Mold Side-Actions: How, Why and When They Work

Understanding the effects of injection on the core, slide and associated components is critical to selecting the best side-action methods for a given application. This first of two articles will discuss the basic physics underlying all side-actions as well as the fundamentals of side-action performance.

Mark Scanlan

As advances in technology have driven market globalization and shortened product life cycles, mold design and production methods have been pressured to keep pace. The success of moldmakers in the future will be defined by their ability to discern the advantages and disadvantages of the ever-broadening options.

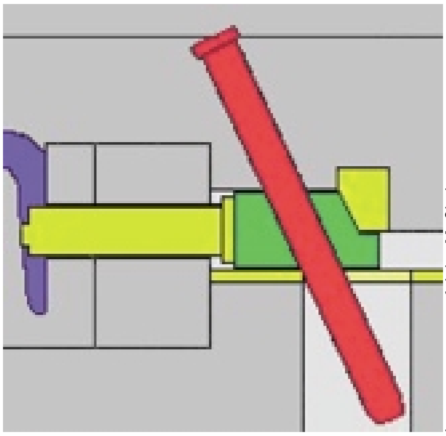
With a fundamental understanding of these various side-action methods, moldmakers can choose and apply the optimal solutions to today's applications. Solutions must benefit all of the players involved in the process — designers, moldmakers, molders and product manufacturers. With demands for improved quality, lower costs, shorter production times and increased part complexity, the need for a deeper understanding by all participants is becoming paramount. The need to think "outside of the box" and embrace advanced techniques has never been clearer.

Perfect Fit Actions — Cam Pin Method

The most basic and familiar of all side-actions employs an angled pin to move the core with heel block backup during injection. In the "ideal" mold, the components form a perfect fit when the mold is closed, with the desire that the components do not move or change shape during injection **(see Figure 1)**. The cam pin method, however, has a fundamental limitation in that steel is compressible and flexible.

Because the load forces in a tool during injection can be very large relative to the modulus of steel, assumptions of rigidity and incompressibility are not appropriate. Even with a "perfect fit," during injection, plastic pressure is applied to the core face and the metal is flexed, side loaded or compressed toward the heel block, resulting in slide face backup. The degree of the side loading, flex and compression will determine the resulting flash and other issues.

The magnitude of these problems is a function of the variation in injection pressure and core/mold geometry. Location of stops, size of stops, guides, core length, shutoff area, etc. will all affect the amount of these errors. To understand how the compressible nature of steel impacts the cam pin method, the engineering relationships of stress and strain on cores must be reviewed. For more detail on compression of steel in general see **Sidebar**.



Images courtesy of John M. Clark.

Figure 1 Cam pin action with backup.

Because injection forces are relatively high and small deviations in materials leads to poor part quality, attention to how steel changes shape under load is critical to good mold design.

Compression Ruins the Fit

Engineering calculations for materials often focus on yield strength, with little attention to change in shape. Because injection forces are relatively high and small deviations in materials leads to poor part quality, attention to how steel changes shape under load is critical to good mold design. While the mold is machined, assembled and spotted cold, it would be more correct to manufacture the steel components at operating temperature and under the anticipated injection forces.

In mold applications, the known factors are often the injection pressure (P), core area exposed to plastic (C), length of core (L), the major diameter area of core (A), and material property modulus (E). What is unknown is the amount of deflection (D) of the core face.

To calculate the deflection for a given force, the "FLEA" formula can be used.

F = P x C

D = (F x L)/(E x A)

Example:

Given a 10" long core pin with a 1.125" diameter major diameter (area of 1 in.^{2}), a core face exposed to plastic of .5 in.^{2} and an injection pressure of 10,000 lbs./in.^{2}, the parameters are:

P = 10,000 lbs./in.^{2}

C = .5 in.^{2}

F = P x C = 5,000 lbs.

L = 10 inches

E = 30,000,000 lbs./in.^{2}

A = 1 in.^{2}

D = FL/EA = .0017 in.

As can be seen, a moderate size core area of .5" (half the pin area) can move nearly .002" under a moderate injection pressure of 10,000 psi. Note that this corresponds to a machine hydraulic line pressure of approximately 1,000 psi[1] x 10 for the screw/barrel. For face area equal to the pin diameter (1"^{2}), deflection would be approximately .004" due to pin compression alone. Changing material to a glass-filled nylon could double injection pressure to 20,000 psi, resulting in .008" movement.

