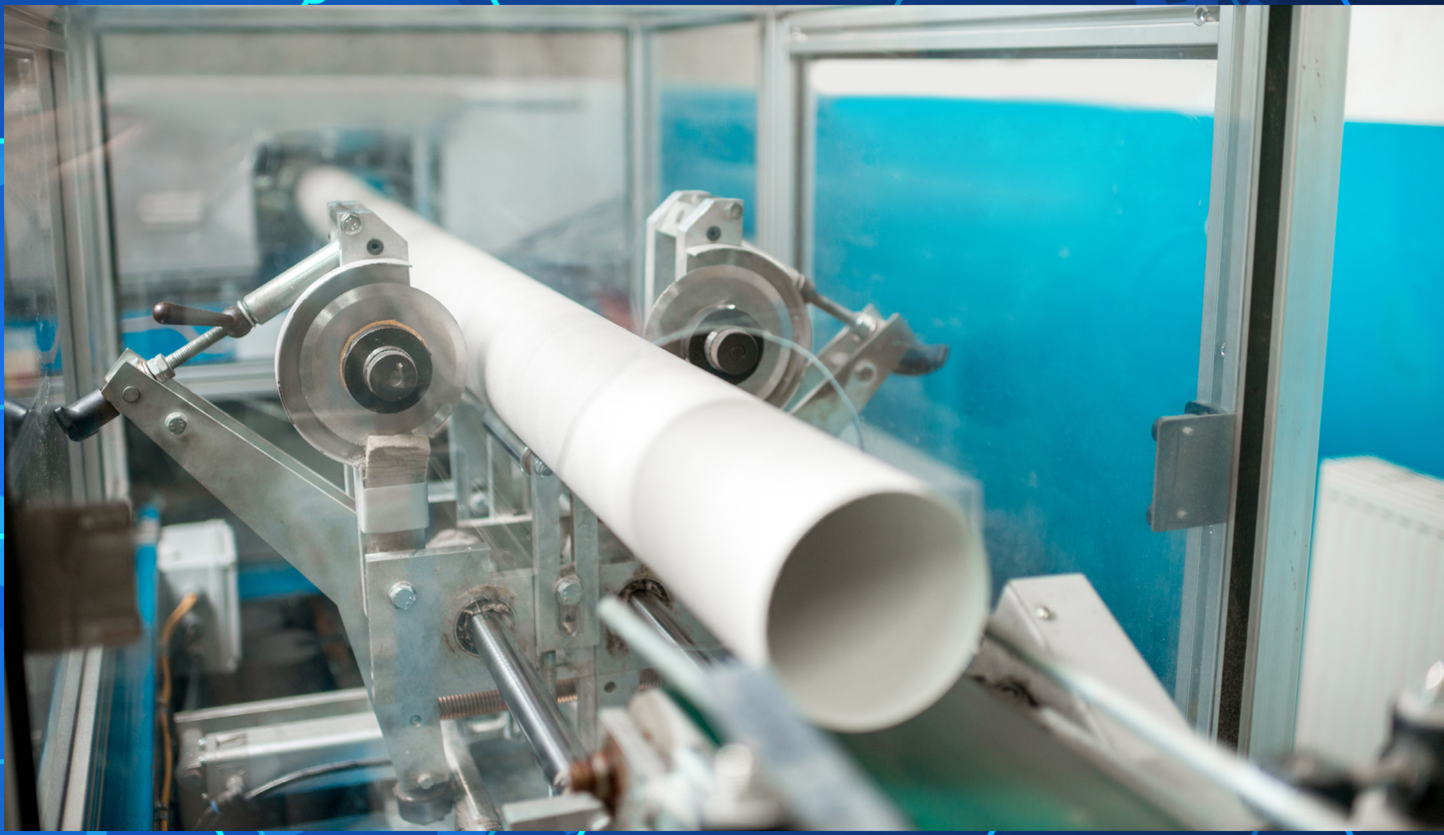
WHITE PAPER

INDUSTRIAL INDEXING SYSTEMS, INC.

