Alternatives to using dowel pins in machine feet

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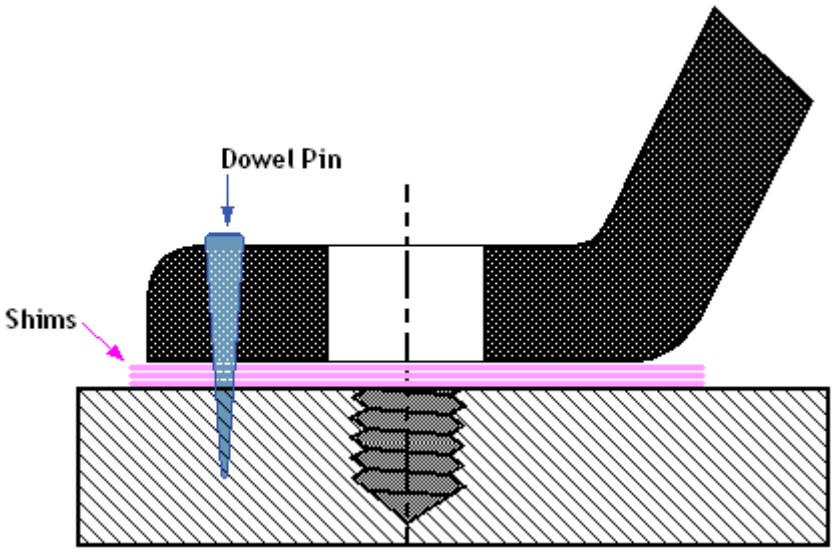
The practice of dowel-pinning machinery was originally conceived within the U.S. Navy well over a century ago. This innovation was triggered by the need for a solution to the extreme conditions faced on board by directly coupled rotating machinery in naval surface vessels and submarines with respect to hull and foundation deflection related to changing temperatures, storms at sea, as well as forces generated by munitions (firing shells and withstanding depth charges). The original and ongoing concern that resulted in the use of dowel pins was positional security.

Given the fact that excess weight is a major concern on Navy and commercial vessels, the proper engineering practice of making the base structure for the machinery weigh three to five times the mass of the machinery mounted upon it is impractical, resulting in flimsier, more flexible foundations. This is the principal justification for dowel-pinning machines in the Navy, and this practice became almost universally adopted.

After World War II, the vast majority of the industrial maintenance workforce in the United States that dealt with rotating machinery came from men who had served in the Navy, as this was the branch of the armed services with by far the majority of such machinery and maintenance needs. As a result of Navy tradition and training, the practice of indiscriminately dowel-pinning all rotating machinery filtered out onto dry land installations, even though there was no longer any technical justification for this practice.

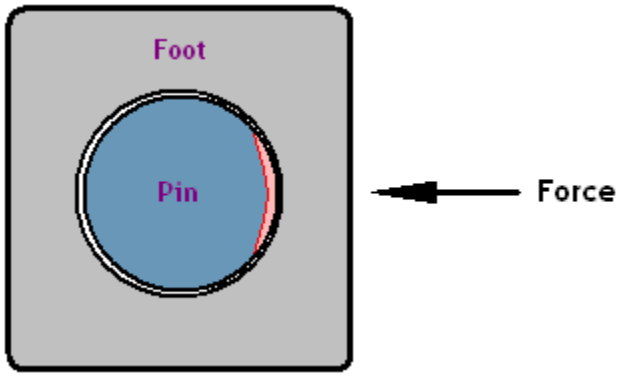


Positional security: Technical considerations

Modern engineering design of machinery takes into consideration the normal positional change that is anticipated from operational load stresses and thermal growth, with the assumption that the machines are installed upon a properly designed base structure, and that the correct grade of anchor bolts or studs and nuts is used, and that these are torqued to the proper values. If these conditions are met, there is no reason to demand that the machine supports be dowel-pinned since the properly torqued anchor bolts of the correct grade are sufficient to do the job of anchoring the machine in place against all operational load stresses

and anticipated positional changes, particularly in the vertical direction. Since the occurrence of lateral (horizontal) positional change is normal, the requirement for positional security is moot. Also, most designs of good quality flexible couplings permit setting the appropriate axial gap to accommodate any anticipated axial growth or movement that may occur. When this movement is not desired, a thrust collar or thrust bearings or other such mechanisms exist to control or prevent this movement.