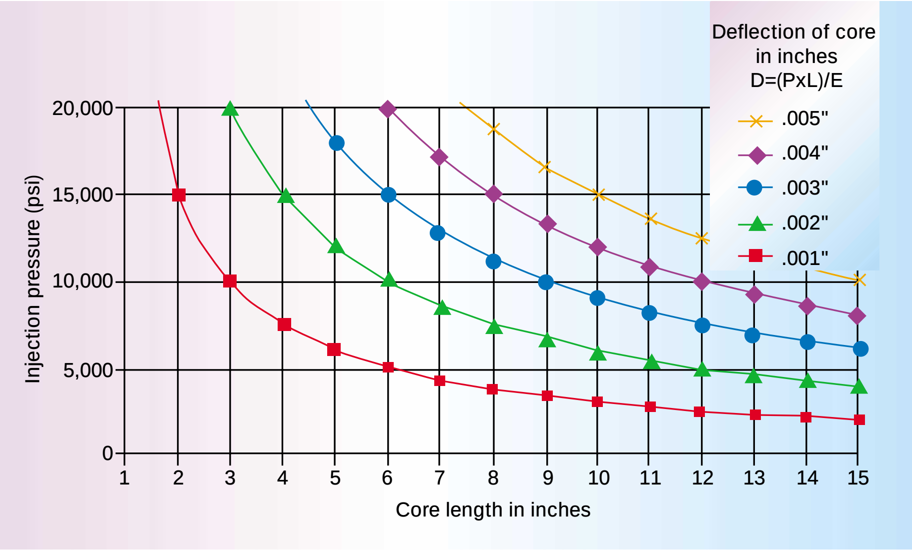
Additional factors — such as flex, thermal shrinkage and timing — must be added to compression to determine overall deviation from the desired shape. Of course there are many other concerns for the components themselves. A short, yet informative, description of slide design and other issues can be found in section 12.9.2.1 of Menges and Mohren's *How to Make Injection Molds*[2]. Discussions of forces on the pin, most favored angles, wear on heel blocks, recommended slide tapers, concern for thermal effects and delayed lifter designs are included.

A Simple Chart

A simplification assumes constant core cross sectional area, core exposed area equals core slide cross-section area and constant material modulus. Thus a plot can be made of deflections for various pressures and length **(see Figure 2)**.

Close inspection of the data below 20,000 psi shows that all cores greater than 3" in length have at least a .001" compression (core deflection). For greater pressures approaching 20,000 psi, any core length will result in some compression beyond .001".

Thus it has been demonstrated that for the limiting case where the core cross sectional area approaches exposed area, generally all captured cores with perfect size-on-size



Figures courtesy of Mark Scanlan.

Figure 2 Constant core deflection vs. core length and pressure.

The cylinder-only application is noteworthy in that the core is still compressed under load, but the compression is done by the cylinder toward the core face prior to injection.

timing will demonstrate at least .001" deflection or backup of the core face during injection. In most cases, for common core lengths between 6" to 10" and injection pressures of 10,000 to 15,000 psi (1,000 to 1,500 hydraulic line pressure), the deflection during injection will be from .002" to .005". Note that this "movement" is strictly due to compression alone and must be added to the core movement due to flex, timing error, mismatches and thermal contraction.

Without getting involved in estimates of cost or timesavings of various methods, the traditional cam pin system can usually be described as providing the following operational and performance advantages in production:

- It is intrinsic to the mold itself — requiring no external setup, hookups or adjustments by mold setup personnel or operators.
- It has unlimited speed.

While not appropriate for a variety of complex applications — which can be listed as disadvantages relative to other methods to be discussed in Part II — a few disadvantages are:

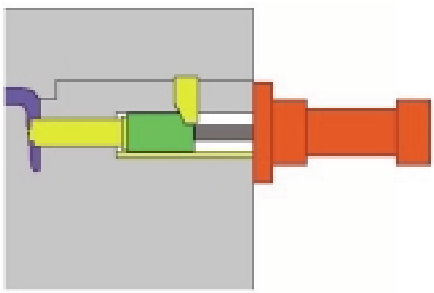


Figure 3 Cylinder with heel block with backup.

- It is complex to manufacture.
- It has a one-off design.
- Flash or inconsistent parts occur due to compression under load.

A note should be made here regarding the use of hydraulic cylinders with heel blocks **(see Figure 3)**. While the use of standard hydraulic cylinders can improve or help solve other problems with cam pin actions, they react in the same manner as a cam pin system during injection. Core compression is a function of the length of the core to the heel block and is the same for any method using a heel block. The cylinder simply replaces the pin as another means to move the core in and out when the mold is open.

While every application must be reviewed with an understanding of how some particularly strange feature may impact this method, in nearly every practical application the use of a hydraulic cylinder in the manner discussed will provide a wealth of advantages over a cam pin system.

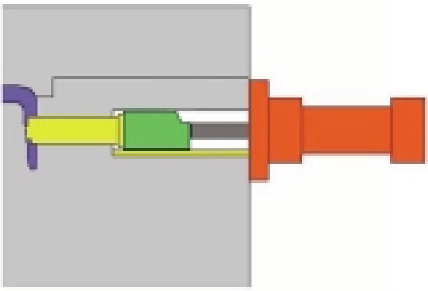


Figure 4 Cylinder only — no backup with full pressure.

Compression Fit Actions — Cylinder Only Method

Using the hydraulic cylinder to position the core — with the heel block to hold it — and using it to both position and hold the core are two completely different applications. In the cylinder only method, while the core may have to be set prior to closing the mold due to a design issue, most often it is set and pulled with the mold closed **(see Figure 4)**. During injection, full hydraulic pressure is maintained on the cores to prevent movement.

While full hydraulic pressure during injection is not commonly available — and using standard hydraulic cylinders to move, hold and compress the cores during injection is not normally a viable option — the physics of operation and the advantages provided by such a method are instructive to other methods discussed later. There may be special circumstances where use of this method, despite its drawbacks, provides the best choice for the application.

