QUICK DIE CHANGE IN HAMMERS

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Introduction

In the late 1980's there appeared in many trade journals articles dealing with Just-in-Time manufacturing and many business men began looking seriously at Japanese management philosophies. Their purpose was to streamline American businesses and transform them into World Class manufacturing operations in order to compete with Far East and European competitors. One topic that was a logical outgrowth of these writings and philosophical changes was Quick Die Change. We have come to recognize the ultimate manifestation of this as the Single Minute Exchange of Dies.

This paper will examine how to adopt operating procedures to conform to the Quick Die Change philosophy. The word "philosophy" is used because, Quick Die Change is as much an attitude as it is a technology; an attitude that calls for extending thought beyond that which is comfortable and familiar to new concepts and adaptations of existing technologies to solve today's problems. The course of change is not an easy or inexpensive one, but one that can bear rich rewards for those who are able to successfully implement some or all of its parts.

Background

Chambersburg Equipment Company and its predecessor have been engaged in the manufacture of forging hammers for over a century. We have built more than 12000 forging machines over this period and have traditionally held a leadership role in the industry. We have done this through equipment development, published data sheets and service digests, and through active participation in organizations such as FIA and SME where we can speak directly to users of our equipment. Forgers have asked what can be done to attain Quick Die Change in Hammers. The subject has been studied for some time to determine if there is a technological solution to the problem that was marketable. Evaluations of various die holding and adjusting methods have failed to uncover any truly successful alternatives. From this it has been concluded that proper application of existing technology is the best approach today and into the foreseeable future. This is true for a number of reasons that shall be explained in the following paragraphs.

Hammers have the capacity to develop a tremendous amount of force in any given stroke of the ram. It is common for a 4000 pound hammer to develop 2000 tons of force on a relatively thin forging made from bar. It is also common to use the same hammer to produce a wheel or gear blank forging from a round cornered square billet. The forgings will be produced with nearly equal efficiency. The cost of the hammer will be considerably less that a comparable 2000 or 2500 ton press to make the same range of forgings. Further, the hammer will make the thin forging more efficiently and with better material flow because of less temperature loss. The hammer is therefore a more versatile piece of equipment because it can do a wider range of work than a mechanical, hydraulic, or even a screw press. It is therefore well suited to jobbing type work in a commercial forge shop or for use in captive shops where the product range is primarily "force intensive". This results in a wider variety of die designs being used in hammers than are commonly found in presses. This variety also encourages transfers of customer owned tooling between shops as sources of supply change. The hammer's versatility encourages users to accept a wide variety of production jobs.

Traditional American hammer design dictates that the hammer structure should have a certain amount of flexibility to absorb the loads of the forging operation. This flexible construction is reflected in the number of machine joints held together by springs and studs. Figure 1 shows this type of construction in a modern forging hammer design. In this design, the side frames are allowed to move vertically on each blow of the hammer. When eccentric blows are struck, the ram impacts against the side frame. The frame is allowed to move slightly to the side to absorb the impact. The movements within the structure cause the surfaces to wear. Users understand and accept that eventually, the original hammer alignment is lost and must be renewed by remachining or refitting of the wear plates provided for the purpose.

Most hammers are also adjustable for die alignment. Figure 1 shows Frame Adjusting Wedges used to adjust the hammer upperworks left to right to align the dies. Alignment adjustments are necessitated due to wear and machining inaccuracies. Further, dies are always designed to use a dowel that locates the dies in the front to back direction. Dowels are often shimmed as a means of adjustment to accommodate wear or machining inaccuracies. Users have become comfortable with inaccuracies and demand adjustability in their hammers.

It is therefore important to recognize three important general hammer characteristics before we can begin to understand how dies can be changed quickly. Hammers are versatile, they are flexible, and they are adjustable. It is for precisely these same reasons that quick die change in hammers has been difficult to accomplish. It must be remembered that in spite of the difficulty, the technology needed to accomplish quick change exists in our forge shops today. The forger simply must be willing to make the investment in the resources to make it successful. The remainder of this paper will develop the ideas and offer solutions to accomplish quick die change.

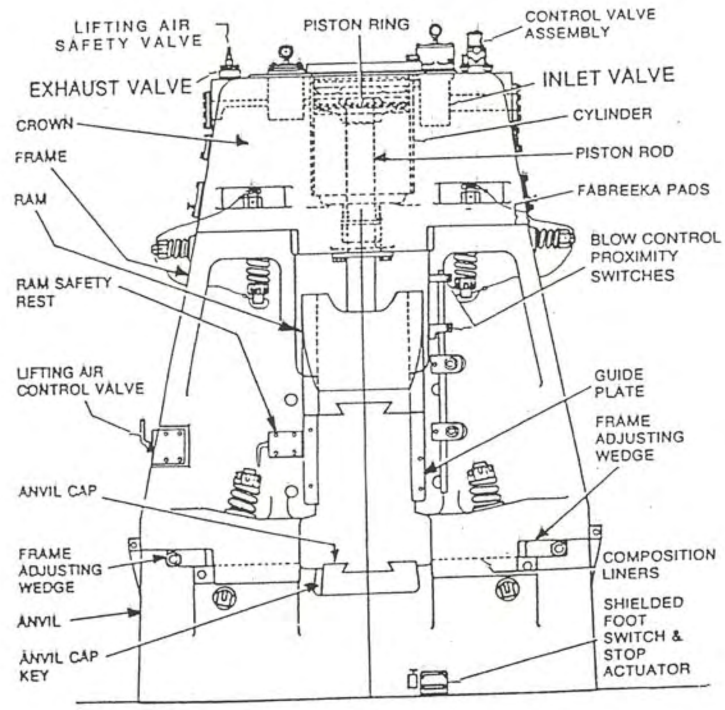


FIGURE 1

TYPICAL HAMMER ARRANGEMENT

Definition of Quick Die Change

Before we can define what a Quick Die Change is, we must understand some of the factors that drive us to achieve it. A die change in the forging environment can be defined as all of the work necessary to change from the production of one part to another. The time for this change is measured starting from the moment the last good forging from the first run is completed until the first acceptable forging of the second run is produced. Just-in-Time manufacturing demands smaller production quantities to meet customer schedules which means more set-ups are required per day or week than were necessary even a few years ago. More set-ups usually mean more non-productive time. Modern management must view non-productive time as lost revenue and lost profits and must seek to minimize this lost time if they wish to remain competitive. There are also ever greater pressures to produce quality parts at a competitive cost per piece.