Reciprocating Cutoff System



Reciprocating cutoff machines are commonly used in industries such as metal fabrication, construction, automotive, and woodworking. Servo Motion Control technology is ideal for the straight, precise cuts in materials of varying thicknesses.

Reciprocating cutoff machines offer high speed material throughput for excellent cutting, punching, or stamping accuracy.

Precise, accurate and uniform cuts using servo technology

Servo motion control systems can play a crucial role in the reciprocating cutoff machine industry by providing precise and accurate control over the machine's cutting motion. Here are some ways servo motion control systems can benefit this industry:

- **High-Precision Position Control** allows the cutoff machine to accurately position the cutting tool at specific points. This ensures precise cutting lengths, minimizing errors and material waste.

- **Speed Control** enables precise control over the cutting speed, allowing for consistent and uniform cuts. The cutting speed can be adjusted based on the material being cut, ensuring optimal results and preventing damage to the material or the machine.

- **Acceleration and Deceleration Control** of the cutting motion, ensures smooth and controlled starts and stops. This feature reduces the likelihood of jerky movements or sudden impacts, which can cause damage to the machine or affect the quality of the cut.

- **Dynamic Response** capabilities can quickly and accurately respond to changes in cutting conditions or input commands. This excellent responsiveness allows for efficient and adaptable cutting operations, accommodating varying material properties and cutting requirements.

- **Programmability and Flexibility** are two features that can be easily adjusted to accommodate different cutting profiles, lengths, or patterns. This flexibility allows for versatile operations and the ability to adapt to changing production needs without requiring extensive manual adjustments.

- **Monitoring and Feedback** devices such as encoders, resolvers and controllers provide real-time information about the position, speed, and other parameters. This data can be used for monitoring and quality control purposes, ensuring that the cutting process remains within specified tolerances.

Overall, servo motion control systems enhance the precision, speed, flexibility, and overall performance of reciprocating cutoff machines. By incorporating these systems, the industry can achieve higher productivity, improved product quality, and reduced waste, ultimately leading to increased efficiency and profitability.