Compression Is the Fit

A hydraulic cylinder is used to hold the core during injection by ensuring that the force from the cylinder rod exceeds the force on the slide due to plastic pressure. To determine the expected force on the slide (F), the known factors of maximum injection pressure (P) and core area exposed to plastic (C) are used.

$F = P \times C$

The cylinder force must exceed the slide force to prevent movement of the core face. The force from a standard cylinder (M) is a function of the piston area — based on bore diameter (B) in inches — and supplied hydraulic pressure (H) in psi.

$M = H \times (3.14 \times B^2)/4$

Using the same data from the cam pin example, force on the core is:

$P = 10{,}000$ lbs./in.^{2}

$C = .5$ in.^{2}

$F = P \times C = 5{,}000$ lbs.

Given an available hydraulic pressure of 2,000 psi and a 2" bore cylinder, the force available from the cylinder is:

$M = 2{,}000 \times (3.14 \times 2 \times 2)/4 = 6{,}280$ lbs.

Note that if the available hydraulic pressure was only half — or 1,000 psi — the force available from the cylinder would be:

$M = 1{,}000 \times (3.14 \times 2 \times 2)/4 = 3{,}140$ lbs.

In the first case, the force of the cylinder is greater than the force of the plastic and the core face will not move. In the second case, the plastic force exceeds the cylinder force and the core will move substantially until the shot volume is expended. This illustrates the problem of hydraulic pressure dropping out or decreasing during plastic injection. Without hydraulic pressure, the cylinder force is zero.

If the above formulae are set equal and solved for bore size, the minimum cylinder bore diameter can be determined. At the minimum bore size, M = F.

$B = \mathrm{SQRT}[(4 \times P \times C)/(H \times 3.14)]$

Figure 5 shows the minimum bore size needed for various exposed areas and injection pressures at 1,000 psi hydraulic on the cylinder. Before using this method, verify that full hydraulic pressure is available during injection and then verify it again. Even if you are lucky enough to have full injection pressure available, note that it doesn't take much core area (about one square inch) to require a 4" bore cylinder at a minimum. A three-square-inch area gets you quickly to a 6" bore. For a detailed discussion of the relationship between press line injection pressure and actual nozzle injection pressure, review Menges and Morhen[2].

For example, with an injection line pressure of 1,500 psi, converted to injection pressure of 15,000 psi, and a core area of four square inches, the point lies above the 8.0, 1,000 psi line and below the 10.0, 1,000 line. Thus at 1,000 psi cylinder pressure, a cylinder larger than an 8" diameter bore would be needed. Since a 10" bore is above the point, it would meet the requirements. Alternatively, use the formula and find the closest larger bore size available.

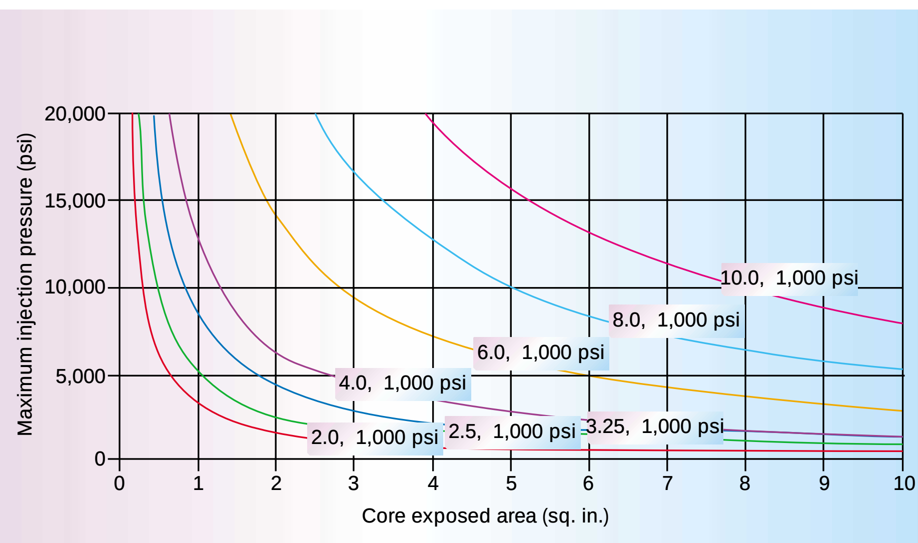


Figure 5 Minimum bore diameter (inches) and hydraulic pressure (psi).

No Core Movement

The cylinder-only application is noteworthy in that the core is still compressed under load, but the compression is done by the cylinder toward the core face prior to injection. Compression toward the core face is very important.

During injection, the core undergoes load sharing with the core stops, but does not move. Zero movement is preferred to compression of the core against the heel block by the plastic force during injection, as seen previously. Hence, for the cylinder-only method, compression against the stop provides a solution "better than a perfect fit."

The Physics of Compression

For a created "standard" hardened steel **(see Figure 6)**, having a modulus of 30,000,000 lbs./in.^{2}, a yield point of 100,000 lbs./in.^{2} and an ultimate tensile strength of 125,000 lbs./in.^{2}, the load curve for a 1 in.^{2} area rod (1.125" in diameter) – 10" long may look like **Figure 7**.

While Figure 7 shows the actual Force in pounds and the actual total change in Length in inches, it cannot be used to solve for other sizes and lengths. To provide a universal chart (material property), the Force is normalized per unit area (F/A) of the rod and the deflection normalized by total length (D/L).

