SELECTION CRITERIA FOR DIP MOLDING EQUIPMENT

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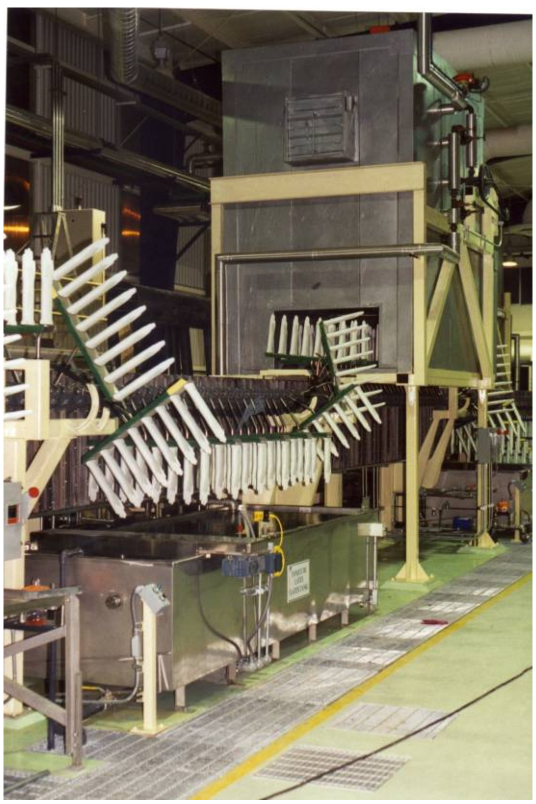
Dip molding is a viable production process for the manufacture of a wide variety of industrial, consumer and medical products. The advantages to alternative methods of manufacture such as injection molding, compression molding and rotational molding is the increased production rates and reduced tooling cost.



Fixed Form Continuous Latex Glove Dipping Machine

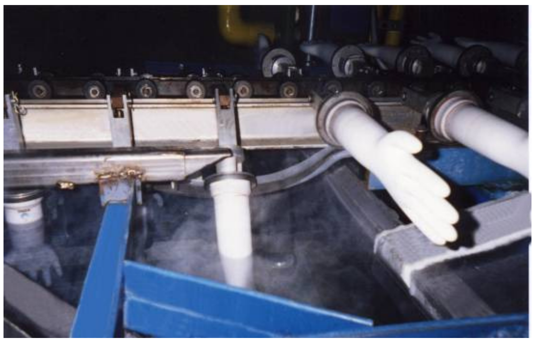
Dip molding machines are segregated into two major classifications.

The first being continuous motion or what is commonly referred to as drag chain lines. The second is batch or indexing systems. Both systems offer an array of benefits that should be evaluated. The advances in automation provide the manufacturers of dip-molded products with an array of options.

Continuous motion or drag chain lines consist of dip molding tooling, also referred to as formers, mounted individually, or in multiple groupings, and attached to a continuous moving conveyor chain. The equipment drives the chain at a constant speed, carrying the formers through the various stations, which make up the process. Typical stations for Natural Rubber Gloves could be oriented as follows:

- Form Cleaning
    - Soak Tank
    - Ultra Sonic Tank
    - Rinse Tank
- Coagulant-Form Conditioning
- Drying
- Polymer Dip – may require multiple dips dependent upon desired product characteristics
- Drying – Pre Vulcanization
- Leaching
- Beading
- Cure – Multiple temperature zones
- Post Leaching
- Polymer Over dip - Chlorination
- Product Removal

Some continuous chain systems feature rotating forms. These systems typically feature single form carriers and as a result they have lower production volume output than their fixed-form counterpart. Fixed forms are mounted in multiple arrays of up to ten per carrier allowing dramatic increases in production.



Rotating Form Continuous Latex Glove Dipping Machine.

The application of continuous chain technology for gloves and condoms is commonplace. The prime reasoning for utilizing this technology is due to the typically lower capital cost and higher output than batch systems. Products such as exam gloves, latex condoms and novelty balloons are extremely competitive and must be manufactured in high volumes to be profitable. A rotating form line running at a nominal speed of 9.1 meters per minute (30 feet per minute) can produce approximately 125,000 gloves per day, while a fixed-form line with similar process parameters, can produce 750,000 gloves per day, six times that of rotating form line.