Quick Die Change therefore is the changeover of the forging cell from one set-up to another that minimizes non-productive time and is able to produce quality parts economically.

Process Considerations

Forging is a process because it involves a series of steps to produce a product. There are unique attributes in each step in the process that effect job change over. Therefore, Quick Die Change, as defined above, is not limited to just the hammer tooling but includes other equipment as well. A discussion of these other pieces of equipment is beyond the scope of this paper but the other process steps are listed here for the reader's own assessment.

- Bar shear requires adjustment for cut length and stock size.
- Heating equipment (induction or electric resistance) requires adjustment for stock length and diameter.[1]
- Forging dies must be removed and new dies preheated, installed, aligned and proven.
- Trim tooling must be removed and new tooling installed.[2]
- Coining tools must be removed and new tools installed.
- Conveyors and material handing equipment must be changed.
- Where appropriate, inspection equipment and procedures must be changed to suit a new job.

As indicated above, change over time is critical to Quick Die Change. Accordingly, it is appropriate to focus on the time issue in the process context. There are those who advocate Single Minute Exchange of Dies (SMED). This should be viewed as a goal, and although it may not be attainable today, perhaps some time in the future it may be.

There are forge shops who are comfortable with die change times of three hours (180 minutes) or more. To them SMED is nonsense and unimaginable. They prefer to think that a 50% improvement is great. Regardless of a forgers current status, the objective should be to set some attainable goal for the forge shop to work toward. A twenty (20) minute die change is achievable and is practiced by some shops today. There may be a desire to extend the goal to ten (10) minutes or even five (5). Once set, the task is to begin looking for those controllable factors that will enable the goal to be achieved.

Tool Design

The design of the forging tools is seldom thought of as a means of quick change nor is quick change considered in most cases when the dies are designed. As a result, dies are mostly designed according to traditional methods and using conventional wisdom. This may not be true of the impression design, which is frequently more scientific, but is certainly true of die block design in the vast majority of cases. Seven areas come to mind as we consider tool design for Quick Die Change. These will be discussed in the following paragraphs.

Engineering The engineering function is most often thought of as the design of the impressions for proper material flow and greatest productivity. There are reasonably well understood rules and techniques for this phase of die design, a detailed discussion of which is beyond the scope of this paper. The designer must bear in mind however, that his job is to design a die which can produce acceptable forgings the first time; that is, without polishing, grinding, welding, or resinking after the dies are in the hammer. It should be obvious that even the quickest die change will be useless if the dies cannot

[1] Ajax-TOCCO Magnethermic or other induction heating company can provide further information.
[2] Forging Developments Inc. provides QTC for presses, trim presses and coining presses.

produce an acceptable forging just as quickly. Each interruption to polish the die, grind some detail, weld some flaw, or remove the die for complete rework adds to the change time and wastes production time.

The designer's responsibility is therefore greater than it had been previously for he is burdened with doing the job right the first time. The discipline of careful record keeping of job successes and failures, thoughtful consideration of reasons for failure and success, diligent documentation of each job, and seeking to continuously improve are all needed to achieve the goal of quick change tooling.

The designer's job is not complete with the impression design only. He must also estimate the stock size. The wrong stock size, if too small, will result in either scrap parts or lost time waiting for the proper material to arrive. Whatever the case, there is a waste of productive time and money. If the stock is too large, die wear and scrap costs will increase due to excess material being discarded in the form of flash. Costs will again increase and the advantages of Quick Die Change may be lost through inefficiency.

The designer must understand the forging process and the concept of progressive deformation. Hammer dies generally require more than one blow per impression. The ability to estimate the number of blows required is critical to getting a job running quickly. There is software available to accomplish this or the designer can make the required calculations by hand. In either case, it is possible to determine the blow program prior to the start of forging. Some refinement may be required but this will be minimal in most cases.

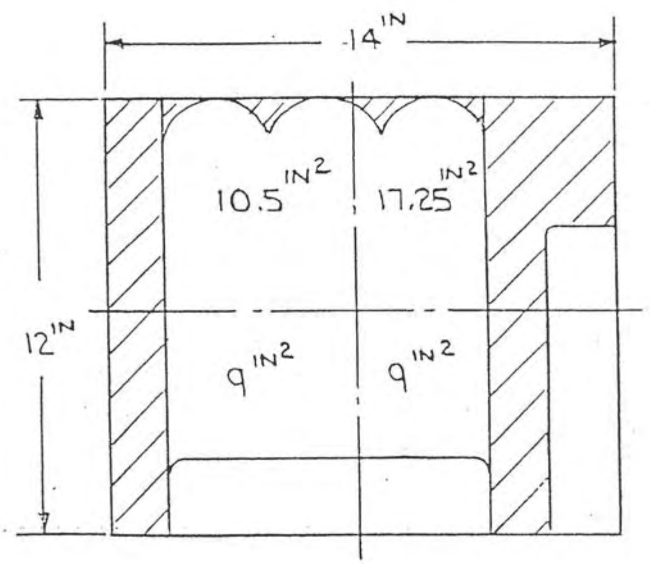
Die Manufacture It seems too obvious to mention that the dies must be manufactured with precision. Die impressions usually receive the greatest attention. Here sinking tolerances of +/- .002" or less are common. However, equal precision must be observed in locating the impressions in the top and bottom dies. It is therefore essential that the impressions be precisely located from the front and side match edges such that when the dies are placed face to face and with the match edges aligned exactly, the die impressions are correctly matched front to back and left to right. If they are not, this is the time to determine the degree of mismatch and mark the tooling accordingly. This practice will avoid trial and error set-up procedures when the dies are set into the hammer. It also means more precision in the die room before the dies ever reach the forge shop.