Figure 8 represents the deflection per unit inch of length as a function of the force per square inch of material. Deflection per unit length d = D/L. Force per square inch of area f = F/A. Since materials are not used beyond the yield point — the point at which material does not return to its original shape when unloaded — only the area where the behavior is linear is used.

The slope of the line is the Modulus (E) of the material and is constant. This allows the determination of any compression or deflection if the geometry and forces are known (E=f/d).

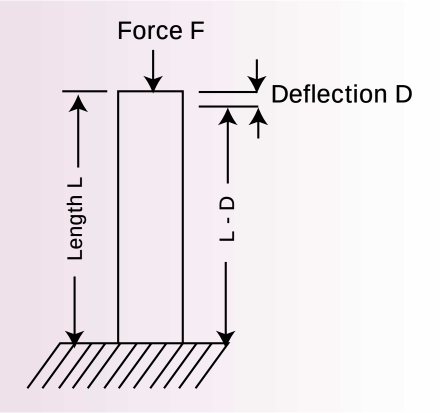


Figure 6 Rod under compressive load.

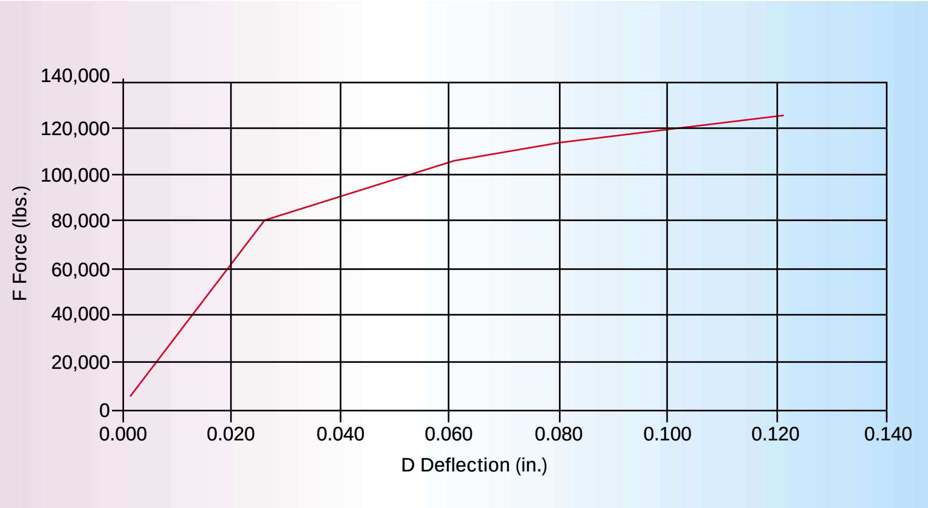


Figure 7 1.125" diameter bar – 10" length.

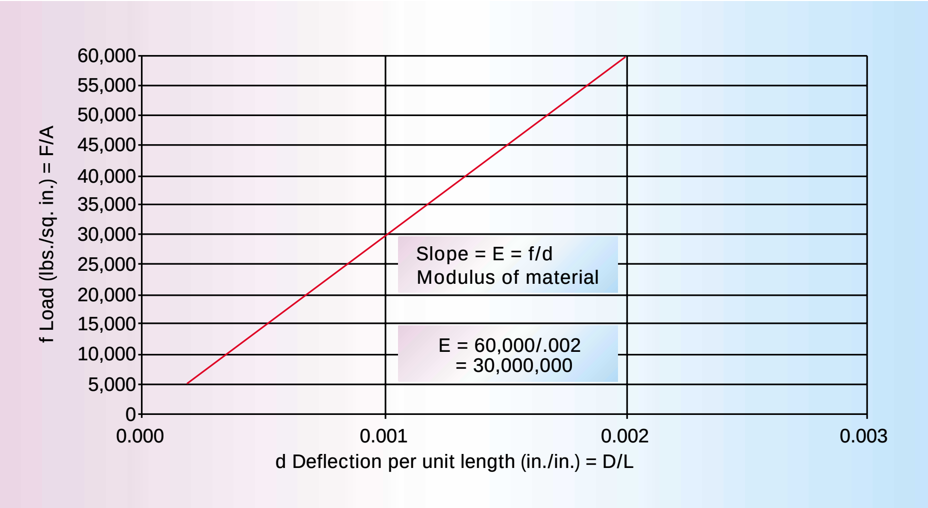


Figure 8 Stress vs. strain for steel (Modulus E).

It is critical to emphasize that this only works with a hydraulic cylinder when the cylinder is:

- Sized large enough to exceed the force of injection.
- Maintained with full system hydraulic pressure during ejection (not common).
- Is not used with a heel block or other core blocking mechanism.
- Is used with stops on the core very near or at the core face to define core position.

While every application must be reviewed with an understanding of how some particularly strange feature may impact this method, in nearly every practical application the use of a hydraulic cylinder in the manner discussed will provide a wealth of advantages over a cam pin system. Of course, there are a few major problems with the implementation of this method, which will be addressed by the modular core compression side-action system (discussed in Part II).

