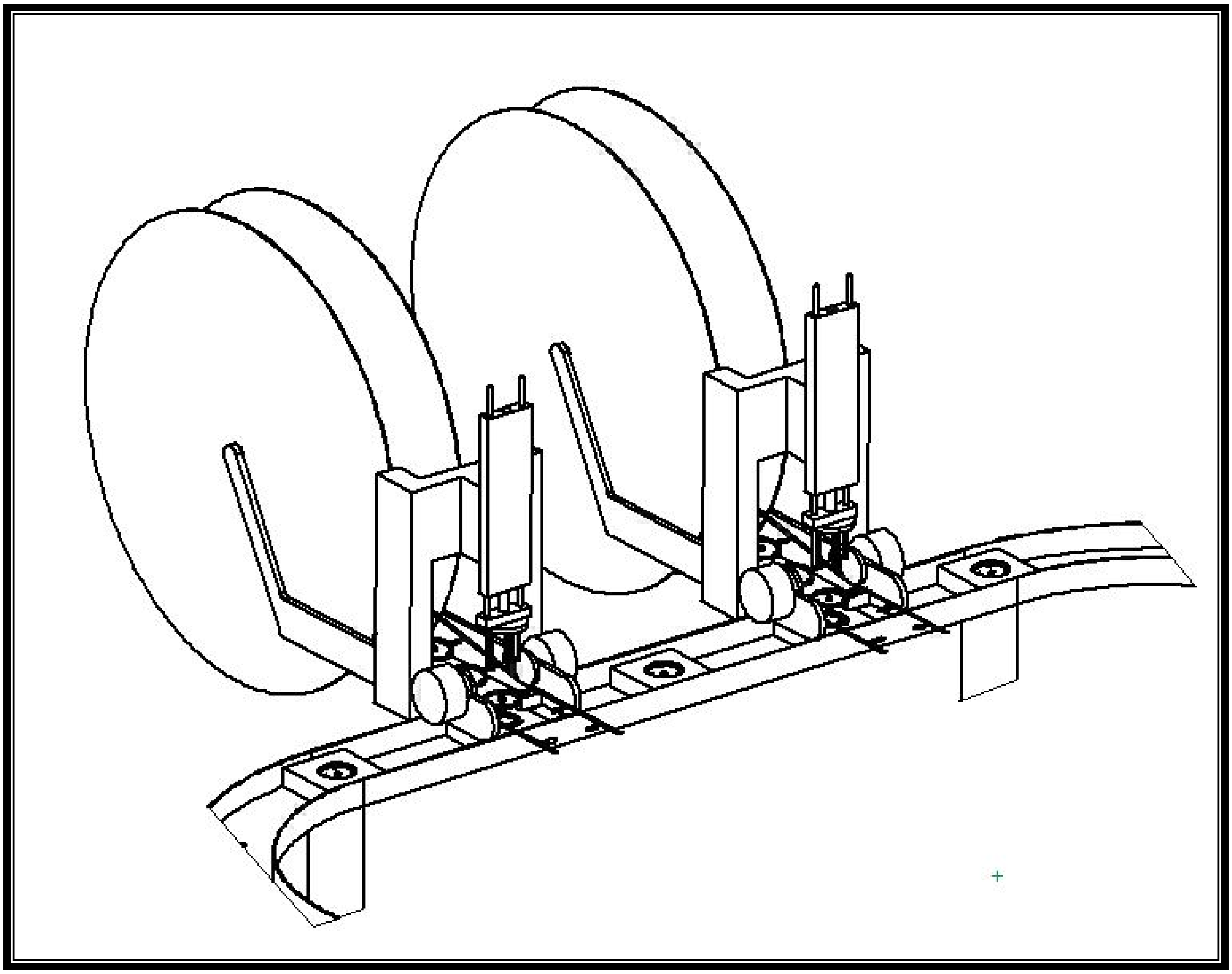
Aligned Parts Assembly System:
An Innovative Approach for Small Parts Assembly



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Overview

The Aligned Parts Assembly System (APAS) has the potential to revolutionize assembly operations.[1] APAS is an innovative, low-cost, manufacturing assembly approach that increases the speed, accuracy, and repeatability of low volume production runs while significantly reducing labor costs. Unlike traditional manual assembly or expensive robotic placement processes, APAS maintains component orientation from part creation through final assembly, thus eliminating the need for re-orientation of the component. APAS can provide high speed precision assembly for small batches at competitive prices.