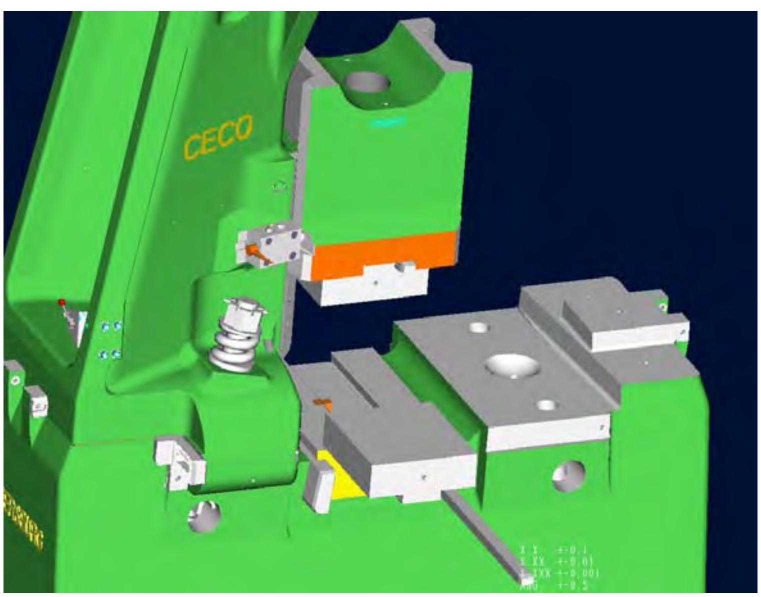
Die Bock Size The observance of minimum die bearing and striking areas is critical to achieving success at quick die change. This factor is not so obvious, for die sizes frequently change to suit the job being produced. Die designers may determine the size of their dies blocks using different guidelines. Old dies may even be used to make a new set. All of this is counter to the fundamental concept of standardization of dies sizes if Quick Die Change is to be accomplished.

Forge shops may argue that they must have different size dies because the customer sometimes provides the tooling or the tooling was acquired from another company who lost the business. Without properly sized and standardized dies however, Quick Die Change will never become a reality. This is attributable in some measure to failure to observe minimum die bearing and striking areas.

Die bearing area is defined as that area of the die in contact with either the ram or anvil cap of the hammer. This area must support the loads generated during the forging process. The bearing area must be sufficiently large to resist deformation or penetration of the hammer components. Table I of Chambersburg Equipment Company's Die Data Sheet no. DD-2 attached to this paper gives a table listing the minimum die bearing and striking areas for several classes of forging hammers. Observance of minimum die bearing areas minimizes or prevents penetration of the dies into the mating hammer components. Thus, when the dies are changed, they too will bear on sufficient area to resist deformation and assure proper alignment. More importantly, standardization assures that the dies always bear on the same surfaces. Thus, adequate bearing area coupled with standard die sizes will result in a common footprint for all of the dies in a shop and greatly extend the life of the hammer ram and anvil cap before remachining is needed.

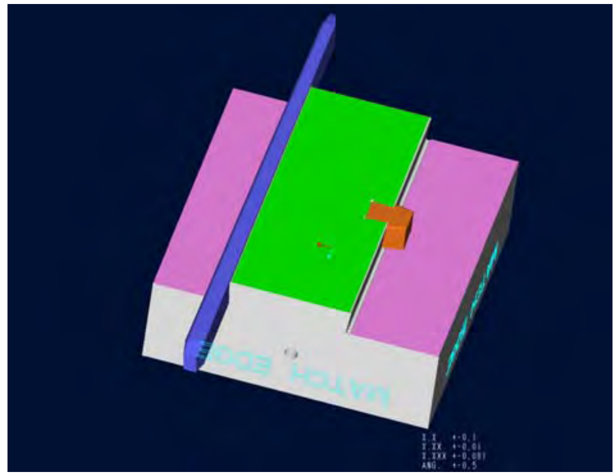
Die striking area is defined as that area of the die faces that contact each other during a die-to-die blow. These are the surfaces that determine the final thickness of the forging produced. Their longevity ultimately determines whether the dies are producing quality parts or not. Adequate area will resist deformation and prolong die life. Besides being adequate, that area must properly distribute over the die face; that is, equally distributed over the four quadrants of the die as shown at the right. This area, along with the area for impressions, flash, and gutters will usually determine the size of the die block used in the hammer. It should be pointed out that all flash forming impressions must be flashed and guttered to assure maximum die wear, proper metal flow, and adequate safety from flying flash.





