, because of the raw material tool steel supply problems. There will be a tendency among members of the management and operating staff to select a general utility type of steel as a universal tool material. This can be done up to certain limits, beyond which this procedure can be a very expensive one. A good quality tool steel that is satisfactory for many purposes will be quite expensive, therefore moderation from management must be constantly exercised. A policy should be initiated to use only the right steel for the right tool, a value analysis policy, geared to the countries needs and to the supply problem. Most important a plan and procedure needs to be established, for a one year period. The plan and policy should be reviewed after six months, changes made in policy if needed and a further look at another year from that point. When possible a longer period should be considered to encompass two or even three years in advance, for establishing targets and projections. During the time that these reviews are being discussed and changes made where necessary, a second phase should review all costs with a view of initiating savings wherever possible, while maintaining tool quality and standards. A third phase for long range plans and periodic review is that of personnel training. The human element is one that must be constantly reviewed always with the objective of upgrading when warranted. The manpower and skill factor is a most critical one. It is critical to train, then to hold for productive needs and again to maintain reliable standards of operation and efficiency.

Management of Dies & Jigs:

A policy of research and improve, is one to be constantly stressed. A key individual should be designated and given responsibility to act where needed, to improve the policy as set by management. When a problem arises with finished tools, their quality or efficiency will be at once condemned. One with ability and background knowledge should be able to analyze the deficiency and decide where the fault lies. At that point the tool may need replacement, should it be determined to be defective by managements representative analyst. Some factors concerning tool problems which will need review and analysis are the following;

a. Design specifications
b. Methods and application specifications
c. Materials specifications
d. Metallographic inspection
e. Failure analysis (if failure occurs)
f. Precision Measurement of critical areas (includes geometric configuration)
g. Historical reports (at application)
h. Vibration analysis (at application)
i. Machine application review (at application)

Management of Dies & Jigs:

Wherever possible management should designate specific responsibility to specialized tool personnel, for the following;

a. Design and Engineering

b. Manufacture

c. Inspection and Materials

d. Care and Maintenance

e. Control, application & try-out

f. Set up and maintain a responsible analysis committee for review of all tool problems and failures.

The size of company may not warrant separate personnel for each of the above. Theoretically a well backgrounded mechanical or industrial engineer should possess the necessary qualifications to handle the above also most problems that may arise in a factory (or plant) which uses (tools), dies, jigs and fixtures. It is unfortunate, however, that often an engineer does not have the practical knowhow which is so essential for the proper design, application and care of tools. A well backgrounded superintendent, who may have served a toolmaker apprenticeship, can provide the knowhow to design and manufacture tools also provide the technical qualities needed for this important assignment. It should be emphasized that if more than one specialty is to be designated to one person he must be well qualified for each, under his responsibility. Satisfactory use, success or failure, in proper tooling, can "make or break", a well organized company. Proper training, both practical and theoretical are highly essential for successful tooling. The author has found the numerous specialty tool manufacturers, most helpful and cooperative to answer a request for information and assist with a particular problem. Many machine tool manufacturers, can also provide highly informative motion pictures, some with microscopic detail, many presented in slow motion, to allow a better understanding of the machine and tool actions, (both direct and indirect,) which are taking place while tools are performing.

The American Society of Tool and Manufacturing Engineers, (ASTME) 20501 Ford Road, Dearborn, Mich., 48128, also the American Society for Metals, (ASM) Metals Park, Ohio, 44073, are both excellent sources for technical educational materials, motion pictures, charts, standards data, and metallographic references.

Note: Several companies providing films of this type are listed in the appendix.

