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Innovative Work-Holding Tool Designs for Enhanced Safety and Learning in Manufacturing Labs

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Abstract

Manufacturing processes laboratory is one of the fundamental hands-on courses that mechanical engineering and mechanical engineering technology students are required to take in their first semester. The main purpose of this course is to introduce the mechanical engineering technology student to the principles and operation of mechanical equipment such as lathes, drill presses, milling machines and measuring instruments.

Individual laboratory projects are typically assigned to each student to reinforce the topics covered in the theory. For example, throughout these projects, students will be able to use a lathe along with proper machining procedures to manufacture mechanical components.

Operator safety is the top priority when working with a lathe. There have been instances of fatal lab incidents working with the lathe [1]. Therefore, any method to increase the operator safety is desirable. This paper demonstrates designing a novel work-holding tool to be used during lathe turning operations. The device, which is called the Integrated Faceplate Dog (I.F.D.), eliminates the need for using the traditional work-holding accessory on a lathe (a faceplate and lathe dog). As a result, students working with lathes will experience not only safer workflow, but also much smoother workflow, with the final manufactured part's quality enhanced and setup time reduced. Overall, there are numerous educational outcomes as well: students will be able to produce better quality components in a shorter period of time.

Introduction

The I.F.D., or Integrated Faceplate Dog is a device designed at SUNY Farmingdale which is a safer, simpler, and easier to use alternative to the traditional combination of tools used to turn work between centers on a lathe. The typical drive plate/faceplate and lathe dog are reimagined by combining both pieces into one smaller and lighter piece that easily fits the stock material to be machined. Setup and teardown are streamlined. This tool is designed for use in various student projects that utilize the lathe in the MET117: Manufacturing Processes course in the Mechanical Engineering Technology Department at SUNY Farmingdale. Any other courses or programs utilizing the lathe could benefit from the use of I.F.D.

The I.F.D. also serves another educational purpose: it demonstrates that it is usually in the machinist's best interest to create custom made fixtures that make manufacturing quicker, easier, safer, or better. When many pieces of the same part need to be manufactured, it is common practice to invest a small amount of time and money beforehand to accomplish this goal throughout the production of each part.

In a student machine shop, the same projects are manufactured semester after semester, replicating the number of components made during the production of a part in the industry. Custom I.F.D.s have been made for different student projects that each student will use. Besides better ensuring the safety of these first-time lathe users, students inherently understand the benefit of such fixtures. With I.F.D.s, the normal drive plate/lathe dog setup is only needed for one-time parts that do not have an I.F.D. prepared.

Normally, the user would install a drive plateand mount it to the spindle nose. This drive plate typically has either a hole or a slot cut into it that extends to the outside diameter of the plate, which accommodates straight-tail and bent-tail lathe dogs, respectively. A pin is threaded into one of these holes on the drive plate, and it contacts the straight tail perpendicularly, prompting rotation of the work. When using a bent-tail dog, the tail is inserted in the slot of the drive plate, and this interference is what prompts the rotation of the workpiece. The lathe dog connects to the workpiece with a single set screw, creating minimal contact with the work, leaving the possibility for user error to misalign the workpiece. In both instances, a headstock center is inserted into the spindle, holding the work on one side while another center is used in the tailstock to hold the work on the opposite side. The components of this standard setup are seen in Figure 1. The I.F.D. simplifies this process by eliminating the need for a drive plate and integrating the lathe dog tail into the I.F.D. itself, which is driven when it is inserted in one of the holes in the spindle nose similar to how the lathe dog's tail is turned by a hole/slot in the drive plate. For this setup, centers are still used in the spindle and tailstock as before. A set screw is still tightened down to clamp the work in place, but instead of being driven into the workpiece, the set screw clamps the body of the I.F.D. around the workpiece tighter, allowing for full cylindrical surface contact.

