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Streamlining the Design of Custom Industrial Machinery

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Introduction

As rapid launch of new products becomes a must, manufacturers of industrial machinery face significant challenges. They must develop better and more complex machines, deliver them in a shorter time frame and often at a lower cost, just to stay competitive. Engineering companies specializing in custom, application tailored equipment find themselves in a unique situation, being heavily relied upon to deliver a machine that works out of the box with little to no testing or modification allowance. This is in contrast to high-volume machinery, which allows for more iterations and whose engineering and validation costs are absorbed and justified through amortization. For this reason, engineering companies of custom machinery must have a close relationship with the customer and have an intimate understanding of a machine's performance requirements and cost targets before engineering design work begins.

Discussion of Challenges

In the initial phase of a project, the customer may be faced with a myriad of choices including whether to purchase an off-the-shelf machine, or design a machine in-house, or outsource the design of a custom machine.

Sometimes an off-the-shelf solution just won't work for the task at hand. The commercial machine may be too costly, the cycle time may be too slow, or perhaps the customer's process is just too unique. The next question may be, "Can we develop the machine ourselves in-house"? This question deserves special attention and consideration. The pitfall is believing that since your engineers excel in area A, then they will easily be able to adapt to area B. Unless the engineers are accustomed to working on a variety of machines or have experience in this area, there may be a steep and expensive learning curve. In certain cases, it is more cost-effective to outsource the design of a custom machine. Generally, the best approach in this case is to find an engineering company that has built similar machines, or has the tools and technical know-how to do so. Be wary of the commodity manufacturer that claims they can build a custom machine or adapt their off-the-shelf solution to meet your needs. Unless they have a track record of delivering or can provide evidence, it is best to go with a company whose business is custom machines.

Outsourcing Considerations

Once the choice of outsourcing a machine is made, there are key steps that should be taken to ensure the success of the project. Communication between the customer and engineering contractor is essential. Before design work begins, the two parties must determine the following:

- Performance and Packaging Requirements
- Cost Targets
- Timing

These requirements seem basic, but performance and packaging requirements from the customer are sometimes scarce. The reason being, the machine may be so novel that the customer isn't sure what the requirements should be, or perhaps the customer is venturing into a new area. The best approach in this case, is to put the engineering contractor in charge of writing requirement and packaging specifications. The upfront cost of this approach is more expensive, but will pay for itself in the long run by minimizing costly design changes midway through a project.

Only after project requirements are well-defined, should engineering design work begin. During this phase, the contractor and customer may plan on meeting weekly or bi-weekly. In-person meetings or remote, web-based design reviews are helpful to ensure that expectations of both parties are met and project scope creep is avoided.

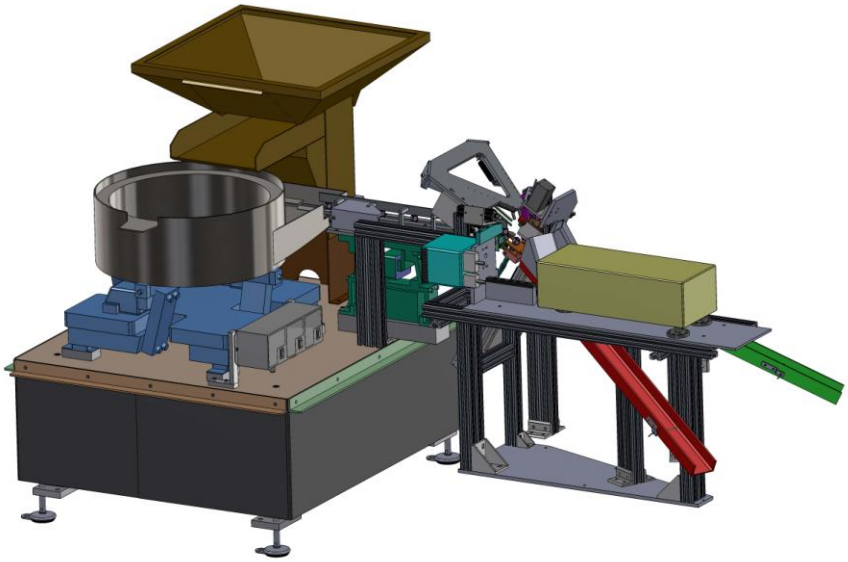

Figure 1: Machine designed to laser mark a cylindrically-shaped medical device at various locations

Design Methodologies

When designing a custom machine, it is best to avoid "reinventing the wheel", meaning off-the-shelf machine components should be used whenever possible to reduce cost. Because engineering time is often compressed for a custom machine, in most cases it is best to error on the safe side and design for robustness. When possible, engineering should include hand calculations and use simple, and quick engineering software tools. For instance, 3D CAD software enables the engineer to perform quick 2D and 3D motion studies that can be used to verify functionality and avoid interference of moving parts. Likewise, finite element programs

integrated into CAD packages may be used to produce estimates of stress values. When designing frames and other structures, software capable of analyzing beam models (2D mathematical model of a structure) is often sufficient. If multiple machines will be produced, then it makes economical sense to spend more time performing detailed engineering studies such as comprehensive FEA analysis to reduce weight, parts standardization, and finding alternative sources of hardware for cost reduction.

Other considerations include serviceability and supplier availability. The machine should be designed in such a way that if failure of a replaceable component occurs, downtime is minimized. When specifying hardware, components should have short lead times and be readily available. Custom components such as fabricated frames and machined parts should be designed so that many supplier options exist. In rare cases, if a unique part is required, then a reputable supplier should be sourced by the designer.

Brief Example of a Custom Designed Machine

Shown in figure 1, is an example of a custom machine designed for the medical industry. The machine is used to laser mark a medical device consisting of a cylindrically-shaped plastic component.

Various challenges existed, including precise presentation of the part to the laser, orientation of the workpiece to achieve multiple marking locations, and also ejection of the part into either an acceptance or a rejection bin if the marking was determined unacceptable by a vision system.

Proof Engineering worked closely with the customer to understand requirements such as marking location tolerances, throughput requirements, and cycle times. An off-the-shelf laser was used for marking and a bowl feeder supplier was utilized to consistently orientate the part.

Once the project was fully defined, engineers used various tools to design the machine. In the beginning phases of the project, tools such as hand calculations and rough sketches were utilized to brainstorm possible solutions. After all possibilities were evaluated, the concept was then realized through CAD design and in this case, FEA analysis which was used to simulate a complex motion in one stage of the process.

Following various meetings and customer approvals, a drawing package was created and custom components were sent to suppliers for fabrication. Several weeks later, the machine was assembled, checked for accuracy, and delivered to the customer for integration into their manufacturing process line.