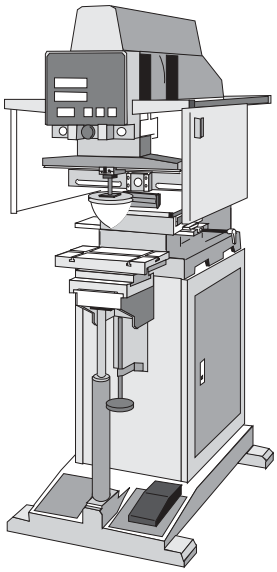
CONTENT

The pad printing technique has developed into an independent printing technique during the course of the last few years. In many industrial applications, it is almost impossible today to imagine life without pad printing. What has made this technique so significant in such a short time?



Pad Printing

- offers new possibilities in printing, which are not possible or too complicated with other techniques or just too expensive
- partially replaces other decorative techniques such as screen printing, labelling or hot stamping
- meets the trend to mark products better and fancier, to give the product a more "expensive" look.

The application field has become so widespread, that we are confronted daily with more and more "pad printed" articles.

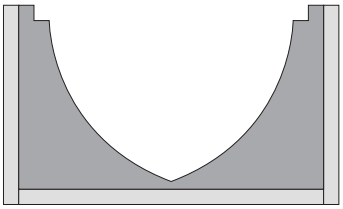
Just a small selection:

Automotive:	Switches, keys, levers, buttons
Electronic:	Components, housings, sockets, relays, tapes, compact discs
Household:	Decorative prints, clocks, ovens, tool labelling
Toys:	Miniature trains, doll heads, cars, construction kits
Advertising:	Lighters, pens, pencils, etc.

The individual components of this printing technique are as follows:

Printing Pads

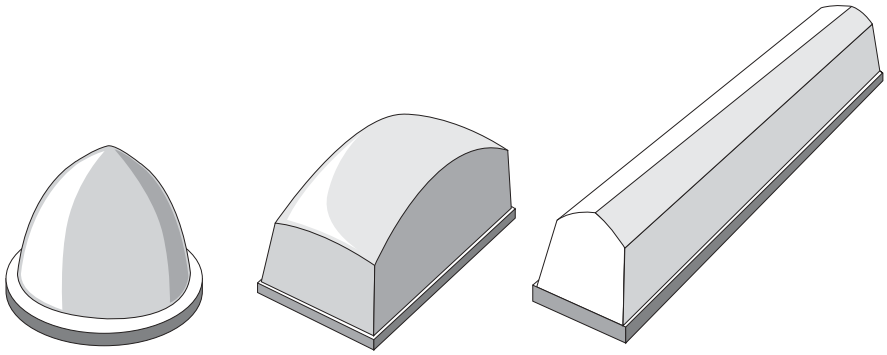
Printing pads are silicone stamps which are produced in various shapes, hardnesses and qualities. The raw material is based upon silicone rubber. The printing pad carries the printing image by picking up the ink from the die plate, transporting it to and then printing it onto the product . For this reason, the pad material needs to be flexible, but it is also imperative that the transfer of the printing image be accurate.
A pad can be used for various designs. This means that other images or other inks may not need a different printing pad.
For the production of printing pads you first need a polished aluminium core, which is then used to build a negative casting. In this mold, a liquid mixture of silicone rubber, silicone oil and additives is poured.



Depending on the quality requirements, the composition varies. Within a certain timespan, mostly over night, the liquid silicone vulcanizes in this mold, so that now the finished pad can be removed.
The holding plate for the pad is usually a wooden or aluminium base. The selection of material for the base plate depends on the pad fixture of the individual pad printing machine.

Pad shapes

All standard pad shapes share one common feature: the printing surface is arched and the sides are slanted towards the centre. The arched top aids the ink transfer, while the slanted sides give the pad the necessary stability to achieve an accurate printing image.



Round shapes
The ideal shape is a half round, pointed pad. This shape rolls onto each side evenly and therefore air cannot be trapped between pad and ink film surface. Through this rolling action, the pad can pick up the ink from the plate as well as transfer it onto the product very well.

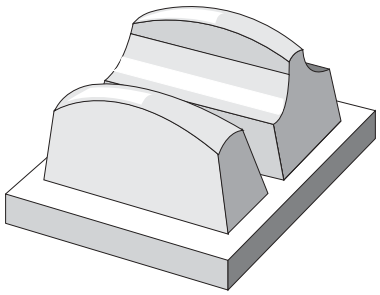
Angular shapes
Not all images or products will allow the use of one of the above described `ideal shapes`, therefore, angular or extended shapes are necessary. With the angular shapes it is also important to try to have a pad with a more pointed center, so that the same rolling action can be achieved.

Extended shapes
The extended printing pads usually have a worse printing result because the rolling action can only happen on two sides.

Extended pads that are rounded at the top usually result in a bad printing image in the rounded area. Many manufacturers keep various standard shapes in stock; but it is often necessary to produce special shapes for special applications.

Special shapes

Standard shapes of pads should be tried first. Sometimes composite pads must be employed. These so-called composite mountings consist of a number of single pads, which are fixed to a suitable surface (aluminium or wooden panel). Furthermore, existing pads can be shortened or cut which is one way to adapt existing pads to special printing applications. When moulding the pad a hollow space can be included which will affect the ductility of the pad. If the printing result is still not satisfactory, a special pad shape will have to be produced as mentioned above. For industrial applications, it is not uncommon to manufacture special aluminium cores. As this is a very labour intensive job, these special pads are expensive. Often different shapes have to be tested before the required results are achieved.



Size

To achieve a precise, sharp print, the pad should be as large as possible. The less the pad deforms, the more exact is the printed image. Especially with difficult printing designs, in which the corners have to be printed at an exact angle, the pad has to be much larger than the image. For this reason, the manufacturers usually state the printing size of the pads smaller than the actual or possible print size. The disadvantage of large pad volume is the corresponding machine power needed, and the fact that the pad will tend to vibrate or wobble. Furthermore, the price of pads is based on volume and weight, which means the larger the pad, the higher the price.

Hardness

Pads are usually offered in various hardnesses between 2 and 18 Shore A. Exceptionally, special hardness from 0 up to 40 Shore A can be supplied for special applications. The larger the number, the harder the pad. The hardness influences the quality of the print as well as the durability of the pad. A hard pad can transfer the image very well and has, because of its high mechanical consistency, a better durability. Very often, it is not possible to use a hard pad because the pad could harm the substrate. When printing onto substrates with an intensely curved surface, a softer pad should be used as it can more easily compensate to the surface than can a hard pad. The pad hardness is often determined by the printing power of the pad printing machine. Using large and hard pads may push a machine to its limit, irrespective of the machine's drive type. The printing force required to print with a large, very hard pad of say 18 Shore A, is very often underestimated.

Quality

Basically there are two very different silicone raw material systems:

- cross-linked by condensation (relatively cheap)
- cross-linked by addition (very expensive)

All measurable characteristics such as, for example, ultimate tensile strength or resistance to swelling because of solvents,

are better with cross linkage by addition materials. The disadvantage is that the raw materials are more expensive. The surface of the pad is also important for the print quality. The smallest dirt particles, or air inclusions caused during the production of the pad, can lead to an unsharp print. New pads also tend to lift the ink from the plate badly. A few prints onto paper or a quick cleaning with alcohol or mild solvents will take care of this problem. If the pad is cleaned with very harsh solvents like ink thinners, the pad will pick up the ink from the plate immediately, but it will print the image with poorer quality.
If a pad is a little "shrunk" with time, we suggest the pad should only be cleaned with adhesive tape (wide brown package tape), to remove the dust particles. For industrial applications, automatic pad cleaning attachments can be used, as explained in the chapter "Pad Printing Machines".