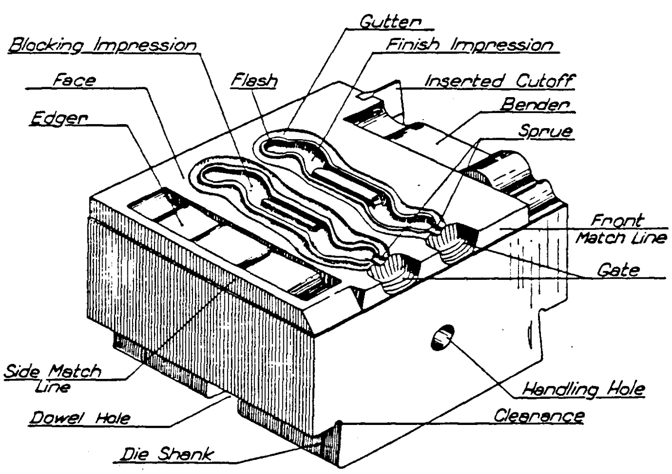
Shank Design

Forging hammer dies are invariably designed with a "dovetail" shank for attaching to the ram and anvil cap by means of a tapered key as shown. Shank designs are almost varied as forge shops themselves; a carryover from the days when shops made customer owned dies to suit their own hammers so that it was difficult to move the job to a competitor. The details of width, height or angles has little to do with quick change. However die bearing and fits are critical. Ideally, the dies should bear on both the shank and the wings of the die. This, however, is rarely found in practice; the die shank is intentionally made larger than the depth of the notch into which it fits so that there is clearance between the overhanging portion of the die and the ram or anvil cap. This clearance must be kept as small as practical, usually .005” or less. Larger clearances will result in premature die shank breakage and shank or notch wear. In addition, where there is only shank bearing, the shank must be equal to or greater than the minimum die bearing area (shaded green). Failing to observe these minimum areas will result in local deformation of the hammer components. This deformation will produce irregular surfaces to which other dies must mate.

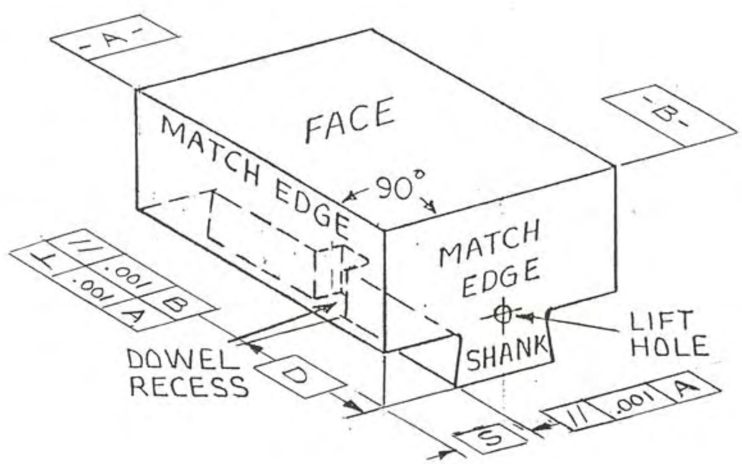


The solution to this problem is to standardize on dies size and establish three point bearing as the norm rather that the exception. This will have the side benefit of prolonging the life of hammer ram and anvil cap.

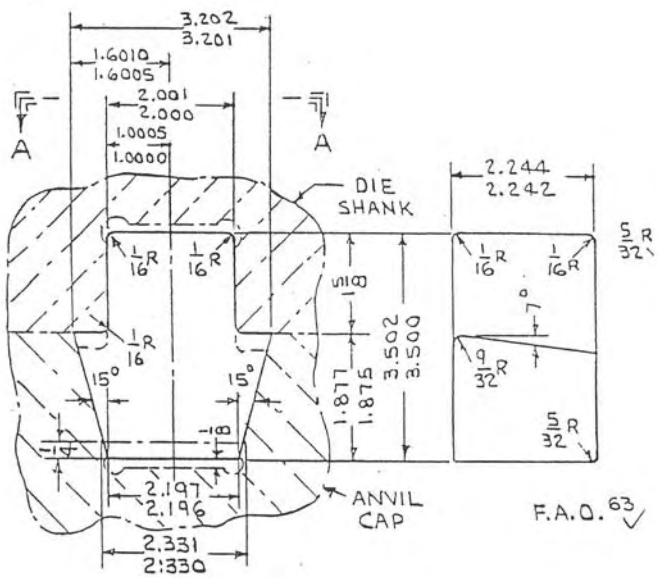
The die shank must also be machined parallel to the match edge of the die within +/-.001” as shown at the left. When the notches are properly machined and aligned, this precision machining of the die shank will result in a quicker and more accurate set-up that requires no twisting for alignment of the impressions.



Dowels Dowels are used to secure the dies in a front to back direction. They locate the die in relation to the hammer centerline and in relation to the opposite die. It is therefore critical to locate the dowel pocket from the match edge within +/-.002” or less. A typical keystone dowel is shown below.



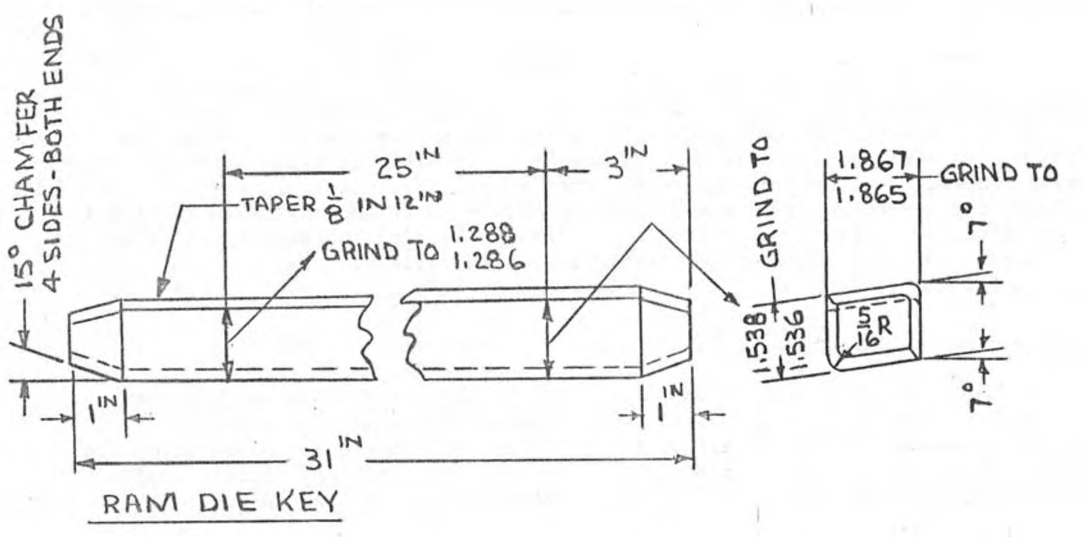
The dowel must also precisely fit the ram and anvil cap. A drive fit into the die shank is recommended. The use of shims, although common, should be managed rather than left to haphazard use. The best practice is to avoid shims altogether.