Batch or indexing systems consist of formers mounted to a carrier pallet. The pallet size will be dependent upon, as well as limited by, the product form size and quantity mounted. Pallets for production equipment range in size from .5 meters to 2.5 meters square in size. Based upon the pallet's design, the forms may be fixed and oriented or capable of axial spin. A fixed-form indexing batch line with a 3-minute index rate can produce approximately 90,000 gloves per day.

As with continuous chain line, batch system stations are based upon the requirements of the process, however, unlike continuous chain systems, the order of the stations does not need to be progressive. The pallet carrier may be designed to transport the pallet to any of the available process stations, in any order, providing the ultimate in process flexibility. For higher volume production requirements, multiple pallets are typically indexed from station to station sequentially.

Batch Dipping Machine

A batch system by definition completes tasks in an allotted time frame. This time frame is referred to the cycle time or index cycle of the system. The stations comprising the equipment can each perform unique process tasks for each pallet of product presented to the station. This flexibility, for example, could allow the dip station to perform a different dip profile on each pallet as it is presented to the station. The process station requiring the longest time will typically determine the index cycle of the equipment. The cure or drying station(s) are typically the process step that will require the most time. This is the norm for most water-based polymers as a result of the need to use lower cure temperatures in an effort to prevent pinholes as a result of water vapor escapement.

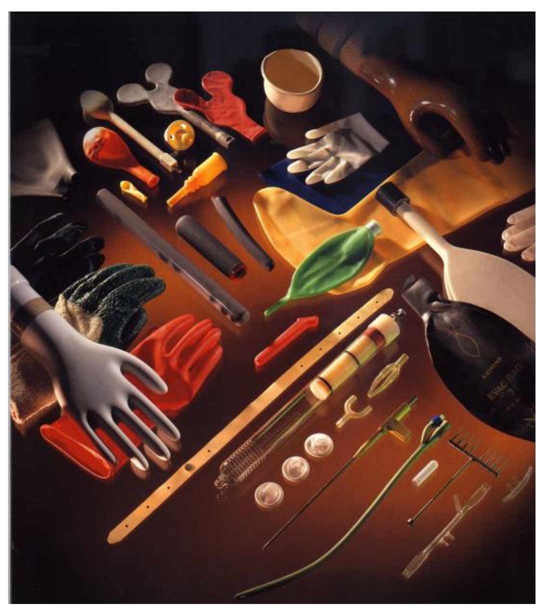
With few exceptions, dip-molding plants are customized for the production application. This does not however require that the manufacturer should customize all aspects of the machinery. For example, continuous chain glove and condom production equipment is offered by various equipment suppliers and is generally offered in standard formats based only upon production capacity. Care should be taken in selecting “standard” equipment, to assure compatibility with existing process criteria and polymer to be utilized.

Multiple criteria are involved in the determination of the proper equipment type. These include product wall thickness, existence of a defined process, tooling geometry, annual production quantity and polymer to be utilized. These are just a few of the defining qualifiers in determining the correct equipment choice for new dip molding and coating machinery.

A series of four questions allows the user to determine which of the two major equipment classifications, continuous or batch, are best suited for the application. Jointly, with the charts and flow diagram provided in this article, the following four selection factors would provide further criteria for selecting the proper dipping equipment.

Selection factor #1 – Product family:

What and how many products to be produced?



Example of Dip Molded & Coated Products

Chart 1.0

Dip Molding/Coating Product List

Angioplasty Balloon	Medical Tubing Connectors	Engine Head Gaskets
Antimicrobial Coating	Nasal Cannulae	Face Mask Coating
Artificial Heart Casing	Penile Implant	Glass Coating
Baby Feeding Nipples	Probe Connectors	Latex Toys
Blood Pressure Cuff	Prosthesis Cover	Lineman Glove
Breast Implant Casing	Re-breathing Bag	Non Shedding Gloves
Cardiovascular Catheter	Stomach Feeding Retention Balloon	Protective Caps
Cast Covers	Surgical Gloves	Supported Work Gloves
Condoms	Urinary Foley Catheters	Swim Caps
Exam Gloves	Venous Catheters	Tool Handle Grips
Face Mask	Biohazard Glove Lining	Toy Balloon
Lubricious Coating	Box Gloves	U.V. Protective Coating
Male External Catheters	Buss Bar Coating	Unsupported Work Gloves
Medical Bags	Can/Bottle Holders	Windshield Wiper Boot
Medical Bellows	Coated Automotive Brackets	Wire Basket Coating
Medical Tubing	Coated Electrical Components	Wire Fence Coating

Listed in Chart 1.0 is a partial listing of products manufactured by dip molding. This list of approximately fifty products denotes the importance of dip molding to the manufacturing industry.