Durability

Under normal conditions a pad will print approx. 50.000 - 100.000 prints. This depends upon:

- Print quality requirements: Pads slowly lose their print quality because the silicone oil will be washed off and therefore will create a matt and absorbent surface.

- Type of inks used: experiments have shown that when using single component inks, the durability is good. As two component inks are usually more aggressive, swelling and the subsequent reduction of silicone oil will appear faster and therefore shorten the pad life.

- Shape, size and hardness of the pad

- Shape of the material to be printed. If the product has very sharp edges or is extremely arched, the pad can be mechanically damaged after as little as 1.000 - 5.000 prints. In this case it is suggested that a more expensive pad of the two component material be used (cross linked by addition).

- Gentle cleaning during production. Ink build-up on the pad (ghost images) can be removed from the pad by using adhesive tape (packing tape).

The durability of a pad can be increased by silicone spray or silicone oil treatment during `resting` or storage of the pad.

It is becoming obvious that there are many factors which affect the quality and durability of the printing pad.

The rule of thumb for achieving top quality printing is to choose a hard, pointed printing pad with the largest possible volume. For two component inks or difficult products, the more resistant two component material (cross-linked by addition) should be selected.

If there are still questions as to which pad to use, we suggest that the product be sent to the pad manufacturer. The well-established suppliers usually select the most suitable pad and give individual advice. As new customer-related special pads are continuously developed, the catalogues from the pad manufacturers can only show a small number of the most common printing pads.

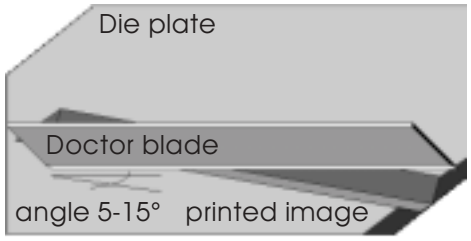
Die plates

The die plate is the carrier of the printing design. For each new design, a new die plate is needed. The design is etched into or washed out of the die plate. The etching depth of steel die plates is, depending on the printing job, approx. 15-30 µ (normally 25 µ).
As the printing pad can only carry a certain amount of ink, a deeper etch would not be any advantage. With an etching depth of 25 µ the pad will only pick up approx. 12 µ of the ink film; the remainder will stay in the die plate. As the ink film consists of a minimum 40 % thinner, which evaporates during the transfer and drying of the ink, not more than 8 µ ink film thickness remains on the substrate.

Repro films

For the die plate manufacturing, a good film positive (emulsion down) is necessary. First the die plate manufacturer must make an artwork film positive from artwork by either using a repro camera or photo setting computer. Even during film setting the printing result is influenced. Only a perfect film can produce a good die plate and printing image. Very often it is necessary to include a halftone film (for large open areas).

Halftone films
The amount of lines per cm (or lines per inch) as well as the gradation of the halftone film are responsible for the depth of the photopolymer die plate. A number of die plate types can only be made by using a halftone film. With steel die plates, halftone films are used with large images to avoid the doctor blade falling into the etched area. With four-colour process printing, the percentage of the process film will determine the colour strength. When printing long lines or designs, the sinking in of the doctor blade can be avoided by mounting the art work at approx. 5-15° angle to the doctor blades on the die plate.



Multicolour films
Films for four colour process printing are made with a scanner (offset-colour separation) and must then be installed in order on the pad printing machine.

Computers and films
Computer techniques have revolutionized the areas of graphic film manufacturing and photo typesetting. For simple jobs in pad printing (advertisement etc.) it is usual for the films and photopolymer plates to be produced in house using basic PC's and corresponding graphics or photo setting software.

A laser printer with 600 dpi definition is often suitable for simple advertisement prints. Instead of printing onto paper, the design is printed on a matt foil, which may then be used instead of a repro film. In this case a top quality print cannot be expected.

A more professional approach uses more advanced computer systems with direct exposure of the repro film. Here a definition of 1200 up to 3600 dpi is normal. This fine definition is suitable for the highest demands of edge sharpness, density, and quality of repro films.

Die plate types

Depending upon print quality requirements and print run, different die plate types are used:

Photopolymer die plates

These consist of a UV-light sensitive coating on a metal base plate. An adhesive coat bonds the thin metal plate with the photopolymer material. The surface is normally covered by a protective foil, which aids problem-free storage and processing. Die plates are available in different versions. Below are the most commonly used:

- water-resistant materials with halftone exposure (single-layer material)
- water-resistant materials without halftone exposure for very fine designs (two-layer material)
- alcohol-resistant materials with halftone exposure (single-layer material)
- alcohol-resistant materials without halftone exposure for very fine designs (two-layer material)

Many companies prefer the water-resistant material for environmental reasons, but the alcohol-washable materials are less complicated in production and have much better quality and durability.

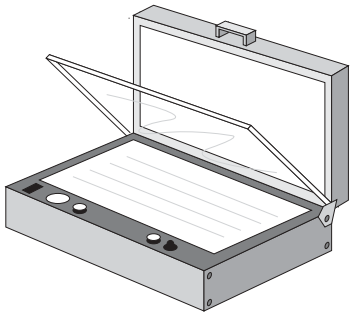
Design

There are two different designs:

- Two-layer material: Here the unexposed part of the top layer (approx. 25 µ) is removed after exposure by the development (only suitable for fine designs).
- Single-layer material: After the exposure of the artwork and the second exposure of the halftone film, a certain amount (up to 400 µ thick layer) is removed. The depth is determined through the choice of halftone film and the exposure time.

Exposure

For exposure a UV-exposure unit is needed. These units are available with or without vacuum suction. The protective foil of the photopolymer



die plates should only be removed in a darkroom with yellow or red light or in a room with subdued light, otherwise exposure faults are possible. The repro film is put at the exact position on the print plate, face up with text readable, and pressed down on the print plate by either the glass pane or the vacuum foil of the exposure unit. The average exposure time of all common print plates is approx. 2 to 3 minutes. In this process, it is important to achieve a good contact between the film and the print plate, which is enhanced by the vacuum suction.

Development

After exposure, the artwork film is removed and, depending on the material, the print plates are washed out either with water or with a water-soluble alcohol solution. This is mostly done by hand with a special soft washing brush or pad. Various automatic washers are available, but they cannot always offer a satisfying and constant production or are too expensive.

After-treatment

An important factor to achieve a good durability is the drying and baking of the plates. The temperature should be approx. 80 -110° C for approx. 10 to 20 minutes. If a special baking oven is not available a domestic oven or similar can be used.

Washout depth

Fine halftone film	flat die plate depth
Coarse halftone lines	deep die plate depth
Long exposure time	flat die plate depth
Short exposure time	deep die plate depth

Application

Within the last few years, photopolymer die plates have become very popular and one cannot think of pad printing without them. They are very suitable for a quick do-it-yourself production; the user is not dependent on manufacturing and additionally, photopolymer plates are much cheaper than steel die plates. Very good printing results can be achieved. The durability of all photopolymer die plates can be between 500 to 50.000 prints or more. It depends very much on the correct plate manufacture as well as on the pad printing machine setting. As the surface material is relatively soft even after baking process, even the smallest impurity can cause damage. It is important to use the right doctor blade for this type of plate. The edges should have no damage and they should be between 0,18 mm and max. 0,25 mm thick. Modern pad printing machines are best suited for this type of die plate.

Thin steel plates

A 0,5 mm thick steel band with a fine surface and hardness of approx. 48 - 54 HRC. In the pad printing machine this steel band is fixed with a magnetic plate in the ink tray. This die plate type is not for self-production, as the manufacturing is a multiple production process (coating, exposure, covering and etching). Special equipment is necessary and the correct disposal of the spent chemicals (for example etching acid) must be ensured. Some manufacturers offer small do-it-yourself sets, but this only makes sense if the user already has the means for chemical disposal. The advantage of the thin steel plate in relation to the photopolymer die plate is the possibility to use the same plate for prints with or without halftones. Also, gradient etching is possible. This means that individual parts of the printing image can be etched more flat or deeper in one die plate. After the exposure, impurities (for example dust spots) can be covered. The print volume depends on the pad printing machine type or its setting, as the thin steel plate is not as hard as the doctor blade. In practice, between 20.000 and 100.000 prints can be achieved.