Dowel slots and the dowels themselves should be standardized. Variations will result in confusion and fitting problems that consume time during die setting.

Dowels must be kept with the die they are used with, especially in cases where some variation exists in the old tooling. This avoids searching for the proper dowel when setting the dies. It also allows prefitting of the dowel into the die before installation.

Keys Die Keys are the critical holding component in securing the die and keeping it in place. The use of keys for this purpose dates back almost 150 years and, in the intervening years, no successful substitute has been found for hammers. The key is designed to provide a preloaded joint that is held together by friction and pressure. This preloading requires excellent fit between the key and the mating die and hammer component surfaces. Therefore, the surfaces must be flat and free from debris when assembled. Tapers must be exact or the key will not hold or may mot be able to be easily removed.



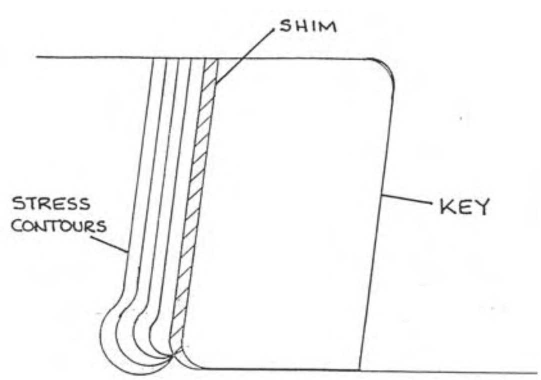
Die key angles must be machined exactly. A key, as shown above, with a 7° angle means exactly that. A tolerance of more than a minute of arc will result in localized contact that will prevent the key from holding properly or may create excessive loads on the notch surfaces of the hammer. A jig should be used to make and check the angles to be certain that they are correct.

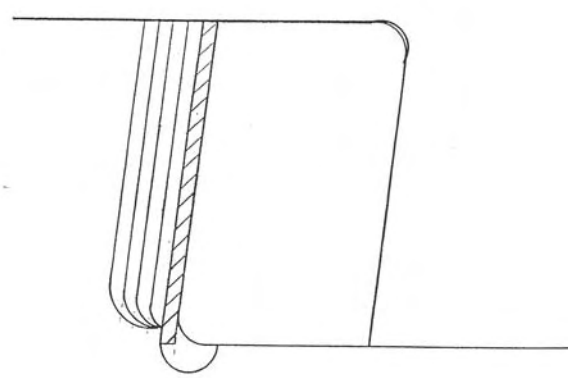
Die key taper is likewise critical. It is the characteristic of the key that enables it to generate the necessary mechanical advantage to create the contact pressures needed to hold the dies. Similar to the tapered shank of an industrial drill, the taper must be self-locking and engagement must be able to transmit the working loads. The ideal taper for most applications is 1/8” (.124/.126) per foot of key length. This taper must be precisely ground as must the matching surface of the ram or anvil cap. If the taper is to vary, it should be such that the small end of the taper touches first. However, in no case should the key and notch tapers differ by more than about .001” per foot. Hand fitting, as commonly practiced today must be replaced by precision machining of the key and its mating surface. A strict maintenance regimen is required to keep the hammer’s surface in good condition to avoid the time required for fitting the keys.

Shims Shim should be considered a “four letter word” in the forge shop and their use discouraged. It is a “Band-Aid” solution to improper machining or maintenance practice. This “Band-Aid” is encouraged by management practices that demand production at all cost without regard to keeping the equipment in good condition.

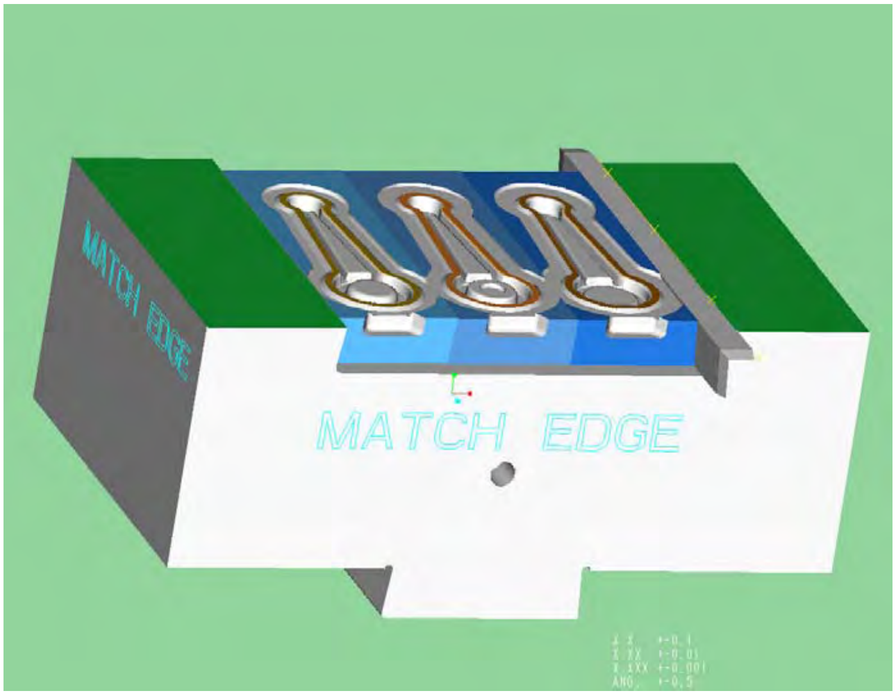
Twist shims will not be required if the dies and hammer components are properly machined and maintained. As described above, shanks and notches that conform to standard dimensions and dies that are sunk in relation to the match edges will not require shims.

