Activities for Automatic Assembly: Internalizing the Guidelines

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Abstract

Sometimes a class activity can help students understand the magnitude of the impact if a principle is violated. This can lead to a greater appreciation for ensuring that principle is *not* violated. An example would be the guidelines for designing a product for automatic assembly. Many of the guidelines are quite simple to understand. Because of this, many find it tempting to dismiss them or at least not give them the consideration they are due. Students can benefit from experiences that communicate the value of adhering to the guidelines.

The purpose of this paper is to describe two activities that have been effective in raising student appreciation of the importance of adhering to the guidelines for manufacture. These class activities have also been adapted for use as a recruiting tool. They are effective at engaging student interest when used with presentations to prospective students.

Background

While attempting to move a manufacturing engineering technology program to the hyflex delivery mode, a grant was received to explore the conversion of traditional in-lab experiences to at-home options. The goal was to use inexpensive, readily available parts and materials to simulate the in-lab experience while maintaining student performance. Results from this grant are reported elsewhere [1]. But from this work, there emerged some activities that have proven effective in the class room.

Design for Manufacture

When learning how to evaluate a design for manufacture, there are many guidelines students need to know. While memorizing the nine pages of guidelines is not expected, the students do need to become very familiar with them. Some example guidelines [2] include

(1) Make parts with as many symmetries as possible.
(2) When machining a component, it is best to restrict machining to one surface to avoid reorienting the component.
(3) When injection molding, keep the main wall thickness as uniform as possible.

Most are not difficult concepts. However, there are so many guidelines that they begin to blur and it is tempting for students to not take them seriously.

In this case, it is important to help students understand the extent of the impact when the guideline is *not* met. Student thinking must be changed from “Yeah, yeah. I get it. Don’t stamp narrow cut-outs in sheet metal parts." to "Definitely do NOT try to stamp narrow cut-outs!" In other words, when there is a long list of guidelines, it is difficult to keep them all in mind when evaluating a design. But after an experience with many broken punches trying to stamp a narrow cut-out, it will not be something often overlooked during the evaluation. It has become a feature that jumps out at the engineer.

Automatic Assembly Activities

One unit in the course MFET 314 Design for Manufacturability covers automatic assembly. Activities emphasizing two guidelines from this unit are described.

Guideline 1: Avoid the necessity to hold down a part/parts while assembling additional components. This is a guideline for all assembly, but is especially important for automatic assembly. Simple idea. Easy to follow. But the goal is to have students so aware of this idea that they automatically, almost subconsciously, start to evaluate a product design as to whether or not it meets this guideline.

Activity 1: Have a bolt taped to the table (or glued to a small piece of metal) so it is facing up. Place a spring on the bolt. Be sure the spring is longer than the bolt. Give the student kitchen tongs. Using the kitchen tongs as a gripper, challenge the student to put the nut on the bolt with the spring. See Figure 1. To do this, the spring must be compressed.

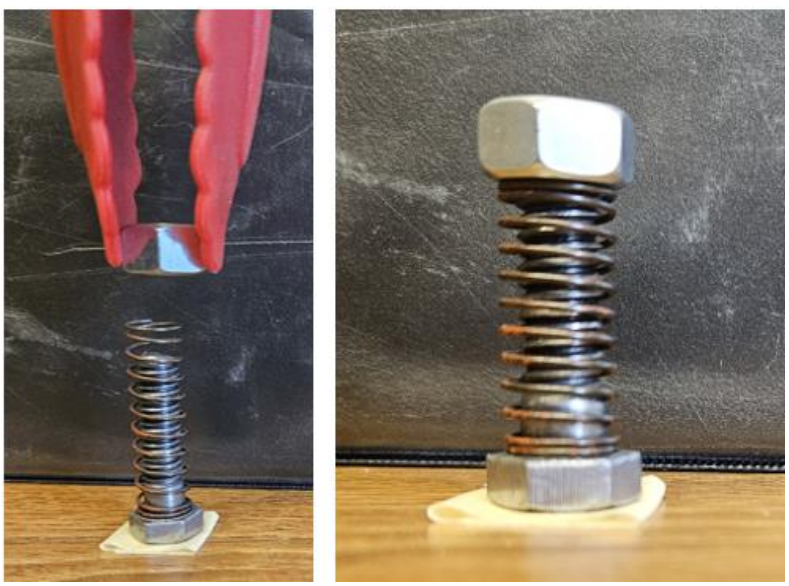

Fig. 1. Spring on the bolt … secured with the nut.

Explain that the student is only allowed to move like an industrial robot arm. And since most industrial robots have only one arm (two is expensive!), then they can only use one arm. They must grip the tongs as demonstrated to better simulate the same amount of control a robot would have. See Figure 2. Watch students at this point. They tend to ignore this instruction and therefore "cheat." Harder to control are the micro-adjustments that a human arm makes that a robot arm often cannot.

Fig. 2. Proper hold for the tongs.

If students are not doing micro-adjustments, they will find this is essentially impossible. The spring will nearly always knock the nut out of alignment. At this point, discuss changes to the process and/or design that would make it possible. If a second robot arm is not practical (as is usually the case), students usually next suggest a fixture of some type to hold the spring down. The question then becomes – if the process is supposed to be automatic, how is the spring placed in the fixture? A second robot arm? But that was deemed economically infeasible. A person? But then it is not an automatic process.