Steel plates

This classic plate type is mostly used in the industrial sector. Steel plates are available in various dimensions. Sizes range from 50x50 up to 350x950 mm and thickness from 1,5,6,8 up to 10 mm. The 10 mm thick plates are the most common and represent approx. 95 % of the steel plates used. For coding attachments, so-called coding sticks are used.

Material

Steel plates are made from a high-quality, abrasion-proof special steel. The processing is very complicated and expensive machines are needed. The raw material from the steel manufacturer is cut according to the required dimensions and all 6 sides are ground, hardened (up to 65 HRC), and lapped. The surface roughness is approx. 3 µ. For a very fine finish, the lapped side can be additionally polished.

Production

The steel plates are coated with a photo layer. This process can already be done individually according to the design. After the film is laid onto the surface, the plate is exposed by UV-light in a vacuum exposure unit. The development is then done in a special developer bath.

Afterwards the plates are coated with a special acid resistant lacquer by hand, to avoid dust spots etc.. During the subsequent etching process, the etching depth can be kept within a range of +/- 2 µ of the needed depth. All kinds of etch depths and combinations of halftone and solid areas are possible on one die plate.

Usage

Steel plates are mainly used in the industrial sector as they are most suitable due to their long service life and are especially suitable for closed ink cup systems. The quality achieved with these plates cannot be reached by other means, i.e.:

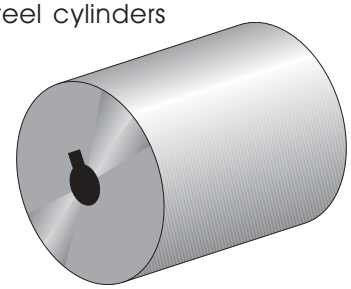
- Absolute definition
- Various etch depths on one die plate
- Use of process of all types
- Very fine surface finish
- No need for additional supporting plate
- Low risk of mechanical damage
- Extreme durability (high print run)

This way steel plates can be used for all print jobs. The number of prints possible with steel plates is mostly given by manufacturers with the magical number "1 million". Since the closed ink cup system has been on the market, the steel plate has won back its great significance, as its extreme surface durability is very important in this application.

Other special types of die plate

Two more die plate types are used in pad printing:

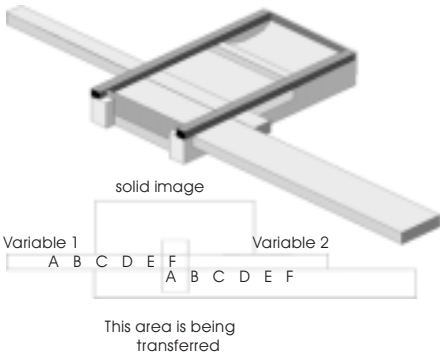
Steel cylinders



They are used for rotary pad printing machines. The processing is similar to the steel plates. As sometimes the print is around 360°, film mounting and manufacturing of the cylinders is very difficult. Special etching machinery is also needed.

Coding sticks

In many industrial production processes it is often necessary to change codes and numbers like date of production, batch number, model number etc.. To avoid continuous new production of plates as well as replacement during printing, it is suggested to use coding sticks. These die plates have the same thickness as steel plates, but are specially ground on both sides. Therefore, the die plate sticks can be very close together and can be moved against each other in the ink tray. Because of this sliding, numerous number/digit combinations can be printed, without having to stop the printing process for a long time. In combination with steel plates, the customer's logo can be printed alongside. This application has been accepted mostly in the industrial sector.



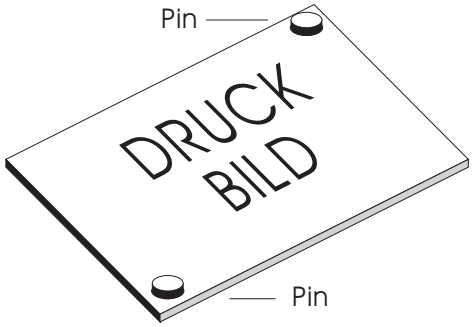
Etching depth

Based on many tests, a die plate etch depth of approx. 25µ has proven to be the most suitable for the average application in pad printing (see 2.0). Apart from that general guideline, an etch depth of approx. 15 µ for very fine lines, and up to 30 µ for very coarse designs is recommended.

For large printing areas, the sinking in of the doctor blade can be avoided by etching a halftone image instead of a solid image.

Perforation

Many manufacturers offer their photopolymer or thin steel die plates with perforations at the plate edges. These holes are used to keep the plates in place in the printing machine. The corresponding fastening pins are inside the ink tray. Specially with the use of closed ink cup systems, this type of holding device is necessary. Almost all pad printing machine manufacturers try to introduce their particular design of perforated die plates to the market. The customer is then forced to continue to purchase from the same company and cannot buy from competitors, as these perforations can only be duplicated with great difficulty.



Costs

If we calculate the cost of steel plates at the factor of 100, the thin steel plate represents around 40 percent, the finished photopolymer die plate at approx. 30 percent and the self-developed photopolymer die plate at about 5 percent. If, for some reason, a second or third plate has to be made because the first plate shows bad printing results and the second gets damaged during printing in the machine, the costs will rise very fast. If you add the cost of a machine standing idle, in many cases the cost of a steel plate is reached or even exceeded.

Conclusion

As a summary, we can say photopolymer die plates (if made in house) are most suitable for small quantity print jobs, test prints, pre-series prints or quick-service print. A big advantage is the suitability for self-manufacturing. Steel plates are used for large print runs and high quality standards. In between are the thin steel plates for medium print runs with good print quality.

Requirements

To achieve an optimal print quality, special pad printing inks have to be used. These were developed in cooperation with ink and machine manufacturers. These special inks show high pigmentation as only a small amount of ink is transferred in the pad printing technique. The corresponding additives, such as thinner, hardener and cleaner ensure a good processing of the pad printing inks. The ink should preferably possess the following characteristics:

- Easy handling (no mixing)
- Long stability (potlife) in the ink tray
- Safe
- Not harmful to the environment
- Easy to clean
- Adhesion on all parts and materials without pre- or after-treatment if possible
- One ink type preferably for all materials to be printed

Depending on the field of application of the material to be printed, the ink requirements vary greatly. For marking only, the requirements are low, but for a decorative print the requirements are very sophisticated. The finished print on the substrate should show the following characteristics:

- High opacity of the ink
- Extreme adhesion and scratch resistance
- High chemical resistance
- Safe (eg; for toys)

All these demands cannot be met by one single ink type even today. Therefore, a variety of special inks has been developed which can meet different demands and applications.

Types

In the printing ink range we differentiate between single and two-component, baking, and UV-curable inks.

Composition

Inks consist of different binders, pigments, extenders and additives. This leads to the special characteristics of each individual type and the fact that different ink types cannot be mixed with each other without losing the original characteristics.

The mixture of a pad printing ink is as follows:

Binders

The binders of pad printing inks are based on one or more types of resins. The choice and the combination of the resins decide on the ink's application as for example adhesion on various materials, level of gloss and chemical resistance. As the resins are usually available in the form of granulates or powders, they have to be dissolved with adequate solvent or solvent combination, to achieve a printable binder.

Solvents

Solvents differ mostly in their evaporation time and solubility. The combination of the solvents in the printing ink will be responsible for its drying behaviour, the printability, as well as the ink adhesion onto certain substrates.