The need for both short and long range project plans in a new developing country cannot be overemphasized. There will be much data missing and ("shotgun" type guesstimates) estimates will be required. In every case they are to be kept on the conservative side. In this way less costly errors will at least be the result. The main objective is to have an actual plan outlined, on paper. A plan that can be discussed at every opportunity. One with which a bank or loan agency can review

Management of Dies & Jigs:

details. The plan must show a profit as well as fill a critical need for its purpose. It should also present a reasonable period of elapsed time, when the project can be fully paid and perhaps continue profitably, or be ready for expansion. At this point the economists and engineers with the statistical personnel, should review and add all pertinent material facts, relating to the project. Most undeveloped countries at lease those familiar to the author, all lack reliable and/or current statistics. The economics of a project should be carefully reviewed, not only to determine that it has marketability, but also assure its productivity. It has been the authors unhappy experience to find equipment still idle, after several years, due to lack of proper dies and tooling equipment. Even though the original project plan required several hundred thousands of dollars and was approved. Yet the small sum of ten thousand dollars could not later be raised for tools. As a result, the project remained completely idle for considerable additional time.

The Economy of Dies & Jigs:

When one is called upon to make an analysis with a decision to recommend specific tools to management, for manufacture or purchase, several important factors must be considered. Indeed these factors are principally concerned with materials, engineering and production. Each are related and each overlap the above divisions, considerations, such as following are needed;

a. Size of market for the product needing tools.*

b. Suitable raw material for tools, at a satisfactory cost. (This is a consideration of both economics and engineering and is usually determined by engineering).

c. Quantity of product needed per man-machine hour.*

d. Volume of product to be sold per year, (determined by market study).

e. Quantity of tools needed for necessary hourly production, * (determined by engineering).

f. Design, manufacture and accuracy of tools, as the needs are determined for satisfactory production and assembly.

The precision tool having a production tolerance of plus or minus .002 inch, should not be made for a plus or minus .010 inch, end product. A tool tolerance having plus or minus .006 to .007 inch, will be satisfactory and its cost will be substantially less that the more

* Valuable data concerning these evaluations can be found in Section 2, of the Tool Engineers Handbook.

The Economy of Dies & Jigs:

precise tool. Here the toolmaker and machine tools needed to make the less precise tool can both be less costly. The hourly rates for precision tool makers is considerably higher, than those for the less precise tool. Some raw materials will undoubtedly change with tool specifications, as the requirement loosens for a less precise tool. The main objective is to gear production to consumption or sales, at the most economical cost, then design the tool to assure suitable working precision for its production of the end product.

The possibility of a misfit during assembly of piece parts made with a particular die or jig must be avoided. It is not economical to attempt perfection in the tool, that would be only extremely costly. Tolerances for the product must be first known. It is then possible to establish a tool-working tolerance. When this is known, then the die or jig maker, will know what his toolmaking requirement really means.

In all cases the cost and engineering aspects must be considered jointly. A detailed estimate is a must to arrive at the assumed cost. The beginner particularly and those who cannot afford a time and financial loss for remaking tools should never try what is commonly known as a "shotgun" estimate. This practice is only for emergency or preliminary calculations. It should be attempted only by one with years of experience, in a variety of toolmaking. The newly developing country and the inexperienced are advised to avoid this type of estimate. The economist and the engineer should have available, or secure needed data from a reliable source and compute costs as follows;

The Economy of Dies & Jigs:

a. Suitable raw material cost.

b. Other materials cost (purchase or make) such as screws, bolts, bushings, pins, and die sets, etc.

c. Detailed estimate of hours to manufacture all "make", items, then compute hours to arrive at a total monetary cost for the complete, assembled and "tried-out" (actually used) tool.

As experience is gained and a reservoir of information accumulated, including actual costs from previous "make" tools, the estimating time will shorten, by making use of cost and hour knowledge gained through past experience. If possible a design, or good working sketch of the tool, will be required. Here there are many variables to be considered, such as the following;

a. What are production needs? (An expensive tool should not be made for only very limited production).

b. With what type of material will the tool be engaged?

c. With what cutting tools, speeds and feeds?

d. At what accuracy?

e. Will the operators using the tool be skilled or semi-skilled?

f. Can the tool be maintained at its home base or will it be necessary to send it elsewhere for repairs?