Shims to move the die due to remachining of the hammer components or the die shanks can also cause the problems. The figure below shows how the load distribution of the key is changed by shims. The stress concentration caused by the shim can result in premature die failure or damage to the mating surfaces. A surface this destroyed by a single instance of shim use will effect quick die change until the damaged surface can be remachined. Shims also create a safety hazard should they break and fly out of the hammer.

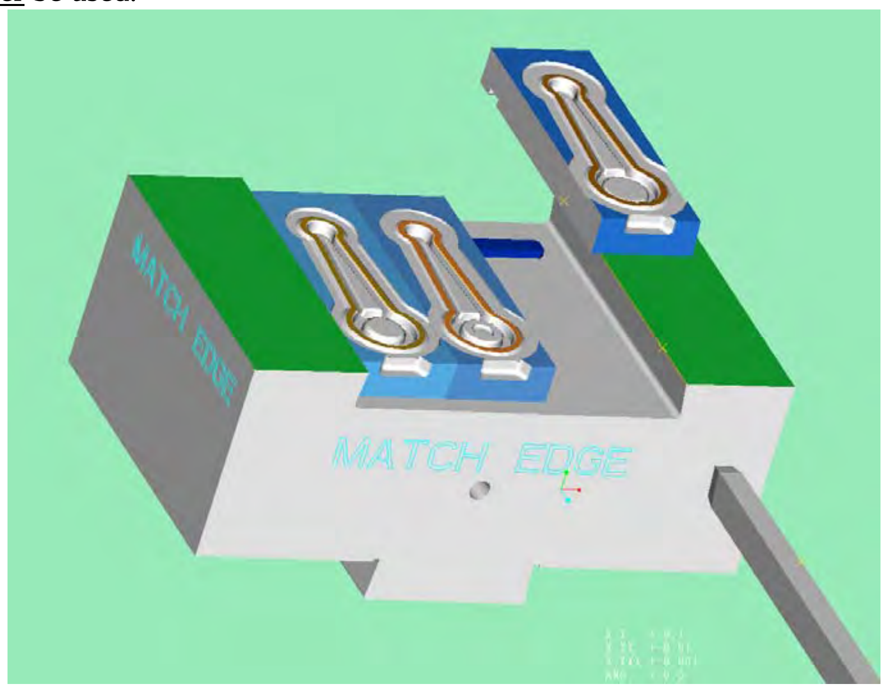




Die Inserts Inserted dies are sometimes used in hammers. In this case, quick die change involves only one or two die impressions, each of which is contained in a single piece of die steel. Keys and dowels are still used, albeit smaller versions of each. Precise machining of each piece is just as critical as with a complete die. The difficulty is in matching the inserts top to bottom. Hammer die inserts are usually stacked side to side. Left to right location is therefore governed by the angular surfaces adjoining one another. Any variation in tolerances of the inserts can result in mismatch that is difficult to correct. Needless to say, standardization is critical. The Figures illustrates typical construction. In order for quick die change to be practical, the holder for the inserts must be as well maintained as the hammer, that is, the surfaces must be flat and parallel, all angles must be exactly right, and tapers must be properly machined. Shims should <u>never</u> be used.



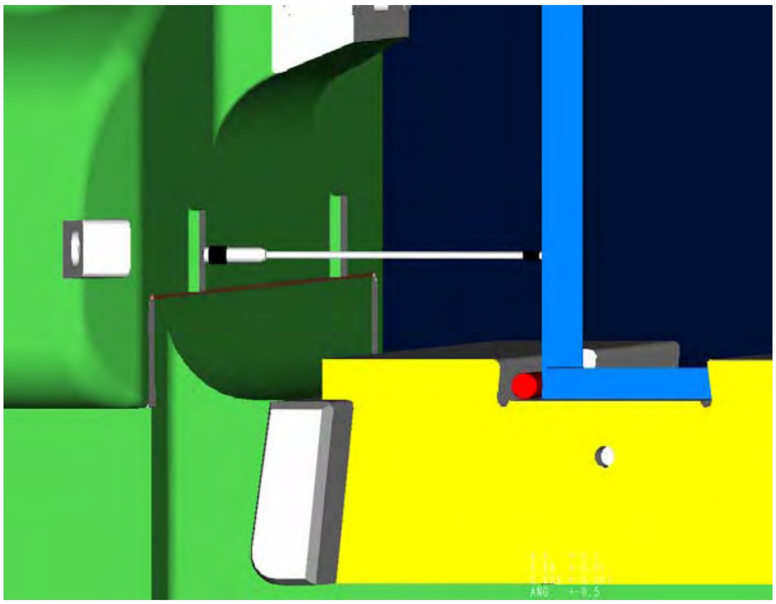
Striking faces should be on the holders to prevent damaging the inserts. Insert proportions must be adequate to resist the high cavity pressures encountered during forging. Minimum wall thickness should be 1.5 x cavity depth and the thickness below the impression should be 1.5 to 2 x cavity depth to resist cracking.