Pigments

The pigments in the pad printing ink will determine the colour and the opacity. There is a choice between organic and inorganic pigments. From the group of inorganic pigments, only those which are free of heavy metal substances in their chemical structure are still being used.

Additives

Additives are additional substances which are normally used in small amounts. Their effect helps to fine tune the ink characteristics, for example the flow, the viscosity or the opacity. They are the so-called flow agents, thickening agents, and filling agents.

Ink systems

Pad printing inks can be divided in various groups because of their drying process. These groups are:

- Physically drying inks: one-component inks
- Chemically hardening inks: two-component inks
- Baking inks
- UV-curable inks

Solvent inks

One component inks

This ink system dries by the process of physical evaporation of the solvents. At the same time, the surface of thermoplastic materials (for example polystyrene (PS), polycarbonate (PC), PVC etc.) is attacked by the solvents. Through this attack of the substrate's surface, a direct fusing of ink and material is created. In this case, a high scratch resistance and a good ink adhesion is guaranteed. Single-component inks are very fast drying.

Two component inks

These ink systems show a very high chemical resistance with good adhesion and scratch resistance, especially on difficult substrates. A hardener must be added to the ink, which will cause a chemical reaction with the binder. It is most important that the correct ratio is used. The addition should be done shortly before printing, as the ink with added hardener can only be used for a limited time span (pot life). Depending on the ink type, the pot life lasts for approx. 6-12 hours. The complete hardening and adhesion of these ink systems is sometimes reached only after a few days. Very often, a common mistake is to try adhesion and chemical resistance tests too early. It is important to follow the technical information of the corresponding technical leaflets.

Baking inks

The baking inks show similar characteristics to the two component inks. The chemical reaction of this ink system is a cross linkage of the binder, which will only take place under the influence of very high temperatures. More information about this can be found in the corresponding technical leaflets.

UV-curable inks

The technique

In pad printing, the ink transfer is normally based on the evaporation of the solvents. The ink film receives a tacky surface due to the solvent evaporation, which causes a change in the ink's adhesion performance. The ink should be transferred as a layer, to receive optimum results in opacity and edge definition. This ink transfer is in contrast to the UV-technology. Due to the absence of solvents in the UV-inks, the ink surface does not change its surface tackiness, so that ink transfer is more difficult.

Application fields

Industrial pad printing with large print runs.
Identification codes, marking, simple decorations, date marking, batch/date.

For example: bottle caps, technical plastic parts for use in all industrial fields, car manufacturers' suppliers.

Advantages
- The ink is always "open", no drying on/in the die plate.
- Continuous production as well as continuous quality of the printing ink.
- Wear of the die plate or doctor blade system is reduced compared to the use of solvent inks.
- Immediate curing through UV-light; parts can be immediately processed.
- No evaporation of solvents (even in the open ink tray).
- No annoyance by the smell of solvents.

Disadvantages
- The opacity of the ink is limited compared to solvent-based ink systems and also depending on the power of the UV-dryer available.
- Doctor blade shadows are sometimes transferred by the printing pad.
- Pad cleaning by adhesive tape is limited, because the ink on the pad will not dry completely, as it would with conventional inks.
- For high quality requirements on the printing image (decoration), the transfer accuracy of the UV-ink cannot yet meet the same high quality as with solvent inks.

Marking/Disposal
UV-inks are produced according to EN71, that is without heavy metal pigments. However, the application on toys should still be avoided. Due to the drying process, there is still a possibility, that not fully linked (cured) parts of the ink remain. Ink waste should be disposed of as per solvent inks.

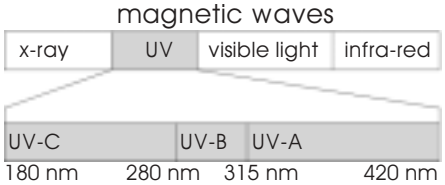
Technical development
In screen printing, the UV-technique has been established for many years and is indispensable. The great advantages and success in screen printing have meant that the demand for UV-inks in pad printing has steadily increased. Ink manufacturers and pad printing machine manufacturers are working together to speed up the process. At the moment, too many things influence this progress and thus prevent a fast change towards UV-curable inks in pad printing (for example die plate etch depth, halftone size or density in the die plate, various printing pad materials, shapes and hardnesses.

UV-curing units

Two different systems are available:

Conventional UV-curing units
This type of UV-dryer is today's standard in UV-technology. One or two medium pressure mercury vapour lamps of 80 - 120 W/cm are used.
Due to the emitted UV-radiation, ozone develops which must be extracted. As ozone is a very unstable molecule, it usually transforms into normal oxygen during the exhaust process. If the exhaust system is installed by experts, there is no danger to the environment.

spectrum of electro-magnetic waves



Cold-UV or Flash-Curing units
The light is "flashed" at shortest intervals. Very little heat and almost no ozone develops. But both units work with different light frequencies and this naturally has an influence on the curing and adhesion of the ink.

Water-based ink systems

To meet the increasing requirements on work safety and environment protection, the search for solvent-free ink systems is becoming more and more important. Ink manufacturers have been working on the new generation of water-based printing inks. These are already used in some printing techniques. In pad printing, this ink system has not been accepted so far, as the print run can only be very slow. The use of water as solvent cannot achieve the necessary characteristics of fast drying, tackiness as well as ink adhesion and chemical resistance.

Solvent-based inks without harmful or irritant components

The efforts to develop solvent-free inks have a positive side effect: "inks without harmful or irritant components". These are solvent inks, which consist of mild solvents, which do not require any labelling and which give the possibility to offer safer inks. But as they are still solvent inks, their application in the pad printing field is quite possible. But through the choice of mild solvents, the drying time is slower. Therefore the inks stay "open" in the die plate for a long time, so that this ink system works very well, especially with four colour process printing.

Ink characteristics

The finished print requires a wide range of characteristics, regardless of the substrate:

- The image should be matt, silky, glossy or high gloss.
- The ink should be resistant to scratching, various chemicals, dishwashing, saltwater, as well as outdoor resistant; it must also be safe and meet EN71 regulations for printing onto toys.
- Special shades, silver and gold effects, luminescent inks should be possible.
- The print should be either opaque or transparent.

It can be clearly seen from these numerous demands of sometimes opposing characteristics, that different ink types are necessary.

Processing

Pad printing inks cannot be put straight from the can into the ink tray of the pad printing machine. Depending on printing speed or print design the ink must have various viscosities, and for two-component inks, the hardener must be added. Here, already two handling mistakes can be made which would have negative results for printing. The ratio of ink/thinner/hardener must be very accurate, as the amount of ink needed to fill an ink cup or ink tray is so small (between 50 and 150 g), just a few grams error would cause a big deviation.
For example:
Two component ink: ink/ hardener 10:1 + 10 % thinner amounts to 100 gram ink + 10 gram hardener + 11 gram thinner.
A deviation of 2 grams in this example when adding the hardener will change the mixing ratio by 20%!! This can cause terrible results because this wrong ratio will completely change the ink characteristics like adhesion as well as the potlife. A complete day's production could be useless as the scratch resistance and adhesion of the ink can only be checked after 48 hours.

Rule of thumb for two component inks:
too little hardener: longer pot life but bad adhesion
too much hardener: shorter pot life and ink becomes brittle

For these reasons, an exact weighing of the components is a must for processing.
The age of the ink and the hardener can also be important. Hardeners are mostly hygroscopic (water attracting), and therefore lose their characteristics when an opened can is kept for a long time unsealed. Please refer to the shelf-life data of the ink manufacturer.

Thinner

The choice of thinner is important mostly for extremely fast printing, double printing or multicolour printing. Fast thinner is used for fast printing or multicolour wet on wet printing. A slow thinner is used for slow printing processes or when printing extremely fine designs, to avoid drying of the ink in the die plate.