The Economy of Dies & Jigs:

When the above details can be considered along with any other pertinent factors that may be involved, such as sufficient power, light and handling facilities, then the tool is ready for engineering and manufacture. At this point and prior to actual making the design or sketch should be approved, by those responsible for its successful use. In this matter, differences can be settled and those concerned with production will be satisfied that their contribution has been provided.

Should it be desired to calculate by mathematical analysis, the economic tool costs. The following formula is applicable to a variety of tool types.

Example: (yearly costs assumed)

P = pieces manufactured, yearly

C = cost of die, jig, fixture (tools)

I = interest, % on investment

R = repairs, % allowed

T = taxes, % allowed

D = depreciation, % allowed

S = setup cost (yearly)

L = labor cost savings, per unit

O = overhead % applied, on labor saved

V = operating profit, over fixed costs

Y = years required to amortize, via earnings

<u>The Economy of Dies & Jigs:</u>

To simplify the values used are as follows;

L = 0.03	R = 10%
O = 50%	D = 50%
Each setup = $10	I+T+D+R = 70%
I = 6%	$Y = \frac{1}{D} = 2$ years
T = 4%	

The number of pieces required to pay the cost of a (tool), die, or jig, can be evaluated as follows:

$$P = \frac{C(I+T+D+R+S)}{L(1+0)}$$

If we desire to pay for the tool (estimated to cost $400.) on a single run the first year, then,

Y = 1

D = 100% and I+D+T+R = 120%

$$P = \frac{(400 \times 1.20) \text{ plus } 10}{0.045} = 10900$$

The economic investment in dies and jigs can be calculated thus:

$$C = \frac{PL(1+0)-S}{I+T+D+R}$$

$$C = \frac{(10900 \times 0.045)-10}{1.20} = \$400.$$

The Economy of Dies & Jigs:

If one should wish to estimate the time that is required to turn a shaft or drill a hole. A simple calculation may be made by the following formula:

T - time in minutes

L - length of cut (or depty of hole.)

F - feed, inches per revolution

RPM - revolutions per minute, then:

$$T = \frac{L}{(RPM)(F)}$$ thus

The foregoing illustration assumes that the tool (or tools) at least will produce the 10900 pieces. All additional beyond this tool estimate quantity, would then be included in the profit margin.

Tool Engineering for Dies & Jigs:

Websters dictionary defines "Tool Engineering", as that branch of engineering in industry, which has the function to plan the processes of manufacture, design and supply the dies, jigs and fixtures, patterns, molds and gages. To integrate the machinery and facilities required, for production of all products, at a minimum expenditure of materials, time and labor. The chief engineer, may also act as tool, product and plant engineer, in a small organization. Perhaps the manager may act in each of the above capacities, if he is capable and has sufficient time.

A tool may be classified as a device to permit economic and efficient manufacture of a number of similar parts. With such a device, interchangability became a reality. Tool design as the word implies, refers mainly to those production devices which can be identified as cutting tools, dies, jigs and fixtures, commonly used in the metalworking trades. A tool can be designed and engineered to encompass many functions. Such as improve operator skill and to reduce machine capability, thereby permitting a better product, utilizing lower grade machine operators and lower quality machine tool equipment, while preserving product quality. It should be born in mind however, that most tools, dies, jigs or fixtures, often require a gage. The gage assures a product that can be processed through assembly and will be satisfactory to the customer.

It can be said that nearly all tools, dies, jigs and fixtures may be classified into two general categories, (1). general purpose, (2). special purpose. An important phase of designing and building any