Maintenance Practice

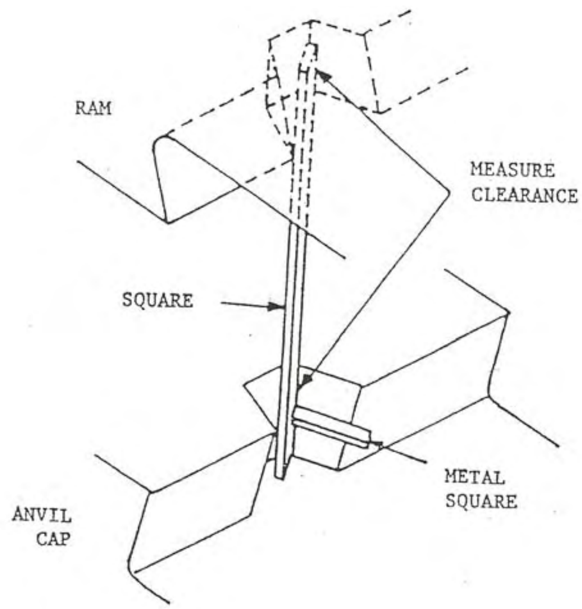
Proper hammer alignment is essential if dies are to be installed and expected to align the first time. Remachined rams and anvil caps must be checked when reinstalled to be certain that their alignment is correct. The following figures illustrate measuring procedures used to assure that the hammer is correctly aligned.

The figure below illustrates the measuring procedure for the straight side of the anvil cap. This procedure is designed to assure that the straight side of the notch is paralleled to the frame guides. This check is performed as a prelude to aligning the ram notch with the anvil cap. Any discrepancy greater than .004" that is found in this check must be corrected before installing the ram. Shims must not be used to make the correction.



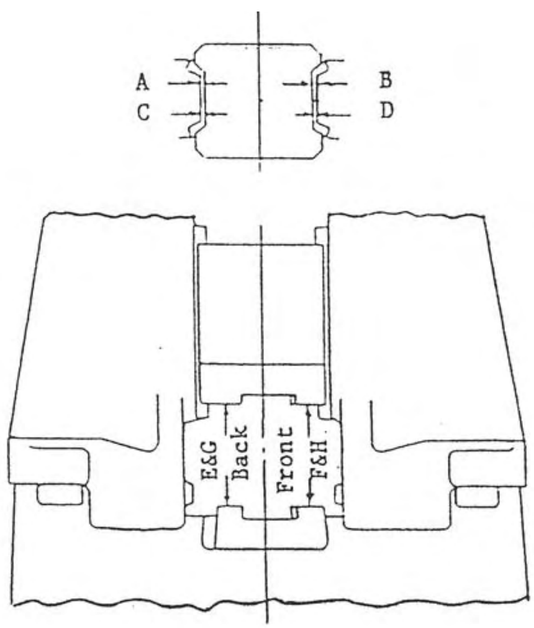
At the right, the procedure to check the alignment of the ram notch with the anvil cap notch is shown. The straight sides must be parallel to one another and in exactly the same vertical plane. Any twists detected or lateral misalignment greater than .004" must be corrected before placing the hammer in service.

Dowel alignment must be checked as shown at the right. Dowels must align within .002" in the front to back direction. If the alignment is incorrect, adjustments can be made to the frame to anvil wear plates on Chambersburg hammers. These plates must be checked regularly to be sure that there is not excessive wear at any one point. Excessive wear can result in "floating" mismatch. Whenever clearance at the frame to anvil wear plates is greater than .006" to .008", the wear plates should be replaced.



Finally, the parallelism of the ram with the anvil cap should be checked. The figure below shows the locations of the check. All readings (A, B, C, D) and (E, F, G, H) should be within .005" to .006" of each other. If all machining was performed correctly, these tolerances should not be difficult to achieve.

Periodic checks of the hammer alignment should be performed as part of a preventative maintenance regimen. Records must be kept of each inspection so that changing conditions can be identified. When conditions deteriorate, corrections must be made immediately. These checks will verify that the hammer remains in sufficiently good condition to make quick die change possible.



Management Philosophy

As can be seen from the foregoing paragraphs, Quick Die Change cannot be achieved by one or two simple and inexpensive steps. A great deal of work is required, significant investment in time and money is needed, and a great deal of planning. Quick Die Change is really a problem of logistics more so than technology. Because of this, management of the process is critical.

Management refers to the forge shop and maintenance management function and to corporate management, for without corporate management's commitment to Quick Die Change, the financial or manpower resources will not be available to accomplish Quick Die Change.

There has been a great deal written about Quick Die Change over the last few decades. It is heralded as a hallmark of Quality Management. It is demanded by forward thinking customers. It is what "everybody is doing". However, the practical side of the decision to get into Quick Die Change rests with whether there is a payback. Corporate management will not commit resources to a project that will not payback the investment. It is therefore critical to be able to accurately determine the costs associated with Quick Die Change. Without reliable cost information, justification is impossible. The difficult part of the equation, however, is in the payback calculation. This requires a rethinking of the entire operation, an analysis of how things are done now, and an assessment of how much they can be improved in the future.

An example of the investment and the accompanying returns will serve to illustrate the potential justification that can be used for Quick Die Change. It will be assumed that the forge shop is being operated at approximately 60% uptime. That is to say, 60% of the available production time of 2000 hours per shift is actually used for production. The remainder is for maintenance, die change, wait time for deliveries, tryout, remediation and so forth. Further, there are an average of 250 die changes per forging cell per year. Each die change averages 150 minutes. Under current conditions, each hour of production represents $2,000 in shipments.