While modular systems can — in some cases — greatly improve on these traditional methods, there are important lessons to be learned up to this point. When building or employing side-actions of any type, you should observe the following:

- Make the core body as short as possible to minimize "core length" (L).
- Place stops on the core as close to the part as possible to minimize length of core at diameter (L).
- Make core bodies large in cross sectional area even if the face detail is small to maximize (A).
- Design molds to operate at the lowest injection pressure possible to reduce core "force" (F).
- Use a hydraulic cylinder only when possible on small cores with sufficient hydraulic pressure.

REFERENCES

[1]*Johannaber, Friedrich.* Injection Molding Machines: A Users Guide, *trans. Rolf J. Kahl, 3rd ed., Munich; Vienna; New York: Hanser, Hanser/Gardner, 1994.*

[2]*Menges, Georg, and Mohren, Paul.* How to Make Injection Molds, *trans. Rolf J. Kahl, 2nd ed., Munich; Vienna; New York; Bacelona: Hanser, 1993.*

Mold Side-Actions: Applications Rule the Action

With a firm understanding of the effects of injection on the core, slide and associated components, this second of two articles will discuss emerging modular technologies which provide alternatives to the limited solutions previously available.

Mark Scanlan

In the first article, *Mold Side-Actions: How, Why and When They Work* (see *MoldMaking Technology* magazine, September 2001), the discussions left two possible side-action systems. The first type is the "perfect fit" action or "backup" action, which comprises all actions that attempt to hold the core position by making components fit exactly. Perfect fit systems:

- React to plastic pressure.
- Compress during injection.
- Compress toward the heel block.
- Have backup of the core face.
- Produce flash easily.

Examples of perfect fit actions discussed were the traditional cam pin method and the cylinder with heel block method. These are methods where the pin or cylinder moves the core and the heel block maintains position during injection.

The second type is the "compression fit" action or "zero movement" action, which comprises all actions that compress the core into position by applying and maintaining a high set force before, during and after injection. Compression fit systems:

- "Pre"-compress against the core stops.
- Share load with plastic and stop during injection.
- Ensure zero movement of the core face.
- Easily prevent flash.

An example of a compression fit action was the traditional cylinder only method. In this method, the cylinder both moves the core and provides compression under full hydraulic pressure before, during and after injection to prevent movement.

Emerging Modular Systems

As with robotics and automation in the last decade, the molding industry is just beginning to embrace the next evolution in mold production — modularity.

As important as part quality and mold performance is to the industry, it no longer overshadows price, speed to market, ROI, lifetime cost, competitiveness, etc., which are ever more commonly reviewed and taken into account in today's global marketplace. A large amount of effort has been expended by innovative companies to provide the industry with more cost-effective methods for producing, maintaining and controlling molds, including more advanced CNC equipment, analysis software, CAD/CAM integration and modular mold components. Perhaps the most familiar modular systems are complete mold bases, hot runner systems, quick-change systems, quick connections and modular wiring harnesses. While slide components such as wear plates, pins and other items have been commonly available as off-the-shelf components, it has only been recently that complete modular side-action systems have become widely known.

As important as part quality and mold performance is to the industry, it no longer overshadows price, speed to market, ROI, lifetime cost, competitiveness, etc., which are ever more commonly reviewed and taken into account in today's global marketplace.

Often identical to common one-off designs, the more simple components focus their advantages on reducing production time, simplifying mold production, providing standardization and most of all, allowing the moldmaker to take advantage of volume production for low volume usage. For example, making core pins one at a time requires extensive handling and labor (i.e., money), compared to purchasing pins made in large volumes by a component supplier. The component supplier makes a profit and the cost to the moldmaker is often significantly less than the cost to produce the same part. This is modular efficiency on a basic level.

Complete hot runner systems, analysis software, quick-change tooling and the like provide similar modular efficiency by providing systems not only expensive to produce in low volumes by the moldmaker, but which also would require extensive R&D — well beyond the efforts of basic component design. In these cases, the benefits are not defined by cost savings as compared to raw materials or direct machining labor, but in advantages provided by less direct but perhaps more important savings such as improved part quality, consistent part quality, reduced cycle times, increased production efficiency, lower production overhead and lower cost per part.

In some cases the new technology provides a completely new method previously unavailable or entirely cost prohibitive prior to its development. The modular systems that follow are part of this new technology.

Not only are the systems important, but it also is equally important to know when to use them.

Modular Mold Base and Cam Pin Systems

Modular mold base systems are basically a built-in side action in the mold base when purchased. The systems are part of a complete modular mold base design. This is indeed a traditional cam pin and mold design without the issues of building one from scratch. Selection is done by choosing the made-to-order or off-the-shelf mold base with installed pins, slides, cores, etc. ready for modification by the moldmaker. Modular cam pin systems limit modularity to the action itself, allowing the mold builder more freedom to place the action in any mold base as desired.

While the modular mold base systems generally emulate the large, traditional cam pin arrangements, the modular cam pin units commonly consist of an angled wedge and integrated angled slide captured in a housing which holds the system together. The device may incorporate a spring-loaded return for small details, automatically retracting the core when the mold is opened. In standard configurations, the drop in system mounts on — or very near — the parting line. When the mold is near full closure, the opposing mold half contacts the plunger/wedge/pin system, driving the core forward to the set position. After injection, the mold is opened and spring force on the plunger pushes the angled arrangement back to the starting position and results in core retraction. Other modular methods provide angled surfaces on manufactured blocks which combine the pin style movements with the heel block attributes and provide similar advantages and operation to traditional systems where the slide is held by a detent and the pin separates from the slide. In any case, these systems provide for simple installation over traditional one-off designs.