Tool Engineering for Dies & Jigs:

tool, is the selection and specification of its raw material. For without suitable chemical composition, the metallurgical qualities cannot be provided, which will assure a satisfactory working tool. Raw material tool steel may be a real problem particularly for the newly developing countries. Great care must be exercised to assure and secure only the most suitable of raw materials. It has been the authors unhappy experience, to learn while visiting several undeveloped countries, that little is generally known, about a tool steel after it leaves its original home base. The methods of marking and identity are poor and the many varieties of steel can be easily mixed, so that the toolmaker ultimately may receive a piece of steel for the necessary tool which is wholly unsatisfactory for its needs. The unfortunate result was to blame the heat treatment process at the tool making location. Such instances happen all too often, resulting in the complete loss of the desired tool and of course a monetary loss which is inestimable. A steel maker can and will guarantee his steel, within narrow tolerance specifications. His written guarantee must accompany the steel raw material, (carefully identified), all the way to the toolmakers workbench and a copy of the tool steels specifications should remain on file with the toolmaker. Only in this way can he apply his knowledge and assure a satisfactory tool ultimately. The next critical step is final finishing, grinding and assembly.

Tool Engineering for Dies & Jigs:

The possibility of a misfit during assembly of piece parts made with a particularly die or jig must be avoided. It is not economical to attempt perfection in the tool, that would be only extremely costly. Tolerances for the product must be first known. It is then possible to establish a tool working tolerance. When this is known, then the die or jig maker will know what his toolmaking requirement really means.

Indeed it has also been the authors unhappy experience to see several hundred, very difficult and expensive form cutting tools ruined because of incorrect grinding and grinding methods. Oftentimes tools of this type simply cannot be salvaged, thus the result is a complete loss, unnecessary and unfortunate. Specific heat treatment procedures will not be discussed in this paper, since such procedures are voluminous and easily available in published form also may be obtained from the steel maker, who is always glad to advise the user, on required procedures It should perhaps be mentioned that the so called carbon tool steels and the more recently developed, (1890s) High speed steels, both of which are excellent steels for tools used for specific purposes, yet the heat treatment also the narrow temperature hardening range for each is entirely different. Each type of steel, requiring special knowledge and special furnace equipment. Many advantages are available to the undeveloped country, by making full use of the technique known as "hard-facing", it is simple for one having limited knowledge of tooling. It requires no intricate heat treatment. The method is best adapted for

Tool Engineering for Dies & Jigs:

welding a bead, or brazing a suitable strip, of the various cobalt alloys, to the edges, or wear areas of the tool. The base quality of the tool can be of lower quality and made more tough. It will be less costly originally also when repair or reconditioning is needed. There will be little danger of ruining the temper or lowering hardness. Some of the advantages of these cobalt alloys are as follows:

a. Abrasion resistance
b. Corrosion resistance
c. Friction reduction
d. Further heat treating not required
e. Hard facing to Rockwell 65 (or higher if the carbides can be used)
f. High heat resistance, without loss of hardness quality.
g. High impact resistance.
h. Operation at substantially higher speeds.
i. Wear resistant.

A word should be added, that several disadvantages do exist in hard facing materials, some of these are as follows:

a. Not machinable
b. Resistance to grinding
c. Low coefficient of expansion
d. Less resistant to impact vs: carbon tool and high speed steel (HSS)

At the first thought of making use of a die or jig we should ask ourselves several questions. The following are some examples:

Tool Engineering for Dies & Jigs:

a. What product material?

b. What die or jig material?

c. Can it be held securely?

d. What is the configuration?

e. What tolerance is needed?

f. What quantities are involved?

g. Could the part be made another way?

h. At what raw materials cost?

i. Which method provides best use of raw material?

j. Can changes be expected in design?

k. What tooling time is available?

l. How many pieces are needed to amortize tool costs?

m. Can production time be met?

n. Which tool or method provides the greatest savings in time, labor and materials?

o. What gaging is needed?

Should it be found that a suitable machine tool is not available to satisfactorily utilize the die or jig, then perhaps a new machine tool can be considered. Production quantities in this choice must be high, or similar products need to be available for manufacture. The operation sequence should be planned to take full advantage of all previously machined surfaces. A saw cut, a cast pad, a web, a drilled or punched hole, a bend, or squared edge will be sufficient.

Tool Engineering for Dies & Jigs:

If the assembly configuration of the piece part is known, then consideration for critical clearance at assembly should be given and piece part locating surfaces should be determined with the clearance factor in mind. Where there may be critical assembly locating holes, perhaps the tool can be designed and made to first pierce, or drill the holes, at least those which are critical and thus use for locating, further bending or fabrication as necessary.