Colour charts

Almost all ink manufacturers offer colour charts and technical data sheets. The technical data sheets offer all relevant information to the user e.g. which ink is suitable for which substrate and what the typical characteristics are, which is especially important because very often, several inks are suitable for one material. For each individual ink type, a material safety data sheet is available as well as the technical data sheet.

To reproduce a specific ink shade exactly, a lot of experience is necessary. Because of the small amount of ink which is transferred by the pad, the basic colour of the material to be printed affects the colour appearance. On dark substrates, a double print is often necessary. Sometimes a first print with white cannot be avoided. This of course has a negative effect on the output.

Euro-Scale

This scale of shades has a special place in the scope of ink shades, and is exclusively used for four colour process printing. These are 4 transparent basic shades of Yellow, Magenta, Cyan, and Black.
By colour separation and screening, special artwork films are produced. The overprint of all these 4 colours will allow a colour image reproduction. On dark substrates, a white base has to be printed before the colours. On a 4 colour pad printing machine, the white will be printed in this case instead of the black.

Example:

4-colour machine shade sequence	white material: yellow-red-blue-black coloured material: white base print- yellow-red-blue

These different shade sequences, which have almost the same results, must of course already be taken into consideration when preparing the artwork films (colour separation). In the professional repro language the yellow-red-blue-black sequence is called "4-colour separation"; the sequence white-yellow-red-blue is called "3-colour sequence", with white as first print. The black is professionally called "depth".

Mixing

Approx. 20 opaque ink shades are offered as standard. These basic colours are intermixable within one ink series. If a certain ink shade is to be mixed, a colour sample as well as a sample of the material to be printed are needed, to take into consideration the base material for the mixture of the special shade.

These shades include the RAL chart, the Pantone chart, HKS chart and manufacturer-specific colour shades. For many of these shades, mixing formulas already exist. Another possibility to achieve these special shades is the use of a spectrophotometer (Mix-computer). It measures the colour shade by reflection of the original colour sample and calculates a mixing formula, which can be adjusted further after a test printing, if necessary.

Plastics identification

There is a very simple method to check plastics for their printability:
If plastics can be attacked with thinner (the surface becomes tacky), they can be printed with a one-component ink. The one-component ink creates a direct compound with the substrate surface and is then absolutely scratch-resistant. If the plastic is resistant to solvents, a two-component ink must be used, which will harden and stick onto the surface. Possibly a pre or post-treatment is necessary (see chapter on machines).

Inks and The Environment

The use of inks and solvents calls for certain safety measures to be followed. Some of the contents are dangerous during processing (contact, inhalation, swallowing, flammability) and others during disposal (groundwater contamination).

When handling inks and solvents, the following precautions should be taken:

- Protective gloves should always be worn when mixing and cleaning; the printing area should be well ventilated.
- Remnants of inks, thinners and other solutions should be collected and disposed of as special waste.

Regarding this matter, new raw materials are continuously tested, to achieve better results for the protection of the environment e.g. solvent inks without harmful or irritant components or solvent free UV-curable inks. As these new inks and/or new thinners have a different smell, psychological problems may develop. This can result in a subjective rejection. Therefore, the introduction of new products and new technologies should be done with the manufacturers' support. The material safety data sheets are just too often ignored. Last but not least, it should again be pointed out that remnants of inks and thinners must be disposed of specially, according to the existing regulations. Information about ink and thinner waste disposal is available from all established manufacturers.

Pad printing machines

Pad printing machines are available in various sizes, models, and with various drive types. All machines have the following in common: a printing pad, a die plate and an ink well system. The differences become obvious when looking at the arrangement of the individual parts and the printing sequence.

Even though standard machines are available for almost all applications, very often special machines have to be designed and constructed. In many cases basic models of standard machines are of modular concept and can therefore be altered into special machines by using the existing components.

Requirements

If a requirement list is to be prepared for a pad printing machine, these may be company-related or application-related requirements. In most cases, a special printing machine is necessary to reach a specific solution for one company, which means, for a specific product. Very often, larger companies try looking for a machine which would be a panacea for all printing subjects, as they want to print all or various articles with the same machine, with various requirements, which are often contradictory. This results in purchasing over-sized pad printing machines for little parts with additional follow-up costs.

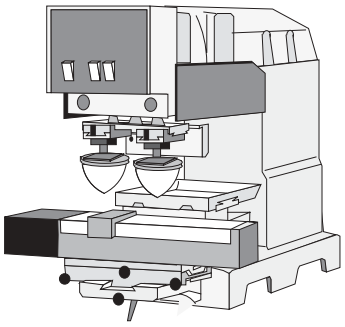
The following are the possible requirements:
- From one-colour up to five-colour printing
- From manual printing up to fully automatic solutions with product handling systems
- Hand machine, table model, stand-alone model, assembly machine
- High-speed printing machine
- Product-related version / universal version
- Flat / half-around /all-around printing

Machine types

All these various requirements can only be met by different machine versions. These main features are explained in the following chapters.

Table-top machines

These are the most used models, as they can be used universally. They consist of a complete pad printing machine, which is suitable for smaller and medium sized images.



Many producers add to these machines a standard work table, so that the use is economical even if the product changes continuously. Table-top models can be set up at work benches, added to production lines or be used at various work places. Specially when printing voluminous, transport-intensive articles, the transport of the machine is usually cheaper than the transport of a large quantity of products.

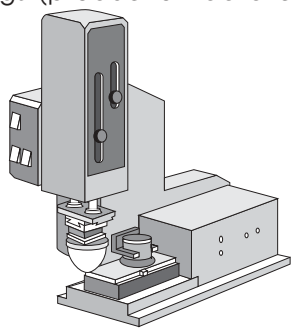
Most table-top machines can later be turned into stand-alone machines by the purchase of machine feet and stand.

Stand-alone machines

Stand-alone machines consist of a complete pad printing machine with an integrated or mounted machine base. The printing machine therefore is an independent unit or independent work station. This machine type can be combined with a large, height-adjustable work table so that products of different sizes can be held.

In-line machines

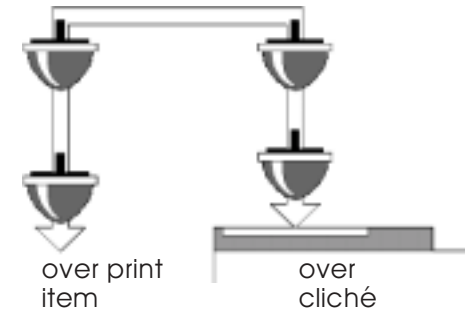
These mostly are very small and compact machines and are designed for the integration into a production line. They should be small and are technically simple machines. Normally these machines are used for markings (production data etc.) in the industrial field, and they are controlled externally (print-impulse by external signal).



The alignment of this machine must often follow the product, so sometimes the machine itself is put on a worktable so it can be transported to the required position. Many of these machines have a swivel-head (see chapter on swivel head machines). Furthermore, this machine type is based only on the assembly line speed, so that quite varying printing speeds can be required (from approx. 60 prints/h up to over 3.000 prints/h).

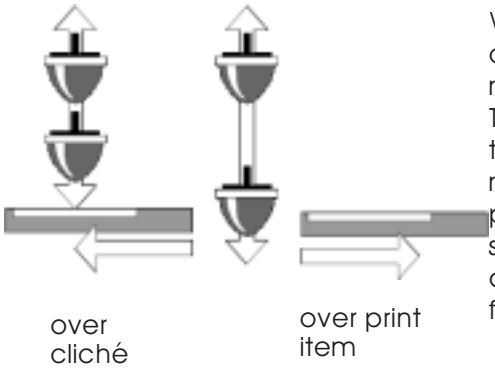
Standard machines

Standard machine types are offered by almost all manufacturers. The basic model meets most applications by the addition of only a few individual parts.