While an excellent opportunity and improvement over traditional cams and pins, these modular cam pin systems provide performance consistent with perfect fit/backup actions. Backup will occur as previously discussed for all modular actions employing a perfect fit technique. Use these where you would a traditional cam pin and save yourself some time and headaches.

Modular Wedge/Locking/Braking/Clamping Cylinder Systems

Similar to the cylinder heel block method, these concepts generally use a cylinder to actuate the slide and a wedging, locking, braking, clamping or other mechanical means to interrupt cylinder rod movement. This is similar to using a cylinder with a heel block, but allows the action to occur totally independent of the mold operation, since the interrupt is internal to the unit itself. With the interrupt or clamp in place, the slide is held in the set position during injection. It is very important to note that the use of a rod interrupt or clamp does not define whether or not the unit will perform as a perfect fit/backup action or a pre-compression/zero movement action.

In almost every case, systems of this type are perfect fit/backup actions. In cases where the rod is held, clamped or blocked in place (like a heel block does without pre-compression), not only is the core compressed toward the heel block during injection, but the cylinder rod also is compressed in the same direction. As in the cam pin discussion, the force on core face during injection causes the slide to compress. Since the heel block is no longer present, the force also compresses the cylinder rod up to the point of clamping, locking, holding or wedging. As these systems often employ an internal means to hold the rod — even in the best case situation — where the clamp is at the rod end of the cylinder, the amount of material compressed is at least a stroke length longer than when using a heel block. Also, the cross section of the rod used is often much less than the cross section of the core body, leading to more compression than would be the case if the diameters were equal. This leads to a total compression of two to four times more than that seen with the cam pin method or cylinder heel block method.

In the case of a locking cylinder **(see Figure 9)**, at the end of the stroke, a groove in the rod accepts locking elements, which are subsequently captured by a cylindrical slide driven by springs.

In addition to the known factors often considered to determine core deflection (D), such as the injection pressure (P), core area exposed to plastic (C), length of core (L), major diameter area of core (A), and material property modulus (E), rod length (available rod + rod stroke = S) and rod cross section area (R) also must be considered.

To calculate deflection of the core face, we use the combined formula previously developed, but calculate deflection for both the core itself and the cylinder rod:

Original formula for slide with heel block:

$F = P \times C$

$D = (F\times L)/(E\times A)$

Revised formula for slide with cylinder lock:

$F = P \times C$

$D = (F\times L)/(E\times A)+(F\times S)/(E\times R)$

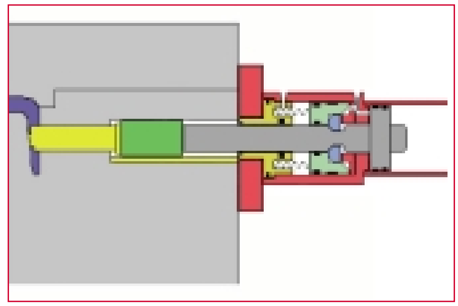


Figure 9 Locking cylinder.

Images courtesy of John M. Clark.

The original example was:

Given a 10" long core pin with a 1.125" diameter major diameter (area of 1 $in.^2$), a core face exposed to plastic of .5 $in.^2$, and an injection pressure of 10,000 $lbs./in.^2$, the parameters are:

$P = 10{,}000\ lbs./in.^2$

$C = .5\ in.^2$

$F = P \times C = 5{,}000\ lbs.$

$L = 10$ inches

$E = 30{,}000{,}000\ lbs./in.^2$

$A = 1\ in.^2$

$D = FL/EA$

$D = .0017$ in.

Same example with locking cylinder:

As above but add stroke of 5" and a 20 mm rod (.787" diameter). Rod cross sectional area is .5 square inches (R = .5) and S = 5".

$F = 5{,}000$ lbs. from above

$L = 10$ inches

$E = 30{,}000{,}000\ lbs./in.^2$

$A = 1\ in.^2$

$R = .5\ in.^2$

$S = 5$ in.

$D = FL/EA+FS/ER$

$D = .0017 + .0017 = .0033$ in.

As can been seen, a moderate size core area of .5 square inches can move over .003" under a moderate injection pressure of 10,000 psi. This is two times the deflection using the heel block. If the core face is the same as the pin diameter in the above example, the deflection would be approximately .006" due to pin compression alone. Changing material to a glass filled nylon could double injection pressure to 20,000 psi (2,000 hydraulic line pressure), resulting in .016" movement of the core face, not to mention additional factors such as flex and thermal effects.

Note that the locking slide is held in position using springs. The lock face is straight and the springs (sometimes these employ hydraulics) simply provide a means to hold the mechanical elements in place — preventing the rod clamp interface from moving — but do nothing to pre-compress or prevent compression of the rod and slide system.