Single-product applications for the production of products such as gloves, condoms and balloons are commonplace.

The dedication of the equipment to one product and associated process steps allows the user to employee continuous-chain technology with associated high- volume output. Glove production equipment today can produce over 1 million gloves per day.

Many of today's larger manufacturers have chosen to utilize these high volume systems in place of multiple smaller machines to aid in product uniformity. Variations between equipment within one facility are common and often a source of aggravation for the producer.

Dip lines of similar design often suffer from varying tank management and control parameters such as tank and cure oven temperatures and uniformity.

Manufactures who wish to produce more than one product may benefit from smaller volume continuous chain lines, which afford less difficult changeover to other similar products.

The products, as well as the polymers utilized on this system, must share very similar process requirements because of the equipment's limited flexibility.

Manufactures wishing to produce a wide range of products, often at lower volumes with higher profit margins may choose to use a batch dip system. A typical plant may produce specialty-dipped goods, such as medical balloons, catheters, bags and specialty gloves, with lower volume requirements but with higher profit margins.

Existing dip molding production plants are producing over 50 types of products with multiple polymers on one-batch machine.

Selection Factor #2 – Product Characteristic.

What characteristics define the product?

One major product characteristic is film thickness. This key attribute determines the product's strength and flexibility. One important quality for most dipped products is that of consistent wall thickness and uniformity. It is a general rule that products requiring a thickness of greater than 15-mil are best suited to be manufactured on batch technology.

Examples of products generally requiring thicker wall dimensions, which are dipped utilizing batch systems, are electrician's gloves, box gloves, baby teats and pacifiers, baby feeding nipples, Foley catheters and breather bags. Wall thickness of greater than 15-mils is possible on a continuous chain line. The system would require multiple dip tanks and thereby increase the associated tank management and product consistency. Some unsupported latex and nitrile gloves are manufactured employing three dips on a continuous chain line to develop desired wall thickness. While, thickness is not a desired result, some condom manufacturing lines also utilize three dips. The desired result producing reduced potential for pinholes.

A second important product characteristic that must be considered in a determining the type of equipment to be utilized is the shape and size of the dip tooling.

Example of Dip Molding Tooling

Evaluating the flow of polymer on the tooling, the motion required to distribute the polymer evenly and with minimal drips or runs, will provide useful information. The time the polymer needs to coagulate or gel is equally important and may often be modified by formulation changes or use of coagulant pre-dips.

The need for increased time with tooling manipulation is easily met by use of a batch-dipping system. The longer the gel time, the manipulation of the dip tooling becomes more critical. Manipulation of the tooling aids in creating even wall thickness and ensures optimum cosmetic appearance. Manipulation can include form rotation and form axial spin.

It should be noted, however, that batch systems are not the industry's predominate choice for products such as condoms, which require increased tooling manipulations such as form spin. Continuous chain technology utilizing tooling carriers, which allow for single form spin and limited rotate manipulation, are utilized providing the higher volume product output the marketplace demands.

Selection factor #3 – Process Maturity

Is the product process defined?

One major disadvantage of continuous chain machines is their inherent inflexibility. The equipment's performance becomes dependent entirely upon the system's line speed. Consider that the manufacturer determines that a change in the polymer formulation, that offers an improved product characteristic, requires the line speed to be increased. The manufacturer must also ensure that the other process areas are not affected with the increase in line speed and subsequent reduction in time.

Critical areas such as leaching, beading, oven curing and automated product removal must be carefully evaluated. Adjustments to oven temperatures and/or flow, if the system incorporates forced air convection oven design, must be evaluated to assure the finished product maintains acceptable physical characteristics. In the event the equipment's ovens are not able to provide proper material drying/curing with the reduced time as a result of the increased line speed, offline curing, by use of tumble dryers, may be required.

Manufactures introducing a new product may benefit from the utilization of a lab scale system. Development of small scale dipping systems permit polymer developers, dip molders and coaters to evaluate and define process parameters on a small scale with minimal polymer required. These programmable systems allow for simulation of either batch or continuous motion style dip lines.

Lab scale systems also provide a method of evaluating polymer enhancements and new product tooling without interrupting production.

Laboratory Scale Multiple Axis System

Small dip molded products such as medical balloons and probe covers utilize flexible small-scale systems to produce salable quantities and allow multiple sizes and polymers to be manufactured with minimal setup.

Selection factor #4 – Type of Polymer

What polymer is being considered?