Reciprocating Cutoff System Analysis

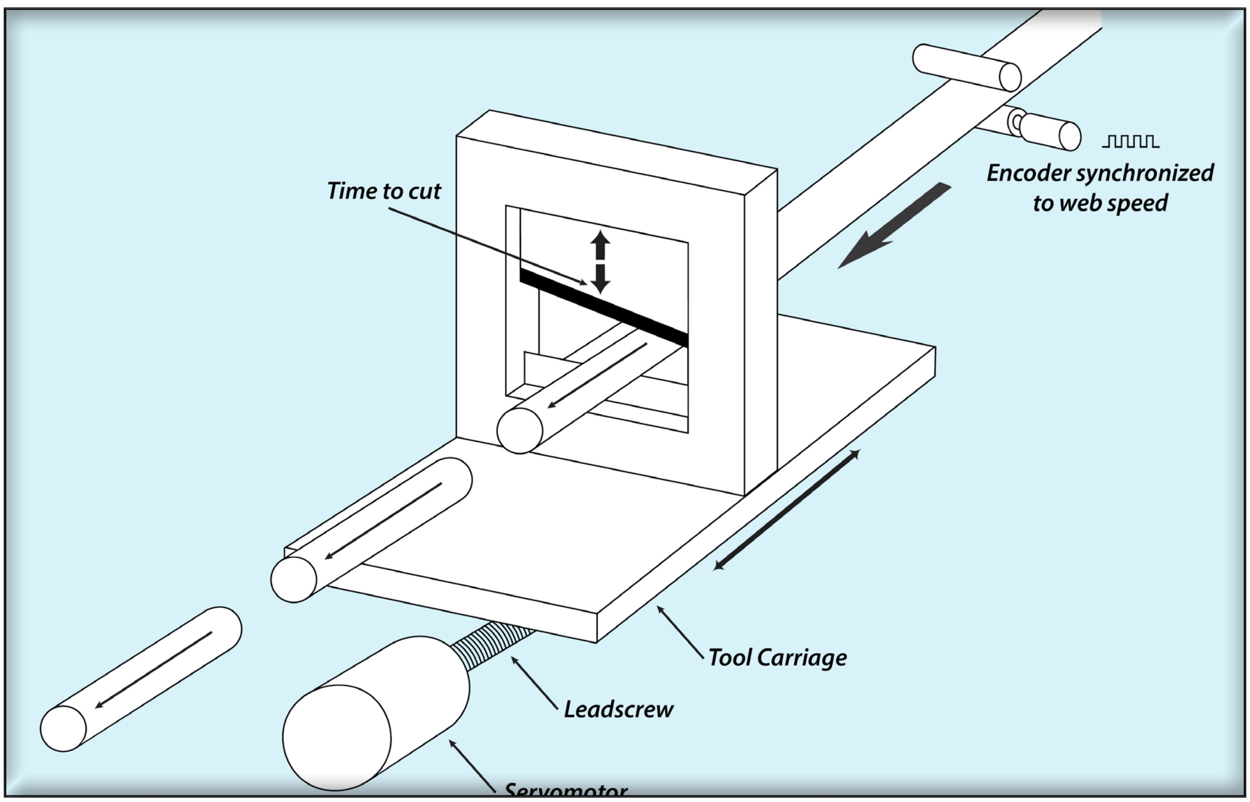


Figure 1 - Reciprocating Cutoff System

Mathematical/Graphical Model For A Reciprocating Cutoff System

A simplified mathematical model in conjunction with Industrial Indexing Systems servo-mechanical analysis (SMA) service will size a motor and drive for a variety of reciprocating cutoff applications.

The high throughput of a reciprocating cutoff system is achieved by running the material to be processed (known as the web) through the machine at a high, constant rate of speed.

A cutting, punching, stamping, or sawing tool is mounted on a carriage which reciprocates along an axis parallel to the continuous movement of the web. The velocity profile of the tool carriage's "forward" motion is designed to accelerate the tool to the point where its velocity matches that of the web (see figure 2). The velocities stay matched while the material processing occurs. Because there is no position or velocity error between the tool and the web during this time, the accuracy of the cutting, punching, or stamping is