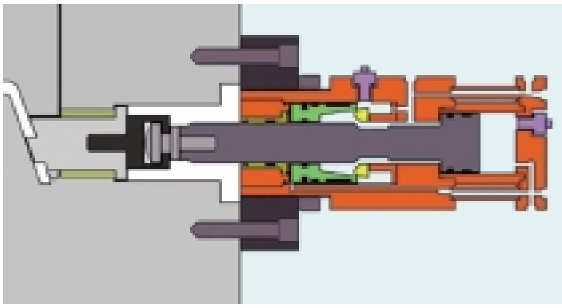


Figure 10 Modular core compression side-action system.

It is not recommended to use standard locking cylinders or braking cylinders on injection molds. While some manufacturers show and recommend spring locking and clamping systems for use on injection molds, do not use them unless you really understand the issues involved.

Modular Core Compression Side-Action Systems

Most similar to the hydraulic cylinder only method, modular core compression side-action systems comprise any system that contains the means to pre-compress the core prior to, during and after injection; are a single modular unit and do not require interaction with the opposing half of the mold.

While other methods may be developed, the only known systems are confusingly similar to the locking cylinder method. These systems use a cylinder section to hydraulically actuate the slide and a tapered mechanism to compress the core to a very high load. In the case of the modular core compression side-action system shown **(see Figure 10)**, a dual action force intensifier section actuates to apply a very large compressive force to the core. The force on the core is maintained mechanically, once applied, and is independent of the hydraulics once set. Even with complete loss of hydraulic pressure to the unit, the pre-compression force on the core is maintained.

Compression fit/zero movement actions of this special type perform with the advantages of the hydraulic cylinder only method in a more compact footprint and without the need to maintain pressure. After the mold is closed, the cores are set under a large force greater than the force on the core during injection. During injection the core face does not move. After injection, the cores can be retracted prior to mold opening.

The force applied to the core must exceed the injection force to prevent movement of the core face. The force by the intensifier is independent of the hydraulic pressure used to move the core slide and can be as low as 1,500 psi. Once set, hydraulics may be vented or secured to the system. Available output forces are a function of the unit selected and independent of supply pressure. Units are readily available with output forces of 12,000 lbs., 40,000 lbs., 60,000 lbs., 110,000 lbs. and 210,000 lbs.

Using the same example data from previous examples, given a 10" long core pin with a 1.125" diameter major diameter (area of 1 in.^{2}), a core face exposed to plastic of .5 in.^{2}, and an injection pressure of 10,000 lbs./in.^{2}, the force on the core is

P = 10,000 lbs./in.^{2}
C = .5 in.^{2}
F = P x C = 5,000 lbs.

Using a core compression side-action system as described, the force available from the intensifier is 12,000 lbs. (M = 12,000 lbs.).

Note that regardless of hydraulic pressure, the force of the side-action system is 12,000 lbs. Note also that this unit has a cylinder bore size of 1.25", much smaller than the 2" bore hydraulic cylinder used in the original example and has an outside diameter of 3". During injection, press hydraulics drop out, but the system maintains full force on the core face. The force of the system is greater than the force of the plastic and the core face has zero movement.

As systems of this nature employ a mechanical pre-compression of the slide, output forces are developed based on mold geometry. As some designs may have aspects that significantly affect assumed compressibility of the core and may exceed the ability for the intensifier to operate, consult the manufacturer for details on sizing, application and use of particular products.

Start With the Application

With a full arsenal of techniques for side action design, we can now discuss how to use them. Begin with the application.

Some questions to consider are: What are my quality requirements? Can I tolerate .005" movement of my cores? Is flash OK? How much? Do I have a seal off? Is this application a medical implant or medical waste container? What is the process? Is the part poly, ABS or glass filled nylon?

Fundamentally, the methods discussed open up a wide range of options. In many cases, designers try to put cores on the parting line, but why? Cam pins.

Well, if you can use a modular cam pin submerged in the block or a modular core compression side-action system mounted on a 30 degree angle to the parting line to make the design perfectly simple, why not do it that way?

Quick Start Design Selection

While highly simplified, consider the following question groups and the flavor of their answers. Exact numbers are not as important as getting in the ballpark. After going through them, refine any data that might make a difference in your selection of side-action method, as desired.

Questions of Quality and Size

1. What is the tolerance of my part and any associated detail where a core might be required?
2. What is the expected and what is the worst-case material injection pressure of the tool? Will the customer change material? Will thin walls require increased pressures?
3. Based on the preferred layout, what are the strokes on my cores and what are my core body lengths?

After considering the part tolerances and material, including thin wall sections, you will have a good idea of the injection pressures needed for the mold. With core strokes and some idea of core lengths, you have the necessary data to determine if the less precise cam pin methods will work for these conditions.

Assuming that flash occurs at .002" and that part tolerances require maintaining quality to this level, enter the chart with core lengths and pressures. If in the safe zone, consider using cam pin methods (for now). If in the transition zone, carefully review the application assumptions and risks for a more defined look. If in the flash zone, use a core compression method to ensure proper mold performance. If the part tolerances are not critical and/or some flash is acceptable, cam pin methods would still be a good option for this part of the review, regardless of the chart zone **(see Figure 11)**.

Questions of Operation and Space

4. Do I have any need to move a core(s) with the mold closed? Do I have enough daylight for opening on cores? Do I desire to run in the smallest press possible?
5. Do I have any face seal off areas and/or precision holes or details that must be perfect, even though general part tolerance is not critical?
6. Based on my preferred layout in the base, are my cores on the parting line or off parting line at some angle?