Background

Manufacturing in the U.S. can continuously and significantly benefit from a better, less expensive means of manufacturing low volume production batches. Typically, small batch runs utilize manual assembly rather than cost prohibitive robotic or automated assembly methods. In order to compete in the new global economy, many American businesses have gone overseas to countries like Taiwan, India, and China to satisfy the demand for less expensive products due to cheap labor rates. "The competitive pressure on U.S. manufacturers has forced them to cut costs, to adopt lean manufacturing techniques and to implement quality assurance programs that guarantee zero defects in production. Innovation in products, processes, and services has become a key determinant for success."[2] Many larger manufacturers have implemented dedicated automated assembly equipment or more robust robotic assembly lines to increase productivity. These solutions work well for high volume production, while low volume production is left to manual assembly. The need exists for a new approach to part production, storage and assembly on demand that will lower cost, enable fast, accurate, short-term production, and that can quickly become a national production standard.[3]

Solution & Technical Approach

Traditional manufacturing methods lose orientation as the part is ejected from the mold and fall into a bin. At time of assembly, part orientation and placement must be reestablished by one of three methods: 1) manually by a human operator, 2) robotically using a robotic arm and grippers, or 3) automatically using expensive, specialized automated assembly equipment, typically dedicated to perform one task.

APAS is a paradigm shift from traditional injection molding methods as it captures the natural orientation of a component inherent to a mold prior to the ejection cycle. By capturing and maintaining part orientation throughout the remaining manufacturing and assembly processes, the need for additional equipment or labor to re-orient parts during assembly is eliminated. Similar in concept to existing tape and reel systems used in the electronics industry, APAS utilizes an indexed carrier with parts set at pre-determined intervals. For APAS, the carriers enter the mold and the plastic is molded onto the tab of the carrier, thus securing the natural orientation of the part. Assembly then becomes a simple operation of trimming the part from the carrier system and placing the part directly into the assembly in its proper location and orientation with no additional manipulation required.

Component design can be simplified by using APAS. Design for Manufacturability (DFM) promotes the simplification of parts through symmetry. When components cannot be symmetric, DFM promotes the exaggeration of the asymmetric features to facilitate orientation and inhibit improper assembly.[4] Exaggeration of asymmetry is even more critical for orientation of components associated with automated assembly.[5] Since component orientation is secured with APAS, the exaggeration of asymmetric features is no longer necessary, component design can be simplified, automated orientation equipment is no longer required and parts cost can be reduced. Maintaining proper orientation for assembly is an important strategy in DFM, which APAS supports.

APAS is not limited to plastic injection molding. The methodology behind APAS can be applied to many processes, but the most significant are: plastic injection molding, metal injection molding, metal stamping, drawing, and casting.

APAS equipment will be adaptable and able to create components of various sizes and shapes, allowing for multiple customers' parts to be run on the same equipment. Therefore, APAS capital equipment costs can be distributed to each company that performs each task. For example, a plastic injection molder would purchase the APAS mold equipment that could be quickly attached to different molds to capture the various components being created (*see Figures 1 & 2*). Figures 1 & 2 illustrate a typical molding machine (1-B) with APAS equipment attached. Two feed reels (1-C) containing carrier material (2-G) feed through the guide (2-F), attach to the component (2-D) and are spooled onto the take-up reel (1-A) which is then used for component storage for subsequent processes.