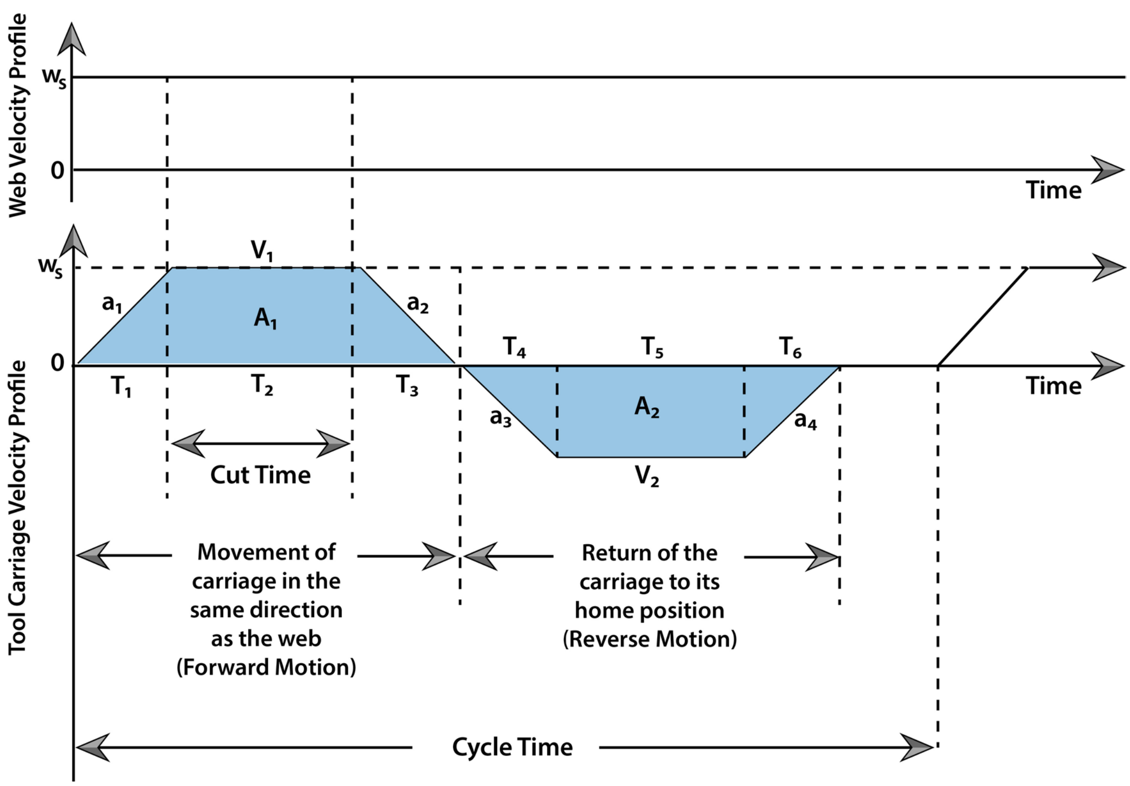


Figure 2. Velocity profile of the web and the tool carriage

excellent. When the processing of the material is complete, the tool carriage decelerates to a stop and then reverses its motion to return to its home position. The cycle is then repeated for the next item to be processed from the web.

As shown in figure 2, the velocity of the tool carriage must match the speed of the web (V1 = WS). However, subject to two constraints, any value could be selected for the acceleration/deceleration rates (a1, a2, a3, a4) and the maximum reverse velocity (V2). The first constraint is that the tool carriage must return to its home position after each cut. Graphically, this means that the area under the curve of the forward movement of the carriage must be equal to the area under the curve of the reverse movement of the carriage (A1 = A2). The second requirement is that the motor and drive must be physically able to drive the carriage at the selected accelerations and velocitites.

It is important to note that if each of the acceleration and deceleration rates (a1, a2, a3, a4) are different from each other, the profile becomes much more difficult to model. To keep the model as simple as possible, Industrial Indexing Systems, Inc. (IIS) has chosen the tool carriage velocity profile shown in figure 3.