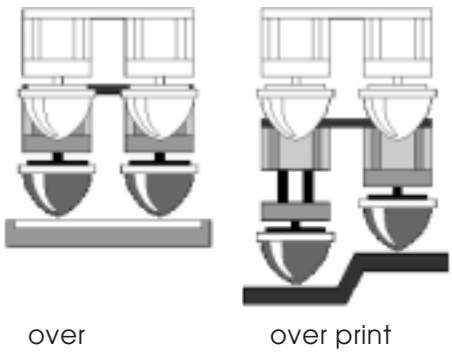
Stationary ink well

With this version, the ink well is fixed in the machine. The pad picks up the ink from the back, comes forward and delivers the ink to the front. This type is most common.



Moving ink tray

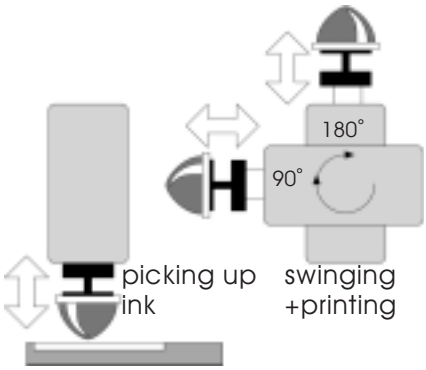
With this version, the pad moves only up and down, the ink tray moves backwards and forwards. The advantage of this design is that the pad will not vibrate so much during fast printing processes. These machines are specially useful for integration in automated processes but only for medium-size images.



Single pad stroke

If the parts to be printed have extreme height differences, very often a regular print result cannot be achieved even when using composite pads (see chapter on pads). In this case single pads can be changed in their pad stroke to be adapted to the print level. During ink pick-up, all pads are at the same level. During printing onto the substrate, some pads are extended further downwards, so that all pads print on the part simultaneously.

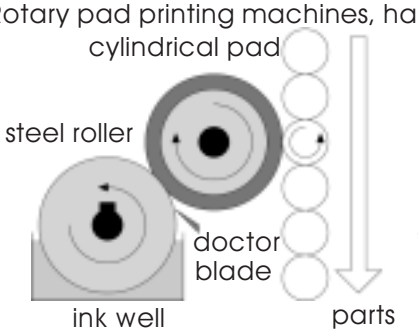
Swivel-head machines
They turn the pad after ink pick-up, by any angle up to 90°, so that the print stroke is not vertically down but horizontal. This machine type is offered only by a few manufacturers as they are in-line models which are integrated in special pad printing machines.



Round-printing
Circumferential printing is required for many products. This can be achieved by two machine types:
Standard table-top or stand-alone models, which use a long printing pad to pick up the image from the cliché. The pad remains at the front position down while the part turns under the pad on a special shuttle.

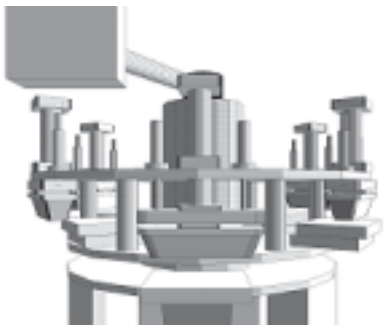
- Advantage: comparably low price, with special attachments on standard machines possible
- Disadvantage: only for small printing diameters (max. 100 mm), lower print quality, small print quantity, not recommendable for automated process.

Rotary pad printing machines, have a cylindrical pad and a cylindrical die plate. The cylindrical die plate is rotated in the ink tray. The stationary doctor blade "cuts" the surplus off the die plate surface. The counter-turning cylindrical printing pad picks up the ink and transfers it onto the parts.



- Advantage: very fast rotation speed, also applicable for flat parts with large number of prints, good print quality, multi-colour printing during one work cycle is possible.
- Disadvantage: high investment, special machine restricted to specific print object, high costs for tooling.

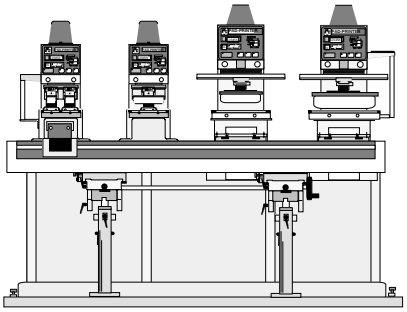
Carrousel printer
This is a special machine type, which is not integrated in a modular system. Multi-colour machine (4-6 colours), with only one jig/part carriage, hand feeding, not suitable as integration into a production line. The pads are aligned in a circular holder, which rotates over the individual, also circular aligned die plates. In one movement, all pads pick up ink, print and are cleaned in-between during the print cycle. These machines are suitable for small and medium print run (comparable: conventional machine with shuttle). Closed ink systems with small magnetic ink cups or half-closed systems (drawer system) for relatively large printing images (image length up to 320 mm) are available. This machine type is still new on the market but will be successfully established in certain applications.



Application:
Small ink cup machines:
small multi-colour images, small to medium print run, advertisement prints.
Drawer system machines:
Large, multi-colour images, small to medium print run, toys, train models, bus models etc.

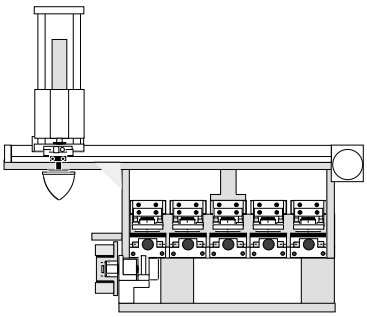
Portal machines
These machines are normally for multi-colour printing. On two moving pivots, for example a revolving head with two different pads is moved over the individual die plates. The pad chosen by the control picks up ink, the axles move to the product and the pad prints the ink onto it. This happens colour by colour.
This machine works only with the closed ink system; pad cleaning is usually integrated. It is a very complex and expensive system, results in very small piece/hour run, but has a very high quality in production. This type is used for example for the multi-colour printing of completely assembled telephones.

Interlinked system
To solve difficult, mostly multi-colour print jobs or for printing on more than one side, printing machines can be linked together. As an example for such an interlinked system, one large 4-colour stand-alone machine can be linked with a 2-colour table-top model, a single-colour in-line machine and a single-colour in-line swivel-head machine, all combined at a large linear conveyor. One machine works as a pulse generator. This means all control functions are generated from its control board.