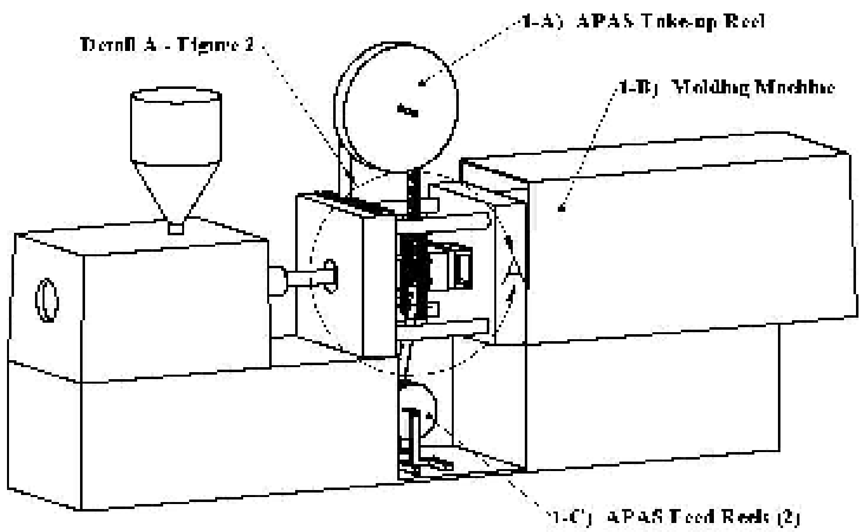

Figure 1 - APAS attached to a molding machine

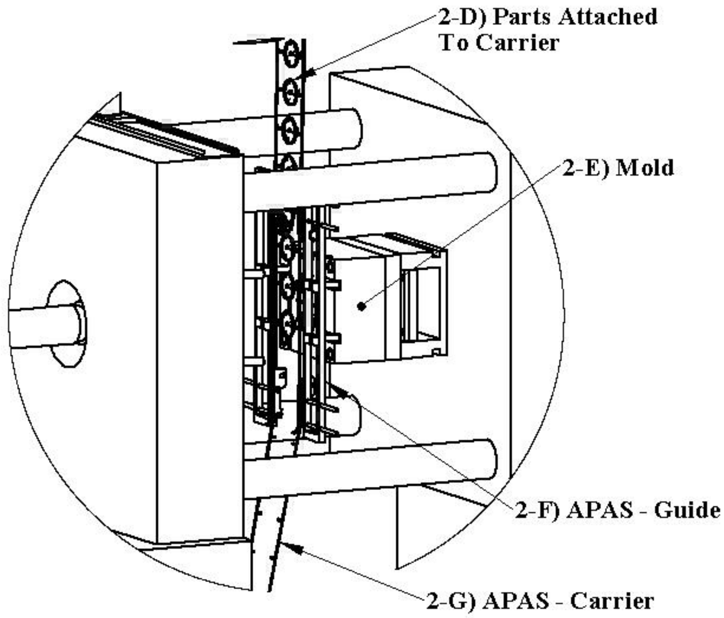

Figure 2 - Detail A

Figure 3 is an example of equipment that a decorative finishing house/ plater would purchase: an APAS drive system (3-K) with a feed reel (3-H) and a take- up reel (3-J). The decorative finishing booth (3-I) could be a pad printer, an offset printer, or a spray booth for decorative coating or plating. APAS eliminates the need for any handling of components during these processes.

Figure 4 illustrates trim and place machines, integrated with a conveyor system (4-O), that an assembly house would purchase. Parts come off the feed reel (4-L) into the trim-n-place machine. As the trim head (4-M) proceeds downward, the part is secured by suction cups and then trimmed from the carrier. At the bottom of the cycle, the part is placed directly into a nest (4-N) or the assembly. The conveyor system will then take the nest on to subsequent stations until final assembly is achieved.