Engineers and technicians, who often better relate to graphs and flow charts, will benefit from chart 2.0, which qualifies each major polymer and the equipment typically utilized to manufacture the products.

While three decades ago latex was nearly the only material available, Today's advances in polymer development have provided manufactures with multiple alternatives.

The protein issues associated with natural rubber latex have increased the need for alternative polymers, especially for medical dip molded products that are invasive to the body. Many manufactures of catheters have begun to increase production of polyurethane designs.

Many hospitals are introducing policies banning latex products from being used. Medical balloon and catheter manufactures are utilizing silicone or polyurethane for this reason. As shown in Chart 2.0 the industry utilizes latex in over 60 percent in the products offered. The predominate reason latex dominates the industry today is due to its inherent characteristics, ease of use and competitive pricing.

Water based materials, such as latex, nitrile, neoprene and recently introduced aqueous polyurethane, are normally adaptable to both types of machines. Many current manufacturers of latex products utilizing continuous chain systems find that conversion to these water-based alternatives permits them to re-gain a competitive edge in what otherwise has become a commodity market. Because of the subtle differences in the process parameters, the conversion to one of these alternative materials may require alterations to key process areas.

Chart 2.0 **Machine ratings for polymer usage** **Key:** N = Never used, S Seldom used, M = Moderate use, F Frequent use, A = always			
Type of polymer	**Industry%**	**Continuous Chain**	**Batch**
Natural rubber latex	63%	F	F
Polyvinyl chloride (PVC)	15%	F	F
Nitrile	7.5%	M	F
Polyurethane	6%	S	F
Neoprene	3.5%	S	F
Silicone	2.8%	N	A
Heat sensitive latex	1.5%	N	A
Styrene butadiene	0.5%	S	F
Polycarbonate	0.1%	N	A
Cellulose	0.1%	N	A

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As mentioned before, continuous chain systems are not flexible in this regard.

Solvent-based polymers such a polyurethane, silicone, styrene butadiene, polycarbonate and PVC are seldom dipped on continuous chain systems. There are exceptions to this statement, due to the fact that a few solvent-based gloves and condoms are currently manufactured with continuous chain machines.

The challenge with this production method is mainly associated with solvent vapor containment.

One other difficulty associated with continuous chain dip lines is the constant disruption of the polymer by the product formers. This disruption increases the vapor emission and increases the potential for bubbles, especially in viscous polymers, which can result in pinholes.

As with any major equipment purchase, the proper choice in the style and abilities of the system will enable the user to realize increased levels of production in a shorter time. The correct choice will also greatly reduce typical new equipment installation/start-up frustrations and often, most important, result in reduced cost and associated labor.

One factor not tied to the style of equipment, however, equally important, is the source of the equipment. The twenty-first century has ushered in a global economy. With "E" commerce, you can access information on equipment manufactured throughout the world at the click of a mouse button. Equally, suppliers can present themselves, in the form of web sites, very convincingly as experts on a variety of levels.

Investments, as financially sizeable as a production dip molding system, should include the careful evaluation of the suppliers and their ability to offer more than a copy of standard industry equipment. As reviewed in the previous portion of this article, equipment is often designed to meet the specific need of the product and associated process or polymer.

Request the equipment supplier to provide preliminary services, such as prototype product manufacturing by means of a lab or testing system, to prove fundamental process and equipment compatibility.

Also, request a thorough engineering study of the project, providing insight as to the equipment required, including support systems such as utilities, raw materials, mixing/compounding, testing and packaging systems.

When the equipment's capital budget is limited and options for decreasing cost are being considered, manufacturers often choose to utilize small suppliers who quite possibly have little experience in the industry. As an alternative, request an established supplier with a superior presence in the industry to provide options for local manufacturing.