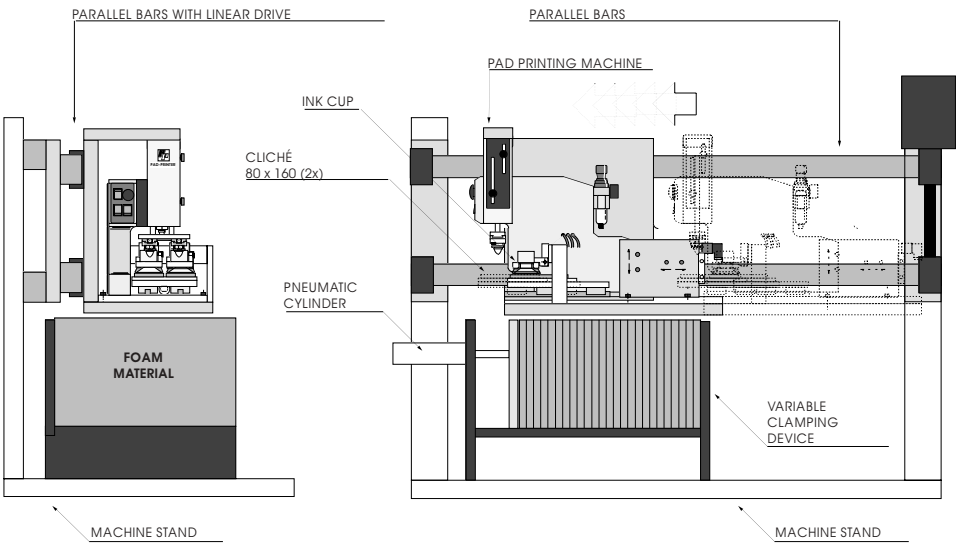


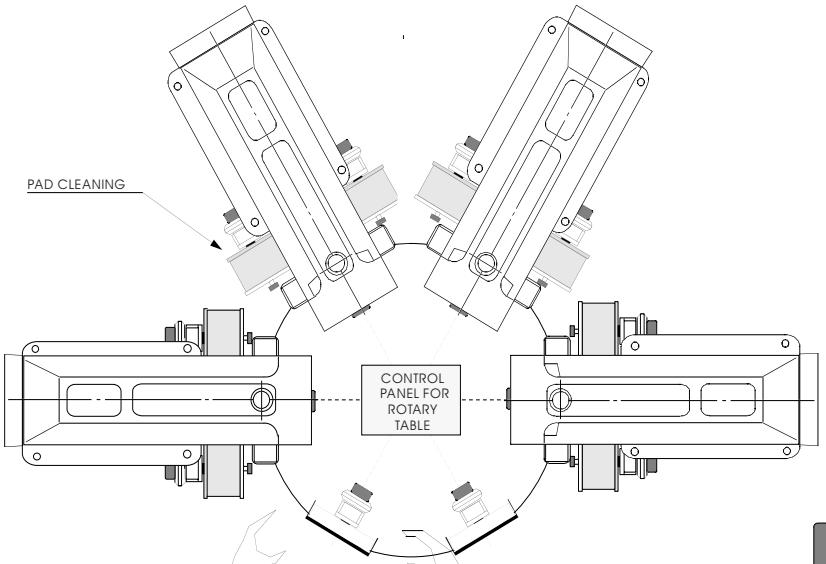
The other machines are connected to this machine (synchronized) and cannot read any impulse from their own control board. The application of such an interlinked system is almost exclusively product-related. If an extremely high output is required, which cannot be met by one standard machine, a few machines together in this interlinked system can accomplish the mission.

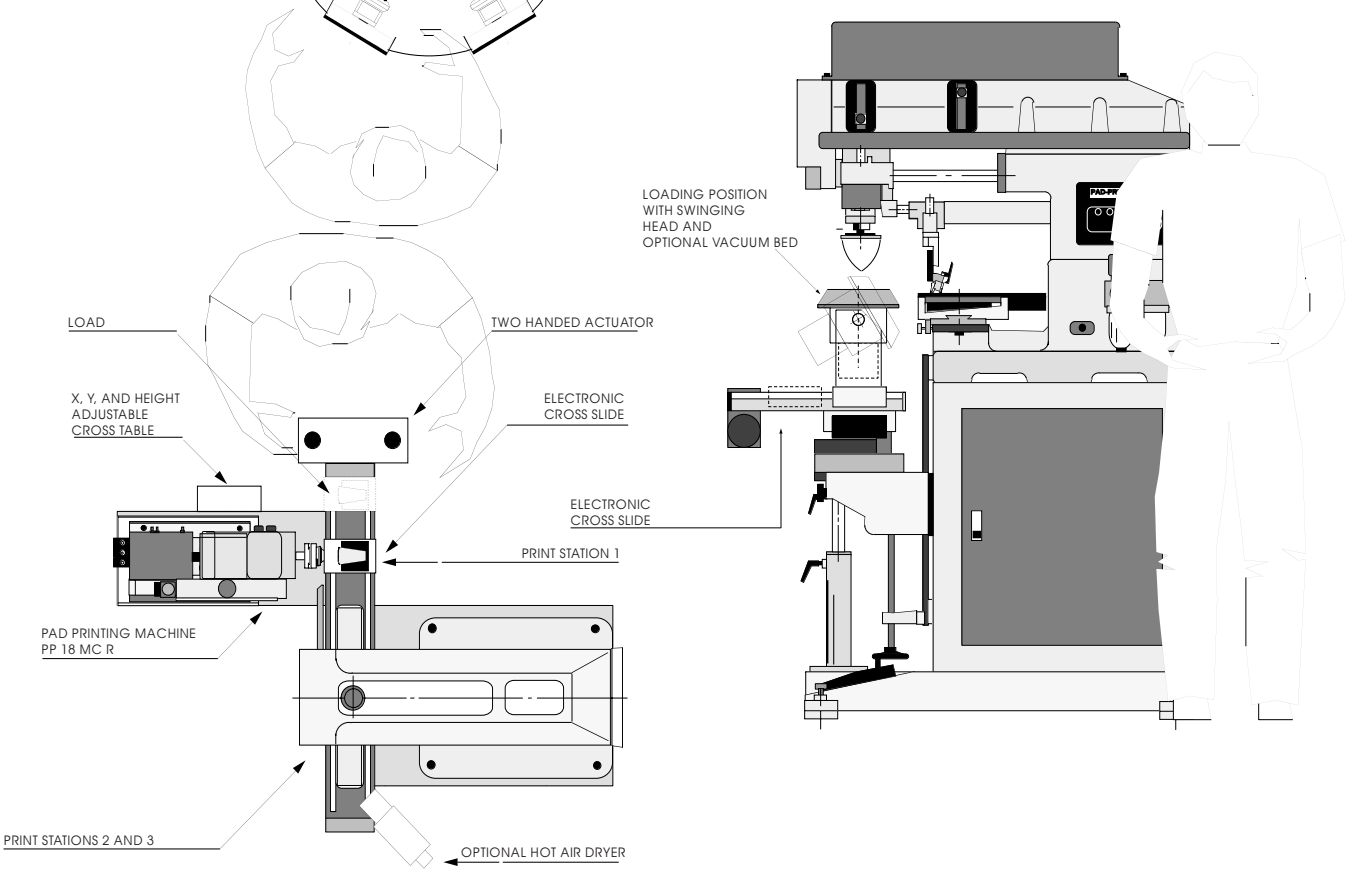
Special pad printing systems
Pre and after-positioned units
For the construction of complete printing systems, special features such as feeders are added, e.g. vibrator conveyor, magazine feed attachment or drive belt feeder. From these feeders, the parts are picked up by specially made handling tools and put onto the machine's own transport belt. After printing, the parts are automatically ejected or placed on a belt for the further processes.