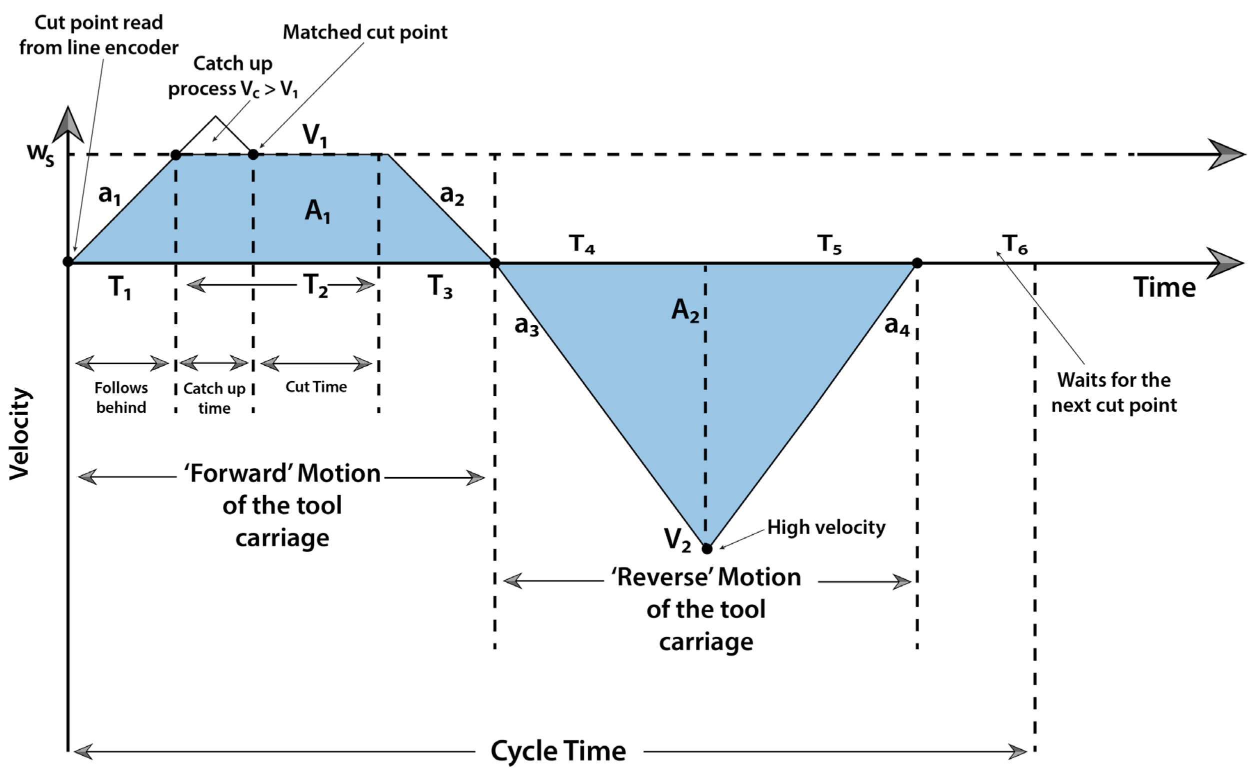


Figure 3. IIS model for the velocity profile of the tool carriage

Some Of The Key Points Of The IIS Model Are:

- The forward velocity of the tool carriage is equal to the web speed (V1 = WS) during the cut time

- The acceleration and deceleration rates are held constant throughout the entire profile (a = a1 = a2 = a3 = a4) and the acceleration and deceleration times of each half of the profile are equal. (ie. T1 = T3, and T4 = T5). However, T1 will always be less than T4.

- The time needed for the tool carriage to return to its home position has been minimized through the use of a triangular velocity profile move. With this triangular profile the carriage ramps up its maximum reverse velocity and then immediately begins to decelerate at the same rate to its home position. The time to execute the reverse motion of the carriage has been minimized to keep the overall cycle time of the carriage's move as short as possible.

- Because of its triangular velocity profile, the reverse motion is more difficult for the servo system to execute than the forward motion. When evaluating motor/drive packages the user should select only a motor/drive combination which can deliver margins of 100% or more of the RMS torque required by the system for the reverse-motion of the carriage. This high margin is required for the system to make the immediate transition from forward to reverse motion.

- The tool carriage may begin its next cycle immediately after reaching its home position from the previous cycle. Therefore, time T6 can be zero.

Production line of a wooden floor factory using reciprocating servo technology

The IIS model carriage offers the following equations to describe the velocity profile of the tool carriage:

$$T_4 = T_5 = \frac{(K_1)(K_2)}{2(W_S)(K_1 + K_2)}$$

Note: $K_1 = L_C + (W_S)(T_2)$

$K_2 = L_C - (W_S)(T_2)$

$$a = \frac{2(W_S)^2}{L_C - W_S(T_4 + T_5 + T_2)}$$

$$T_1 = T_3 = \frac{(L_C/W_S) - (T_4 + T_5 + T_2)}{2}$$

$C_T = (a)(T_4)^2$

$V_F = (W_S)(60)/S_P$

$V_R = (a)(T_4)(60)/S_P$

Where:

W_S	=	Web speed (inches/second)
$T_1 = T_3$	=	Acceleration/Deceleration time for forward travel of the carriage (seconds)
T_2	=	Cut Time (seconds)
$T_4 = T_5$	=	Acceleration/Deceleration time for the reverse travel of the carriage (seconds)
a	=	Acceleration of the carriage (inches/second) (A constant throughout the entire motion profile)
L_C	=	Distance between cuts on the web (inches)
C_T	=	Carriage Travel (inches)
K_1, K_2	=	Constants, used for intermediate calculations only (inches)
V_F	=	Forward Velocity of the carriage (RPM)
V_R	=	Reverse Velocity of the carriage (RPM)
S_P	=	Screw pitch (or lead) (inches/revolution)