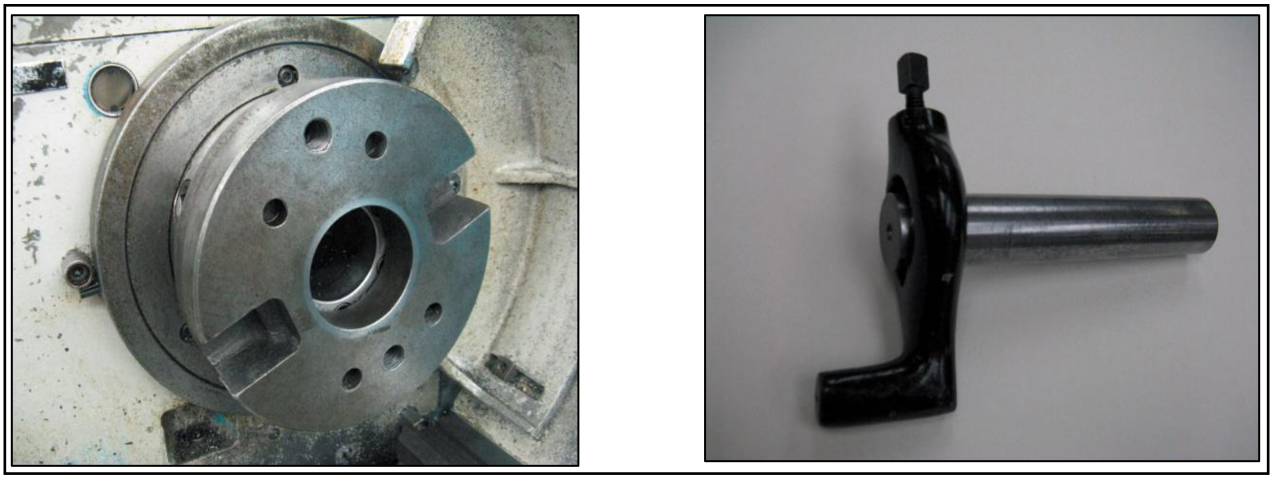

Figure 1: Left: Drive plate on the spindle nose of a lathe; Right: Lathe dog on a workpiece

The I.F.D. in essence, combines the work-holding ability of the lathe dog with the capability to transmit rotational force from the drive plate and pin into one tool. The style of clamping onto the workpiece approximates what is seen in a collet, which is superior to set screw contact. Figure 2 shows a schematic of an I.F.D.

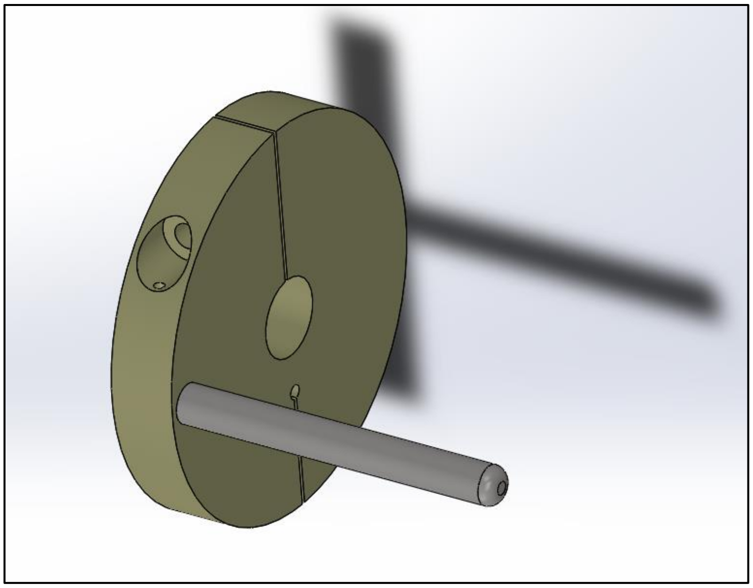

Figure 2: Schematic of an Integrated Faceplate Dog

Construction

The construction of an I.F.D. is relatively simple and involves only three parts: the disc (body of the I.F.D.), the pin or tail, and the set screw. The disc is cylindrical, typically around half an inch thick, with a diameter that is around the size of the spindle nose (~6 inches). To make the I.F.D., three holes need to be drilled in the disc. The first is a through-hole in the center of the circular faces, drilled and bored out to accommodate a specific workpiece, which can vary in diameter significantly. The second hole is drilled through one of the flat faces, parallel with the center hole, but offset close to the outside diameter of the disc. This hole is tapped to allow the drive pin to thread into it. The distance from the centerline of the I.F.D. to this hole should be equal to the distance from the spindle centerline to a hole on the spindle nose. Cam holes for a chuck can be used. One thin, straight relief cut is made from the center hole to the outside diameter of the disc to allow for a flexing/tightening action. The last hole, perpendicular to the first two, is drilled and tapped through the slot, originating in the round face of the disc allowing for a setscrew that will provide the clamping force on the part. It can be constructed from any alloy readily available, but aluminum is a good choice due to its low weight and high machinability. Its design can be radically altered to accommodate many different workpieces, which means that there is no real limit in terms of how many possibilities there are when creating dimensions for an I.F.D.