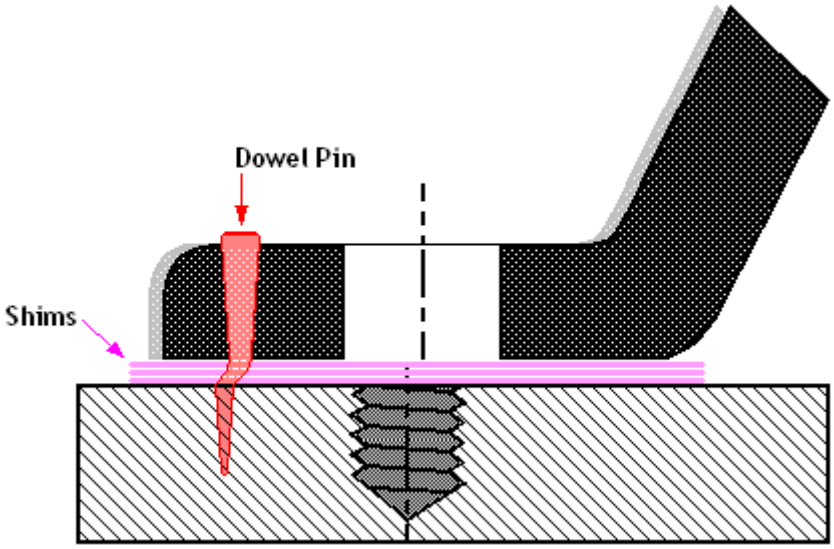
Therefore, the only concern remaining is positional security in the horizontal plane. Dowel pins are ill-suited as a solution for this concern for a variety of reasons. The first of these arises from the physics of the dowel pin mechanism itself:



If a lateral force is applied to the machine foot, this force will be concentrated at just one point on the circumference of the circular, tapered dowel pin. This pin is, in essence, nothing more than a smaller circle inside of a larger circle (the anchor bolt hole). From plane geometry, we know that two circles of different diameters, one within the other, if approaching, will first touch at only one point. It can, therefore, be stated that the pin will not offer great resistive force to the lateral force being exerted upon it, and will readily begin to crush. This crushing distortion will continue until the pin now becomes slightly elliptical in shape, and the surface area that it offers, in terms of its resistive force against the load being applied to it, is now greater than the strength of the pin itself. Thereafter, the pin begins to bend.

This effect can be easily proven: Mount a dial indicator against the side of the dowel-pinned machine foot and apply a lateral force on the other side with a sturdy jackscrew. Ten- to 15-thousandths (0.010 to 0.015) of an inch of relatively unhindered movement will be observed. This failure to resist lateral movement disqualifies the dowel pin from serving as a suitable deterrent to this movement and, therefore, renders it impractical as a mechanism to ensure positional security of the machine.

In addition to the above argument, if, as stated before, the external forces being applied are great enough, then after the movement that results in slightly crushing the pin has taken place, further movement will cause the entire dowel pin to bend.



This distortion occurs all the more readily in that the dowel pin is supported in the lateral plane by the interference fit within the foot and by the interference fit within the base; however, in the region where the shims support the foot, there is no support whatsoever for the pin – literally, it is in the air. Therefore, it bends easily in this region, resulting in an S-shaped or dog-legged dowel pin that is extremely difficult to extract and causes the millwright no end of trouble.

Positional security: Alternative solutions

If a particular machine installation requires that additional measures be taken to ensure positional security in the horizontal plane, the best option, in our opinion, is to install well-designed horizontal and axial jackscrew mechanisms that can be left snug against the machine feet. However, great care must be taken so that no positional change in the machinery under running conditions is expected to occur, since, if it does, the machine may buckle or twist between the jackscrews, thereby creating more serious problems than any that might have been occasioned by the unrestricted movement of the machines to begin with.

Precisely the same argument can be made against dowel-pinning the machine supports in more than one location, since the same overconstrained conditions will thereby be created. It must be remembered that the occurrence of lateral and axial growth or movement between the “cold” stopped condition and the on-line “hot” running condition is normal. The flexing of a well-designed flexible coupling and of the machinery itself allows this movement to be absorbed and to be compensated for by deliberately “misaligning” the machines in the cold and stopped condition to the exact target specifications for the positional change that will occur in the hot and running condition.

Additional considerations: Positional repeatability

If positional repeatability is the principal concern, rather than positional security, then dowel pins are not the best mechanism to fulfill this requirement. Instead, after a satisfactory final alignment has been achieved, it is recommended to carefully tack-weld two small pieces of key stock to diagonally opposed corners of the machine. The machine can then be removed and replaced with excellent repeatability, or correlation with its initial position. Dowel pins, on the other hand, almost never fit exactly as they did before they were removed. This results in the machine being skewed with respect to its initial position when it is reinstalled. Moreover, when a dowel pin cannot be gotten to fit readily in its original hole, rather than

fight the situation by attempting to minutely reposition the machine until it does, experience has taught us that a millwright will instead opt for drilling a new hole, as this is often less tedious and time consuming. When this practice is prohibited, the worker under time pressure may instead simply opt to surreptitiously cut the dowel pin and hammer the top of the pin into the hole as a "plug" in the hole. It is impossible for the supervisor to detect this without actually removing the altered dowel pin.

Tapered dowel pin

Conclusions

In view of the considerations presented above, the use of dowel pins to guarantee positional security of rotating machinery is not recommended. The use of dowel pins to guarantee positional repeatability is also not recommended. Instead, more effective alternative solutions should be employed.

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