The selection of a press with ample capacity and in good working condition is always important. It goes without saying that without satisfactory machine and tool maintenance, endless trouble can be expected with the die or jig production. If press capacity is low and/or the ram is slightly misaligned, a deflection of the frame under the cutting, (forming,) load will cause premature wear of the edges of the die. Play in the bearings of the press, will result in a slight overtravel of the punch and can further result in metal to metal contact of the punch and die edges. When this happens die life will be extremely short. The machine should be stopped and necessary repairs made before proceeding further to operate the tool. If repairs are not made and further operation is permitted, it can be disasterous to the tool and perhaps also to the machine.

Production Vs: Non Production Tools:

Perhaps a further word on tool materials is appropriate at this point, particularly relating to the cutting and wear types of tools. The carbide and ceramic types have a definite place in certain application where ridgidity can be had and technical knowledge and equipment is available to use them. They cannot be applied just anywhere and the hazards of their application are many. Great care and proper technical preparation is advised for all, especially the inexperienced, before applying these tools. Their value is undeniable for a special type of application, particularly on a high production run. The most suitable conditions must however be adapted, with careful analysis by a tool engineer, or experienced technical tool specialist. Whenever applications are considered for the carbide or ceramic tools, the high cobalt alloys should also be evaluated, since they are somewhat more tough and withstand much more shock, although operating speeds are higher than the carbon and high speed steel tools, they are not as high as the speeds for carbide and ceramic. Should the application be one of wear only, then the ceramics and carbides are unexcelled. It must be reiterated that special grinding and working equipment are necessary, as well as special technological analysis of the planned application.

Below are some tool materials available for non-cutting purposes, such as dies, jigs, fixtures, forms for forming of light metal, and molds for plastics, etc.

Production Vs: Non Production Tools:

a. Epoxy Resin compound

b. Kirksite (Casting) compound

c. Hardwood

d. Aluminum

e. Cast Iron

f. Steel (cast and/or fabricated)

These materials may be especially useful for small lot tooling. They can be extensively used by new companies, the undeveloped countries have much to gain by making full use of the Epoxy Resins particularly. In some types of jigs and the drawing and forming dies, tooling costs have been reduced as much as 50 to 90 percent. Mainly this savings is brought about by the difference in additional machining time, required for the hard tool steel materials. The Epoxy tool can be made in hours, or perhaps days, compared to the weeks, or months, required for the tool steel die. The Epoxy die can be easily repaired or modified, whereas the tool steels would require extensive time and perhaps complete remaking. It must be recognized however, that the Epoxy tool may not produce the large quantities, while retaining its hardness, shape or form, as compared to the tool steel.

The Epoxy material, in plastic form, is poured into a prepared mold (may be made of plaster) usually with a metal back-up nest, which has been adapted to the desired press for use. The Epoxy cures at room temperature into a hard, tough faced surface, well bonded to the base

Production Vs: Non Production Tools:

metal. If it is desired, the strength and toughness can be further increased, by the addition of a fibreglass laminate sheet, set directly into the plastic (Epoxy) mixture. Indeed this type of die or jig design can be made into configurations, not possible with the tool steel. The original plaster (mold) masters, can be retained and a new male or female die can be repoured at any time. A number of applications of this type die construction have been in use for months, in the refrigerator and automotive parts industries. Production lots of well over one hundred thousand pieces have been realized without tool changes.

Tools for the Undeveloped Country.

One of the most valuable assets any country can possess is that of skilled manpower, those having the skill to recognize the qualities and limitations of the tool steels and other raw materials. To further possess the ability to turn it into useful and efficient tools, this training can be, indeed one of the most rewarding factors, to raise the moral and living standards of a people. The skill becomes another tool, perhaps one of the most valuable available to mankind. The development of skilled manpower must expand continuously. It is the authors emphatic opinion that skills training, within the undeveloped countries, are extremely essential and should receive multitudinous expansion.