Advantages of the I.F.D.

The first advantage is student safety. A drive plate and lathe dog combination has a large mass concentrated off the spindle axis of rotation. Improperly setup parts that are not clamped or locked in properly can come free and cause much damage. An I.F.D. is much lighter and smaller and would also remain encircling the workpiece even when loose, preventing it from being thrown at the operator. Lathe dogs are typically cast iron or steel, while I.F.D.s can easily be made from aluminum without compromising their effectiveness. This, combined with the fact that the drive plate is rendered obsolete, causes this very significant reduction in weight that leads to much safer conditions for the operator in the event that something goes wrong.

As mentioned, the eccentricity of the shape of the lathe dog makes it dangerous when spinning around. Although the pin of the I.F.D. can be a risk of danger, it is significantly less than that of the drive plate and lathe dog. The bulky large diameter of the lathe dog/drive plate setup makes it easy for a student that has lost focus to get caught on a long sleeve of a lab coat. Figure 3 shows a student's coat tangled around a traditional setup right before the emergency stop was pushed. The chance of this is significantly diminished with an I.F.D.

Figure 3: Student's Lab Coat Caught on a Lathe Dog

The modularity and customizability of the I.F.D. are one of the best features it has. A huge advantage of the I.F.D. is its ability to mount threaded or irregularly shaped workpieces with good gripping power that will not damage the workpiece. Instead of using a split-nut in a lathe dog, the center hole of an I.F.D. can be threaded to match the part. Tapered parts can be held by machining the associated taper in the I.F.D. Soft alloys prone to galling can also be held.

The fact that the set screw is relocated from being through the frame of the lathe dog and consequently being driven directly into the workpiece, to being through the disc and the slot (in the same direction as the angular velocity of the disc), allows the I.F.D. to clamp workpieces tightly with a much smaller chance of damaging or galling the part. This is especially true for those workpieces that are irregularly shaped, already threaded, made of a soft alloy, or any combination of these traits. Instead of clamping the object against the inside of the frame of the lathe dog by forcing a set screw directly into the workpiece, the clamping force is directed entirely around the workpiece. It originates from the slot in the disc being pulled together by tension on the set screw. This allows a firm grip with a significantly larger surface area of contact than with a lathe dog.

A lathe dog might not damage a ¾ - 10 American trapezoidal form thread made of hardened steel, but many applications would be damaged due to being made from aluminum, having fine threads, threads cut very deeply, or having a thread shape that is not strong in terms of resistance to deformation from being crushed, such as a buttress thread.

The IFD allows for new possibilities in the order of processes that can potentially reduce time and reduce the number of times the workpiece is removed, re-oriented, and reinserted into the machine. This can save downtime in a production environment and allows the user to focus more on the machining operation itself. Furthermore, it demonstrates to students that there are many other fixtures or work holding devices that could and should be made for repeated operations, since this investment is in the best interest of the machinist.

Conclusion

In this paper, we focused on the different aspects of an Integrated Faceplate Dog (I.F.D.) which was designed at SUNY Farmingdale to enhance student safety, reduce the time and complexity of setting up the lathe, as well as produce higher quality projects undertaken in the Manufacturing Processes course. The simple construction of the I.F.D. along with its work-holding and rotational force transmission capability, as well as its modularity and customizability for tapered, threaded, and irregularly shaped workpieces make it an invaluable tool in a student machine shop. The effectiveness of such a device is magnified by the fact that the same projects are manufactured by students semester after semester, illustrating to students the value of creating a fixture for a workpiece in general.

References:

[1] Fatal Yale University Incident, See: https://www.nhregister.com/news/article/OSHA-faults-Yale-in-fatal-lab-accident-in-which-11576186.php