Discussion eventually turns to considering what else can be done to make sure this guideline is met. The original goal was to suggest changes to the design of the component – not the process. So return to that idea. How can the component be changed? At this point students start to consider making the spring shorter or the bolt longer to eliminate the need to hold the spring down during assembly.

Guideline 2: Avoid parts that nest, tangle, or shingle. Although this is also helpful for manual assembly, it can be extremely difficult for automatic equipment to separate such parts.

Activity 2: Lay out a strip of paper to simulate a conveyor belt. Use a small dish (a butter dish works well) to hold 3 dozen regular paper clips. Shake the dish first to simulate a vibratory bowl feeder. Then have the student simulate feeding the parts by gently shaking the dish to spread the clips roughly evenly along the “conveyor” (strip). See Figure 3.

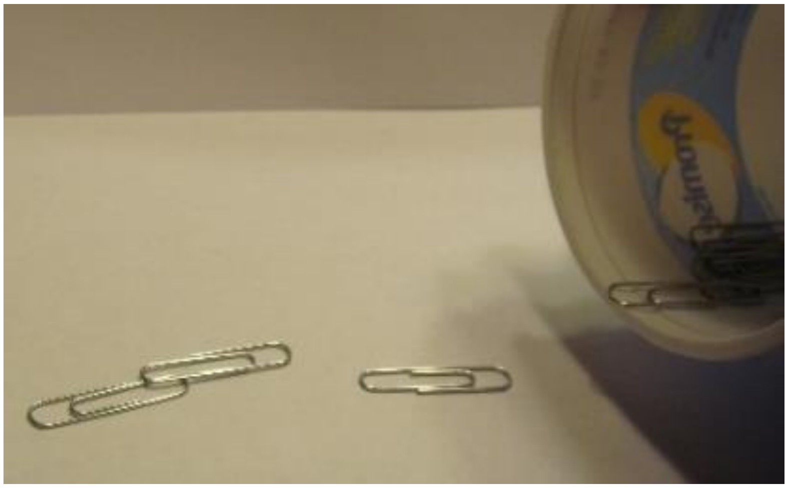

Fig. 3. Distributing the clips.

Take 2 dozen paper clips and pull them apart slightly. See Figure 4. Put these modified clips in the dish and repeat the simulation. The pulled-apart clips will tangle terribly and fall in clumps. See Figure 5. It is not possible to spread them out on the "conveyor."

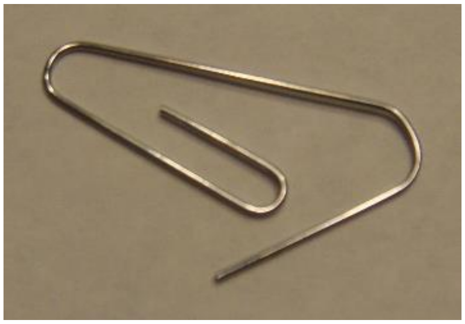

Fig. 4. Modified paper clips.

Fig. 5. Clumped paper clips.

This activity is usually quick because students can immediately see that this is not just an obvious guideline, but a major issue, one that cannot be ignored. As a follow-up, students can be asked, “Which of these two parts should be recommended?” See Figure 6. Before this activity they typically choose part A, believing it would make assembly easier. After the activity, the obvious choice is part B.

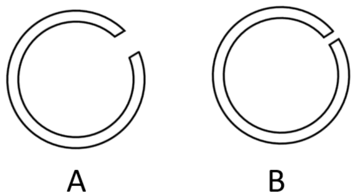

Fig. 6. Follow-up question.

An additional bonus for these activities is that they are effective as demos when recruiting students. They are easy to transport, fun, and give prospective students a glimmer of what the field of manufacturing entails.

Summary

Familiarity with the guidelines for automatic assembly can be accomplished using nuts, bolts, butter dishes and paper clips. Students often dismiss the guidelines as “obvious” and approach these activities as simple tasks. But they soon start to express frustration as they struggle to accomplish tasks that violate the guidelines. Eventually they start to indicate they understand how critical it is to meet them. After repeatedly trying to secure the spring with the nut, one student remarked “This is a good activity. It *really* drives home the point,” which is the goal. Subsequently, when evaluating designs for manufacturability, students rarely fail to note when these issues exist and are quick to suggest changes to the design of the component.

Simply reading the guidelines is often not enough for a student to truly appreciate their importance. Experience with the resulting struggles that arise when a guideline is violated can be very effective at cementing these principles in the student’s mind.

References

[1] N.K. Sundheim and E. Little, Developing At-Home Labs for Online Courses. *Lilly Conference on College & University Teaching and Learning*: Austin, TX. January 7, 2018

[2] G. Boothroyd, P. Dewhurst, & W. Knight, *Product Design for Manufacture and Assembly*, 3rd Edition, CRC Press, 2010.

Biography

NANCY SUNDHEIM developed and is currently the director of the Manufacturing Engineering Technology program at St. Cloud State University. She has degrees in Math, Mechanical Engineering, Statistics, and Industrial Engineering. Her favorite place to be is at the intersection of manufacturing engineering and statistics with special interests in lean manufacturing, ergonomics, and continuous improvement. She passionately applies continuous improvement principles to her teaching as well.