Without the services of resourceful craftsmen, the making of dies, jigs, fixtures and other tools, is not advised. The manager, the engineer, economist, superintendent, or other supervision will all know, in a general way at least, what type of tool will be most useful. The observations of the author, after more than 40 years of experience, is that few in this group, even in the developed countries, will have sufficient "know-how" in the art of toolmaking, to impart specific instruction for making tools, to one who may have very limited background. With this fact recognized the new activity may proceed to develop other needs for manufacture, or semi-manufacture, of the desired tools. The following check list (minimum) may be useful to a new developing country, or an inexperienced facility.

Tools for the Undeveloped Country:

a. Manpower

b. Skills available:

1. Engineers (mech or Ind.)
2. Tool and die designers
3. Tool and die makers
4. Machinists (metalworking)
5. Machine operators
6. Apprentices (for 1 thru 5 above)
7. Schools (for 1 thru 6 above)

c. Machine Tools (one each is minimum suggested per establishment) at minimum cost of about $45000. (U.S. dollars)

1. Lathe, with tooling
2. Mill, with tooling
3. Drill, with tooling
4. Jig borer, with tooling
5. Grinders, with tooling
   - plain tool, (HSS) with tooling
   - carbide and ceramic, with tooling
6. Drop hammer, with tooling
7. Die making and miscellaneous hand tools.

d. Furnace equipment (one each is minimum suggested per establishment) at min. cost of about $12000. (U.S. dollars)

1. Heating (high temp., with controls for hardening)
2. Heating (low temp., with controls for drawing)
3. Heating (salt bath solution) with controls (for hardening H.S.S.)

<u>Tools for the Undeveloped Country:</u>

Measuring equipment will be required in addition to the skills, machines and furnace equipment. A shadowgraph is needed along with its charts, arbors and accessory tools. The usual size blocks, verniers, micrometers, hardness testers, standards, charts and graphs. The cost for this equipment, considering a minimum operation would be about $18000. to $20000., (U.S. dollars.)

The above suggestive form is simply offered as an example. Each situation should be analyzed separately for its own merits.

Care, Use and Maintenance of Valuable Tools:

Most tools are expendable, that is, they either wear out by normal use, or simply become obsolete due to change of product, design, or methods of fabrication or use. A tool may however be immediately ruined, due to misuse or misapplication. It can also be ruined through neglect, or care during idle periods. Climatic conditions are important to consider and dry storage, in a wax or plastic encasement is probably the best means of preserving the tool and its usefulness. Where steel bushings, (jig), banking blocks, landing pads, locating pins or other critical points exist, they need to be protected. The cutting edges of steel tools, reamer flutes, plug gages etc. are similarly to be carefully preserved. Aside from preserving tools carefully while idle they of course need care continually while in use. Working joints and locating pins and screws should be kept tight, well oiled, and not abused by hammering, with wrenches or other tools. In the case of a cutting die, its edges must be sharp and surfaces smooth and clear. They must not be permitted to operate after becoming dull. When sharpening is being accomplished proper clearance and rake angles must be maintained at all times, if the life of the tool is to be preserved. Again proper training and skills are most essential for satisfactory tool care and maintenance. It is the responsibility of management to see that capable personnel are assigned to this critical activity.

All special tools, dies, jigs, fixtures or gages must carry a tool identification number. This should be stamped upon a non-working surface, clearly identifiable with the stamping, or perhaps etching, if the tool has been hardened, a record and locator card needs to be completed and filed, for future reference when the tool is needed. All delicate tools should be further boxed, crated or plastic coated, whenever placed in storage.