Using APAS leaves a relatively small investment by the customer for any customized tooling that may be required. With robust APAS equipment, and by distributing the costs to each specialized manufacturer, production runs with lower volumes can benefit from automated assembly.

The following theoretical case study was performed using Boothroyd/Dewhurst's (B/D) DFM methodology to analyze and compare

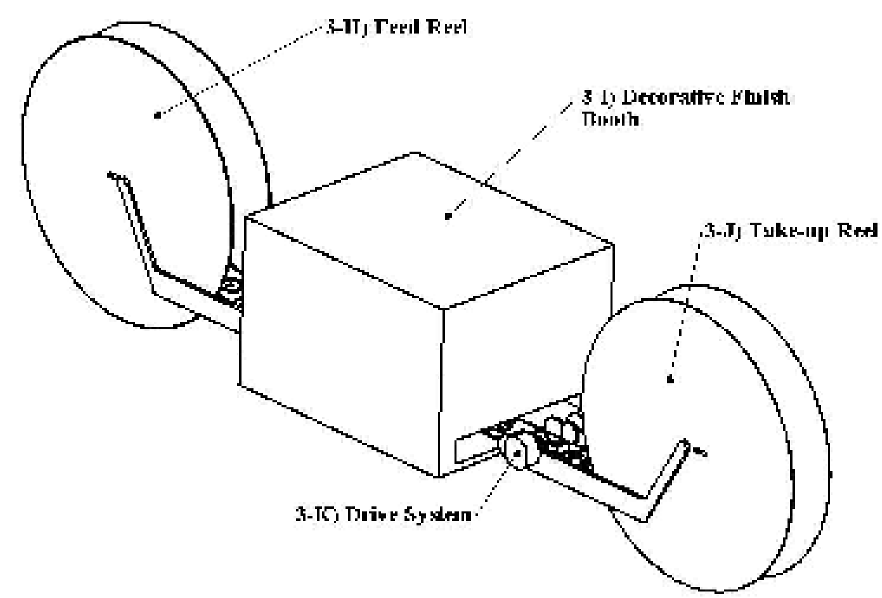

Figure 3 - Example of APAS Drive Attached to a Decorative Finish Booth

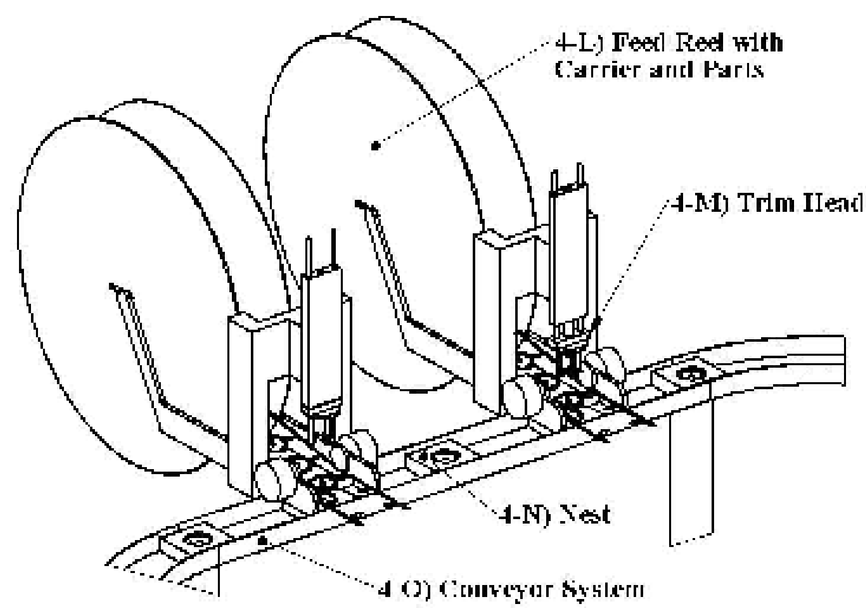

Figure 4 - APAS Trim-n-Place Assembly Equipment (Two Shown with Conveyor)