Yearly Period	1	2	3	4	5
Annual Investment	$150,000	$150,000	$150,000	$150,000	$150,000
Die Change Time (Min)	100	67	44	30	20
Add'l Capacity (Hrs)	208	348	440	502	543
Annual Shipment Increase	$416,667	$695,000	$880,370	$1,003,826	$1,086,048
Mfg. Margin	$125,000	$208,500	$264,111	$301,148	$325,815
Cash Flow	-$25,000	$58,500	$114,111	$151,148	$175,815
Payback Period	1.2	0.9	0.8	0.6	0.6
Net Present Value (Cash Flow)	-$23,585	$28,480	$124,290	$244,013	$375,392

It is proposed to embark upon a Quick Die Change program that will reduce die change time by 1/3 each year. An annual investment of $150,000 is required at each forging cell. The program is to be carried out over five (5) years. The number of die changes will remain the same as will the dollar value of shipments per production hour. Current manufacturing profit is 30%. If the Quick Die Change program results in increased available production time, it is assumed that increased capacity can be sold.

Based on these conditions, the table shows that, except for the first year, there is a positive cash flow each year of the five years used in the example. Cash flow is calculated as the net result of manufacturing profits (on new sales) less investments (expense) for the period. A positive cash flow indicates that profits exceeded the cost of the investment. Due to the law of diminishing returns, the change in production hours and sales dollars increase at progressively slower rates each year.

To decide on justifiability of the investment, Net Present Value is used. In the first year of the investment, a negative value of NPV would indicate an unfavorable investment. However, one must look at the long-range effects. Thus in the second and succeeding years NPV is positive which indicates a good investment strategy. A payback calculation, considering that this plan involves a series of investment, results in approximately 1.2 years to recover the initial investment given the assumptions stated above. All succeeding investments are recovered in less than one year as shown.

You will have to apply your own justification to the above train of thought. It will likely have to be more rigorous that this and more detailed, but it can be done and the justification can be successfully completed. It simply remains to be carried out reliably.

No matter what the numbers say, management must be committed to Quick Die Change. They must support extra precision in die making and offer encouragement to the die makers to achieve it. There must be an investment in training: for designers, for die sinkers, for operators, and for maintenance personnel. There must be a preventative maintenance program to keep the hammers in better condition and to keep them running longer. There must be a commitment to continuous improvement, for without that incentive, Quick Die Change improvements will not reach their ultimate potential.

Conclusion

Quick Die Change in Hammers is practical and technologically feasible today. There is no magic solution or a single item to purchase that can make it possible. It will require an investment in people and a commitment in financial resources. It will require attention to the details of the forging operation, its tooling, its equipment, and its management. It will require a dedication to doing things differently than they were done in the past. When all parts of the plan are in place, the rewards, in terms of increased business and the potential for increased profits, will follow.

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Our Divisions:
Chambersburg Equipment Co., The Ajax Manufacturing Co.
Forging Developments (Int.), Inc.

Ajax CECO

TABLE I - MINIMUM DIE BEARING AND STRIKING AREAS FOR HAMMERS

HAMMER SIZE	GRAVITY DROP HAMMERS		GRAVITY DROP HAMMER CONVERSIONS, MODELS CDF AND BHD		ACCELERATED BLOW HAMMERS AND CONVERSIONS, MODEL DHP AND DHF		IMPACTER SIZE			DIE FORGER SIZE		
FALLING WEIGHT (LBS/KG)	A (SQ. IN./SQ. CM.)	B (SQ. IN./SQ. CM.)	A (SQ. IN./SQ. CM.)	B (SQ. IN./SQ. CM.)	A (SQ. IN./SQ. CM.)	B (SQ. IN./SQ. CM.)	NO.	A (SQ. IN./SQ. CM.)	B (SQ. IN./SQ. CM.)	NO.	A (SQ. IN./SQ. CM.)	B (SQ. IN./SQ. CM.)
500	37	13					3	56	20	4	69	25
227	239	84						361	129		445	161
750	51	18					8	120	42	8	120	42
341	329	116						774	271		774	271
1000	64	23	90	32	130	48	15	170	60	14	170	62
455	413	148	581	206	839	310		1097	387		1097	400
1500	82	30	120	43	190	68	25	250	90	23	230	84
682	529	194	774	277	1226	439		1613	581		1484	542
2000	110	40	160	56	230	82	40	330	120	38	300	110
909	710	258	1032	361	1484	529		2129	774		1935	710
2500	130	46	180	65	270	97	70	440	160	66	370	130
1136	839	297	1161	419	1742	626		2839	1032		2387	839
3000	150	55	210	75	300	110						
1364	968	355	1355	484	1935	710						
4000	190	67	260	92	400	140						
1818	1226	432	1677	594	2581	903						
5000	220	78	300	110	450	160						
2273	1419	503	1935	710	2903	1032						
6000	260	93	350	120	550	200						
2727	1677	600	2258	774	3548	1290						
8000	360	130			660	240						
3636	2323	839			4258	1548						
10000					780	280						
4545					5032	1806						
12000					870	310						
5455					5613	2000						
16000					1100	390						
7273					7097	2516						
20000					1300	460						
9091					8387	2968						
25000					1520	550						
11364					9806	3548						
35000					1900	680						
15909					12258	4387						

A = MINIMUM DIE BEARING AREA (SQ. IN) (SQ. CM.)

B = MINIMUM DIE STRIKING AREA (SQ. IN.) (SQ. CM.)

These minimum striking areas must be distributed evenly front-to-back and left-to-right. The above table is predicated on using die blocks with hardness in the range of Rc 37-41. If softer blocks are used, proportionately larger areas must be used.

To determine this, use the following formula:

New Area = Area B x Yield Strength (psi)/125,000

Note: Bearing area is the area of the die that is actually in contact with the Ram or Anvil Cap and excludes keys and dowels.

Ajax CECO