Regardless of the ability to use a cam pin for questions 1, 2 and 3, location relative to the parting line for ease of operation and blocking becomes important to consider.

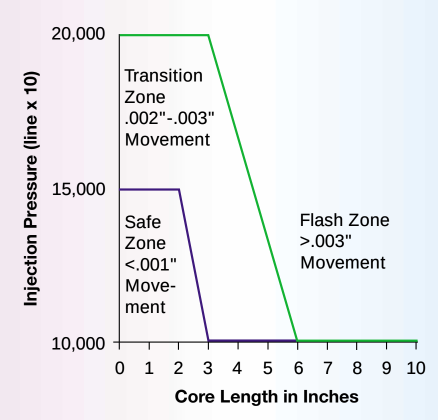


Figure courtesy of Mark Scanlan.

Figure 11 Perfect fit/backup zone.

First of all, do you need or desire for the design to pull the core with the mold closed? Is the core best off the parting line? If yes, consider if the cam pin will work at all, if it can be submerged for the off parting line case or if a core compression system that can be easily mounted at any angle to the parting line is a better choice.

Even on low tolerance parts, seal offs are often used to create holes in the part. Movement of the cores in this case, even if overall part tolerances are not demanding, will often result in holes flashing over. Flashing of holes for any part is usually a problem. With the exception of straight pin holes, all detail cores with small shutoffs have a high propensity for movement and flashover. Such cores should use a core compression/zero movement method to prevent lifting of the seal offs.

Daylight and press size issues become important for long core applications. Modular core compression side-action systems can be mounted external to the mold base, allowing the mold base be much smaller to fit in a smaller press than would be the case with an internally supported cam pin system.

For long cores where part tolerance requirements are loose and the core is close enough to the parting line for heel block access, the cylinder with heel block may be an adequate solution. As long cores are strongly affected by compression, all but the sloppiest parts should employ core compression/zero movement systems.

Questions of Risk

7. What is the risk to my company if the customer is unhappy, the mold must be modified or the material is changed?

Risk may be the largest design concern in some cases. For simply placed and smaller cam pin actions, perhaps tool modifications and changes to get the mold to work would not be overly costly or painful. In some cases, the designer may or may not have planned for such changes, if they would be needed.

For larger cores and more complex molds, the risk of failure is high. Often, problems cannot be corrected without expensive modifications, lost time and great embarrassment. For these cases, it is better to put the design effort in on the front end, cover all of the bases on part quality and ensure that the parts have the best possibility for success on the first shot. As core compression/zero movement systems often prevent many problems and provide other advantages for design simplification such as non-parting line mounting, pulling with the mold closed, smaller mold bases, etc., the small disadvantage of using a core pull circuit and hydraulics is easily justified.

Creative Problem Solving

Even a straightforward approach to side-action applications is easily derailed by the vast number of variables and demands of the mold design. With a clearer understanding of the physics of various side-action techniques and a basic laundry list of items to consider, it is the designer's challenge to think "outside of the box" and approach the complex mold design from all angles.

Smaller mold bases and smaller press sizes make both parts and molds less expensive. Simpler mold layouts make molds less expensive to manufacture and easier to assemble and maintain. Modular systems allow faster mold builds and more competitive bids. These are just a few examples of how mold design may go well beyond part shape and tolerances.

Simplified Recommendations

Based on the overall value of modular methods and giving some tradeoff value to the disadvantages of hydraulic requirements for core compression/zero movement methods, here are the final results.

Use perfect fit/backup cam pin and heel block systems (modular when possible) for:

- Very low tolerance parts, as desired.
- Core areas less than 0.5 square inches.
- Very short stroke cores.
- Small exposed areas and large slide cross-sections.
- Short core lengths of perhaps two to three inches.

In these cases, the risk of problems is minimal and the unlimited speed of operation, simplicity of installation and limited press requirements make this a good choice.

Use compression fit/zero movement cylinder only (requires full hydraulic pressure during injection) or the modular core compression side-action systems previously discussed (where hydraulics are not needed during injection) for:

- All high quality part requirements.
- Core areas greater than 0.5 square inches.
- Long stroke cores.
- Equal exposed core face to body areas.
- Moderate to small slide cross sections.
- Slide lengths greater than 2".
- Off parting line cores.
- Cores angled to the parting line.
- Core movement prior to mold opening.
- Reducing mold base dimensions.
- Reducing daylight requirements.

While requiring a core pull circuit on the molding machine, the advantages of these systems help ensure part quality and mold performance. The use of the modular core compression side-action system discussed provides the following advantages over the cylinder only method:

- Does not need full hydraulic pressure during injection.
- Mechanical — core compression force even if the hydraulic pressure drops to zero.
- Only 1,500 psi set pressure for full performance.
- More compact than hydraulic-only unit due to intensifier.
- Faster cycle times due to very small bore cylinder section.

It is quite common for all of us to use what we find familiar and it is understandable that demands on our time make discovering and learning new things difficult. However, with demand for improved part quality and increased part complexity sweeping the industry, we must take the time to optimize our use of technology and refine our approach to problems by applying more specific solutions to them.

Gone are the days when all side actions were customized pins and blocks. Current customers demand better.

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