Lab Dipping/Prototype Evaluation

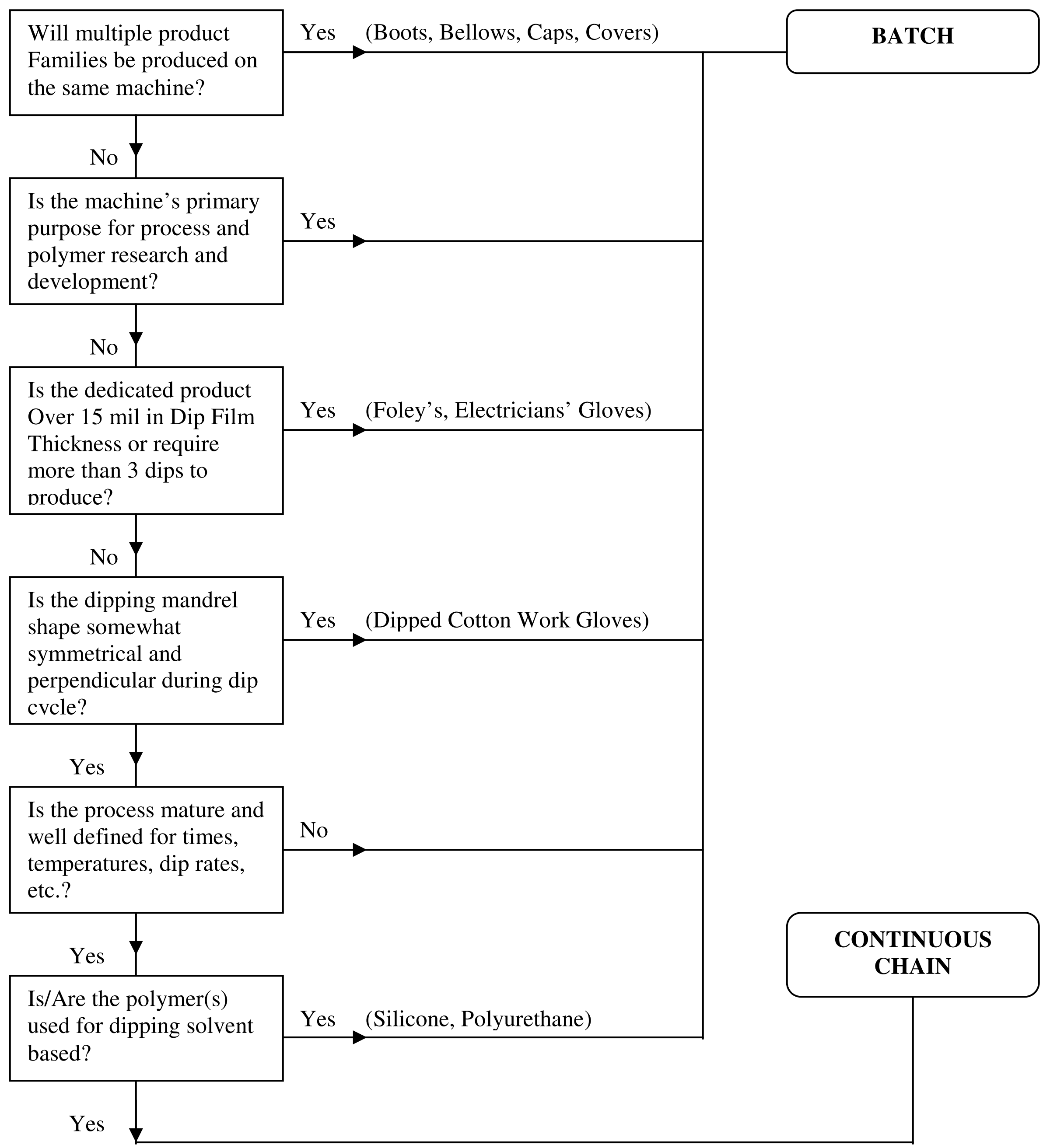
In the case where several identical production systems may be required, a design agreement allowing the client to manufacture part, or all, of the system locally, may offer a lower cost alternative.

Support and longevity are also two important factors to evaluate in an equipment manufacture, especially for the first time dip molder. Sourcing equipment supplier(s), who has a proven track record and offers continual support from installation to commissioning, is often the key to success.

Services such as training and production support in the form of troubleshooting, repair and spare parts, result in improved utilization of the equipment and increased uptime.

Your equipment supplier can also serve as a long- term partner in the success of the project.

Figure 3 Flow Chart Selection Process



PRESENTER'S BIOGRAPHY

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Mr. Charlton is a 1987 graduate from The University of Akron, Akron, Ohio, with a degree in Mechanical Engineering, specializing in automation and robotics. Mr. Charlton was VP of Sales and General Manager of ACC Automation Co. for ten years and is now Vice President of DipTech Systems. During his tenure he has been involved with numerous production dip line design projects, and has developed a line of automated testing and laboratory equipment.

Mr. Charlton's previous professional background was focused on the development of robotic assembly systems for industrial products. His experience with state-of-the-art design concepts has been utilized in several of DipTech's batch dipping systems and other auxiliary devices.

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