manual assembly, APAS and a conventional automation process. A television remote control was the object analyzed for the case study. The assembly consisted of four plastic components, a PC board, battery terminals and screws. Some general assumptions were made: 1) labor and burden rate of $23.40 per hour, 2) a daily shift consisting of 8 hours, 3) a cost of $3.42 for all components without any labor included and 4) an annual usage of 100,000 components. From the B/D analysis, cycle times were derived and used to determine production requirements and process capabilities shown in Table 1. APAS dramatically improves line capacity over manual assembly from 780 to 8,734 units of daily production, while reducing the daily number of assembly-hours required from 16 to 1.9. These two factors play a major role in reducing the cost to manufacture. Table 2 shows the results of the study. Although the cost of capital equipment is greater for APAS than manual assembly, the reduced amount of necessary labor keeps the overall cost of APAS lower. According to the case study, possible labor savings of APAS over manual assembly could be as much as 95%. Figure 5 is a chart projecting the return on investment of each manufacturing technique. The break even cost for using APAS versus manual assembly could be as little as 31 days. As seen in Figure 5, the cost to implement a typical automated assembly process has a break even point of about 393 days, which, for many low volume products, is too great an investment to justify.

Table 1 - Case Study Production Requirements

Description	**Manual Assy**	**APAS**	**Automation**
Cycle Time	32.32	2.50	1.75
Takt Time	64.64	14.50	14.50
Down Time (breaks, parts)	1.0	1.9	0.05
Line Capacity (Daily)	780	8,734	16,354
Lines Required	1	1	1
Days of Production for Yield	128.3	11.4	6.1
Man Hours Req'd (Daily)	16.0	1.9	1.0
Scrap Rate	10.0%	1.0%	1.0%

Table 2 - Case Study Summary

Description	**Manual Assy**	**APAS**	**Automation**
Cost of Equipment	$ 35,800	$ 135,200	$ 264,000
Cost of Components	$ 342,000.00	$ 344,027.93	$ 342,000.00
Cost of Labor & Burden	$ 97,101	$ 1,511	$ 572
Cost of Poor Quality	$ 50,310.14	$ 3,420.00	$ 3,420.00
Total Cost (First Year)	***$ 525,211.55***	***$ 484,159.26***	***$ 609,991.90***
Total Cost (Second+ Years)	***$ 489,411.55***	***$ 348,959.26***	***$ 345,991.90***