Industries That Use The Reciprocating Servo Technology:

Reciprocating servo technology, which involves back-and-forth linear or rotary motion achieved through servo control, is utilized in various industries where precise and controlled reciprocating motion is required. Some industries that commonly use reciprocating servo technology include:

- **Manufacturing:** Reciprocating servos are employed in manufacturing processes that require precise material handling, assembly, packaging, and quality control. They ensure accurate positioning and motion control for consistent production.
- **Automotive:** Reciprocating servo systems are used in assembly lines for tasks such as welding, painting, and component placement, ensuring precise positioning and controlled movement during manufacturing.
- **Pharmaceuticals:** In pharmaceutical production, reciprocating servos can be used for dosing, filling, and capping processes in the packaging of medications and medical supplies.
- **Packaging:** Industries that involve packaging products, such as food and beverages, consumer goods, and cosmetics, use reciprocating servos to control the movement of packaging materials and products on conveyor systems.
- **Printing:** Reciprocating servo technology is employed in printing presses and equipment to ensure accurate paper feeding, registration, and alignment for high-quality printing results.
- **Textiles:** Textile machinery uses reciprocating servos for processes like fabric cutting, sewing, and embroidery, ensuring precise patterns and designs.
- **Material Handling:** Industries that deal with moving and positioning materials, such as warehouses, logistics, and distribution centers, utilize reciprocating servo systems for efficient and accurate material handling.
- **Aerospace:** In aerospace manufacturing, reciprocating servo technology is used for precision drilling, riveting, and assembly of aircraft components.
- **Electronics:** Electronics manufacturing employs reciprocating servos in pick-and-place machines, soldering equipment, and surface mount technology (SMT) processes to ensure accurate component placement and soldering.

❖ **Medical Equipment:** Medical device manufacturing requires precise assembly and testing, and reciprocating servos play a role in processes like catheter assembly, precision cutting, and testing equipment movement.

❖ **Energy:** Reciprocating servos can be used in energy-related industries for tasks such as controlling valve movement in power plants and maintaining precise equipment alignment.

❖ **Research and Development:** Industries engaged in research and development may use reciprocating servo technology for experimental setups, prototype testing, and fine-tuning new processes.

These are just a few examples, and the applications of reciprocating servo technology can extend to various other industries as well. The key advantage of using servo-controlled reciprocating motion is its ability to provide high precision, repeatability, and controlled movement, which is crucial in industries that require consistent and accurate processes.

Touchscreen HMI

This allows users to interact with a device or machine by directly touching the screen rather than using physical buttons, keyboards, or mice. The touch-sensitive screen detects the user's input, such as tapping, swiping, or pinching, and translates it into commands or actions for the underlying system.

Touchscreen HMI

Call us today at (585) 924-9181 to discuss your application needs.

Team IIS

Our objective is to bring state-of-the-art servo system products to practical use on the factory floor. Whether it is a complete turnkey system or servo components, IIS' commitment to quality products and personalized support is unsurpassed. Our business philosophy is pretty simple. We take responsibility for everything we sell. By doing that we make a long-term commitment to our customer's success.

Headquarters in Victor NY

To accommodate the steady growth we've enjoyed over the years, our facility has been expanded several times to its present 17,000 square foot capacity. This location houses all critical departments - Sales, Marketing, Applications Engineering, R&D, Production, Warehouse, Panel Shop, Quality Control and Customer Support. Having everything under one roof speeds communications and provides better service to our customers.

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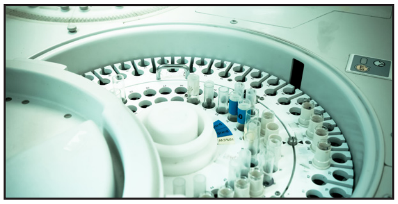

Ready to elevate the efficiency, consistency, and repeatability in your operations? Call us today at (585)924-9181 to discuss your application needs

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