The Education Needs to Make Tools, Dies, Jigs and Fixtures:

The toolmaking art is probably as old as the oldest industry, indeed industry could not exist without toolmakers and toolmaking. The present day precision of our instruments, time pieces, manufacturing and transportation equipment would not be what it is, were it not for good tool design, making and application. The present day craftsmen have had to devote years at study and high school, with additional years for practice and further specialized study. It is true that many toolmakers and other craftsmen have been trained to pursue their chosen field of activity, yet fail to fulfill the necessary talents to make good craftsmen. But their training alone has developed a feeling of self assurance. They can do many things with their hands and use their minds and hands together for some other activity. In short their training has made them much more useful citizens. Many have started a business for themselves, perhaps in an entirely different activity, but their training has instilled a certain self confidence within themselves and provided a means of self help. The author does not imply that everyone should be trained as toolmakers. It is, however his emphatic opinion that thousands of our young people in all undeveloped areas, should receive some type of craft training, one to their choice is preferable. Good practical craft training could provide a large percentage of initiative toward self help, as they make their way in life, while effectively helping their respective country to raise its living standard. Toolmaking is among the first order, of the highly specialized, it is a most important one for any country, state, city, community or locality.

The Education Needs to Make Tools, Dies, Jigs and Fixtures:

In several countries there are many companies, requiring the services of toolmakers, who will provide an in-training agreement with the individual, whereby the necessary practice can be accomplished, at a minimum salary, while high school or technical education is combined. This is an excellent means of developing real good toolmakers. The practice and theory education, are usually carried out at alternating periods, of two weeks to one month each. At the end of four years, or minimum 4000 man hours of practice, the learner should be capable of building a suitable die or jig. He will have had sufficient machine and bench practice to work out the tool details to specifications, with little or no supervision.

If the learner is not immediately employed by industry, he will find his own way, perhaps into a useful business of his own, the following are some examples of low cost (garage) operations.

Making of simple hand tools, metal or other fabrication.

Saw and hand tool sharpening and repair.

Clock repair.

Automobile accessory specialist.

Agricultural and construction machinery repairs.

Household appliance repairs.

The Education Needs to Make Tools, Dies, Jigs & Fixtures:

When industry has need for the trained skills, they are available and ready. Skills training will never be forgotten by those who make use of its benefits. Its blanket has forever kept the author warm. Even though the high level of university learning has been extremely useful. The early years of toolmaker training have been perhaps much more useful, in every day understanding of problems, of the industrial age in which we work and live.

The making of dies and jigs particularly, calls for an understanding of machine tool capability also fits and limits of tolerance, required for interchangability, for production or thousands of useful places in industry.

Appendix:

Some sources of valuable motion pictures relating to tools, their use and raw materials.

American Society for Metals
Metals Park,
Ohio, 44073

American Society of Tool and Manufacturing Engineers
20501 Ford Road
Dearborn, Michigan, 48128

Carmet Division
Allegheny Ludlum Steel Corp.
1100 Mandoline
Madison Heights
Michigan, 48071

Cincinnati Milling Machine Co.
Cincinnati, Ohio, 45209

Appendix:

General Electric
Metallurgical Products Div.,
Detroit, Michigan

Kearney and Trecker Corp.
Milwaukee, Wisconsin

Kennametal Inc.
Latrobe, Pennsylvania, 15650

Monarch Machine Tool Co.
Monarch, Ohio

United States Steel Co.
Box 86
Pittsburgh, Pennsylvania, 15230

Warner and Swasey Co.
Cleveland, Ohio

Appendix:

Most US Embassies, located in the capital cities of many countries carry a stock of technical films that may be useful.

Those seeking details concerning the manufacture or use of dies, jigs, fixtures, or tools in general, are invited to review the following technical reference material:

a. Tool Engineers Handbook, published by:
The American Society of Tool & Manufacturing Engineers
20501 Ford Road,
Dearborn, Michigan, 48128

b. Metals Handbook, (b, c, & d) published by:
The American Society for Metals
Metals Park, Ohio, 44073

c. Tool Steels

d. Engineering Alloys

e. Die Design Handbook, published by:
McGraw Hill Book Co.
330 West 42nd Street
New York City

f. Jig & Fixture Design

Appendix:

g. Die Methods

(f & g) published by:

The Industrial Press

93 Worth Street

New York, 10013

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