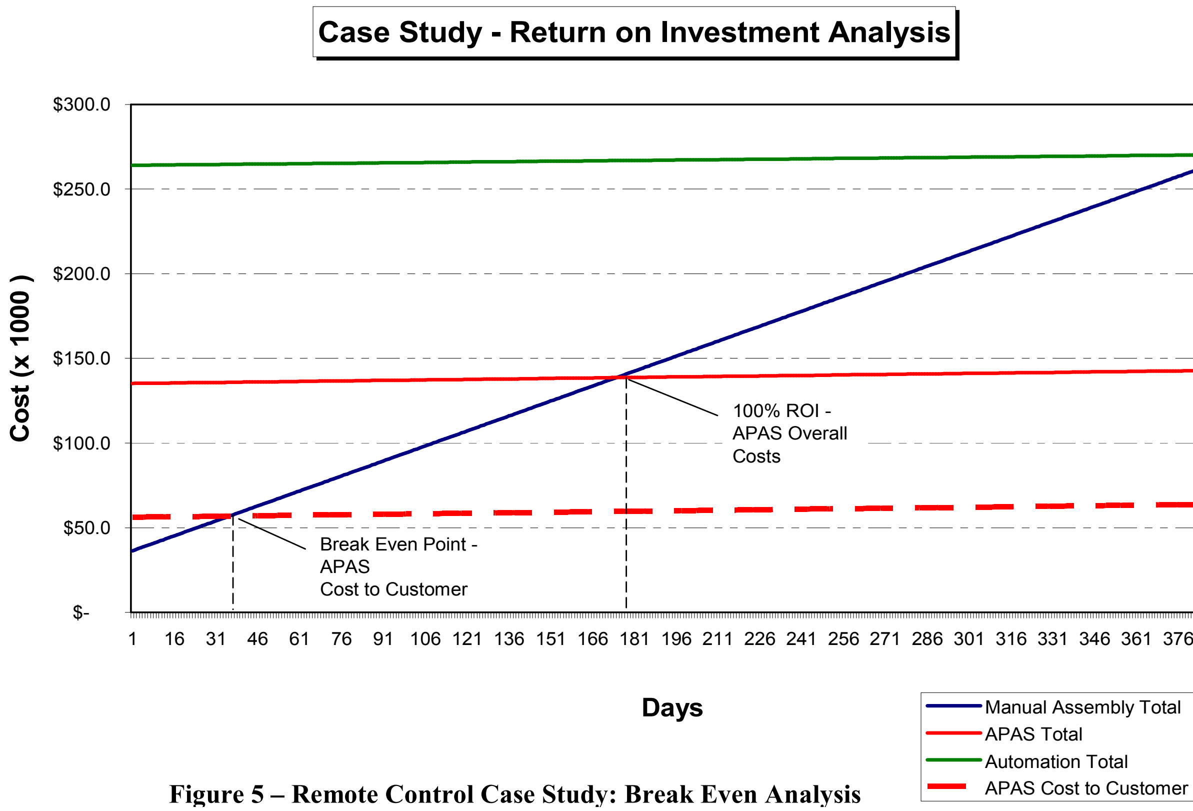

Figure 5 – Remote Control Case Study: Break Even Analysis

Benefits

The overall objective of APAS is to help reduce costs and increase speed and accuracy of low volume production runs. Benefits include:

- High speed capability for low volume production batches
- Improved quality through increased uniformity and repeatability
- Reduced parts costs through simplified designs by reducing the amount of DFM features for proper alignment in the assembly
- Estimated labor cost savings of up to 95% compared to manual assembly
- Less handling of components

There are many possible components that could benefit from APAS. Here are just a few examples:

> Cell phones, two way radios, music players, remote controls, video games, toys, navigation systems, stereos, hand tools, computer peripherals, sporting goods, and much more.

Conclusion

APAS is a disruptive small production run assembly manufacturing process. As such, APAS will make a significant and relevant impact on costs of products requiring high-speed precision in small batches, run on intermittent schedules where minimal inventory is desired. Using APAS can reduce labor costs by up to 95% while improving product quality, uniformity, and repeatability. APAS incorporates the best principles of Lean Manufacturing, Design for Manufacturability, and Six Sigma to significantly increase speed to market, Just in Time inventory fulfillment and optimal production.

America's competitiveness depends on using its creative capabilities to significantly improve the nation's manufacturing processes and systems. The Aligned Parts Assembly System is a 21st century paradigm-shifting, creative innovation—much like Ford's assembly line was in the 20th century—that will significantly improve the manufacturing advantage of the United States.[6]

[1] Strong, Dr. A. Brent, "Aligned Parts Assembly System – Reflections and Comments", Aug. 2006
[2] "Manufacturing in America", US Dept. of Commerce, Jan. 2004, p. 7, http://www.ita.doc.gov/media/Publications/pdf/manuam0104final.pdf
[3] "BAA 06-34: DISRUPTIVE MANUFACTURING TECHNOLOGIES (DMT): Proposer Information Pamphlet", p. 1.
[4] Boothroyd, G., Dewhurst, P. and Knight, W., "Product Design for Manufacture and Assembly", Marcel Dekker, Inc., 1994, p. 64.
[5] *Ibid*, p. 166.
[6] Strong, Dr. A. Brent, "Aligned Parts Assembly System – Reflections and Comments", Aug. 2006.