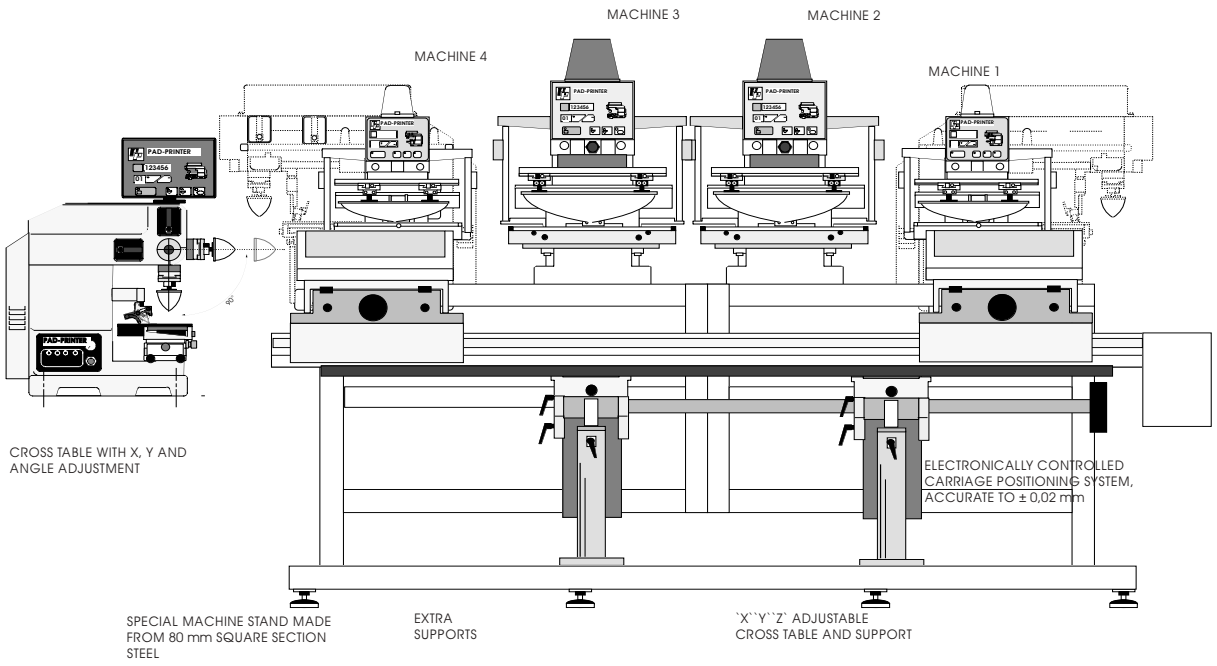


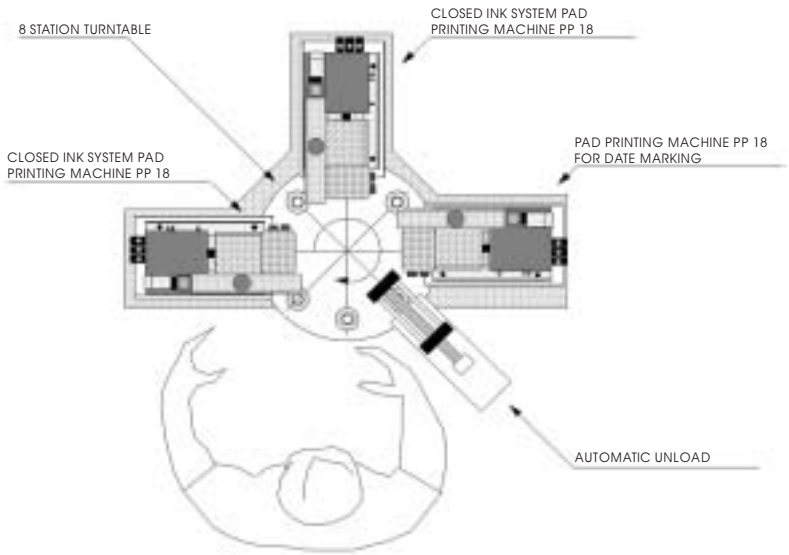
Special machines
A high proportion of manufacturer and product-related machines fall under this category, but not all can be described here. A few are outlined on the next page.

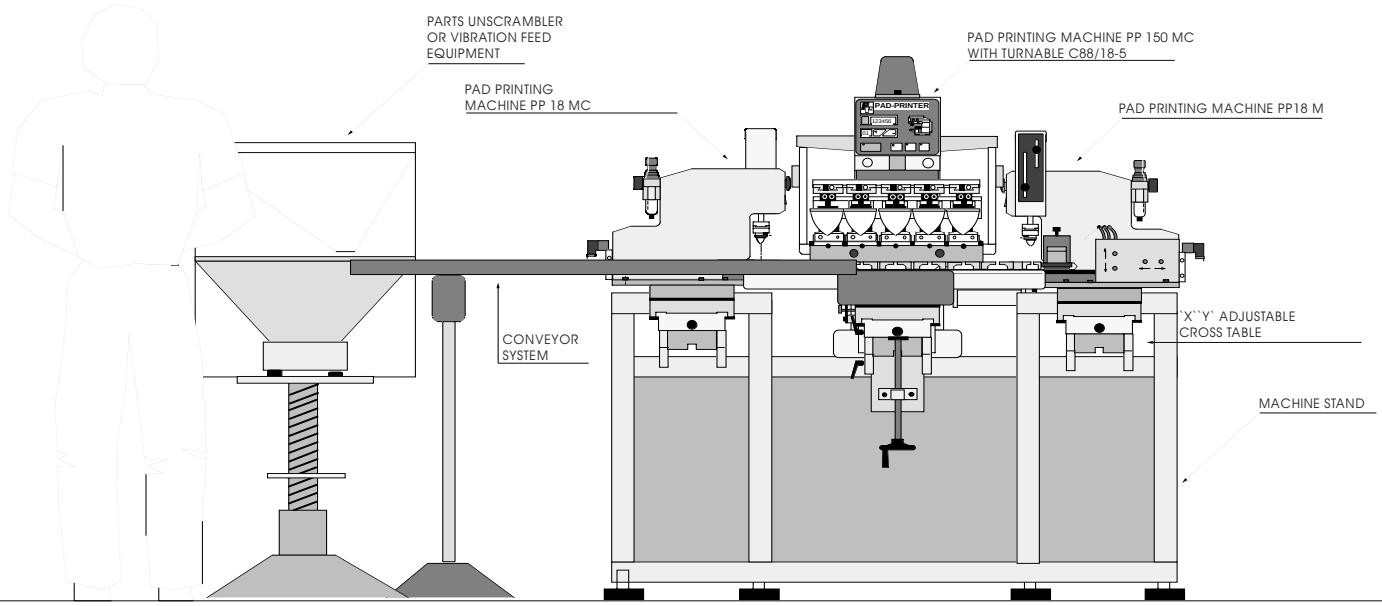

PARALLEL BARS WITH LINEAR DRIVE
PARALLEL BARS
PAD PRINTING MACHINE
INK CUP
CLICHÉ
80 x 160 (2x)
PNEUMATIC
CYLINDER
FOAM
MATERIAL
VARIABLE
CLAMPING
DEVICE
MACHINE STAND
MACHINE STAND

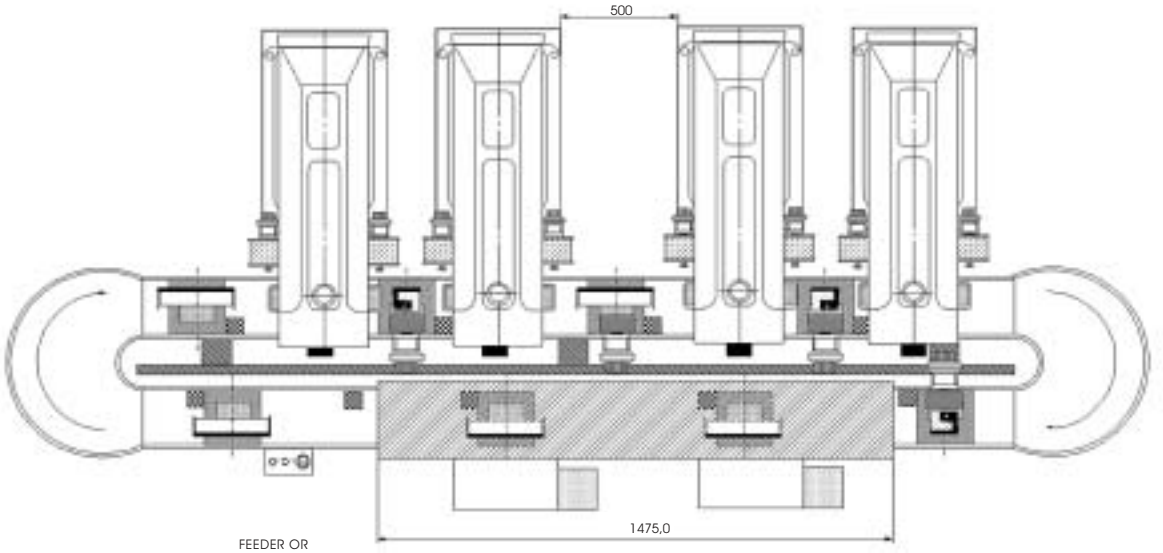

PAD CLEANING
CONTROL
PANEL FOR
ROTARY
TABLE

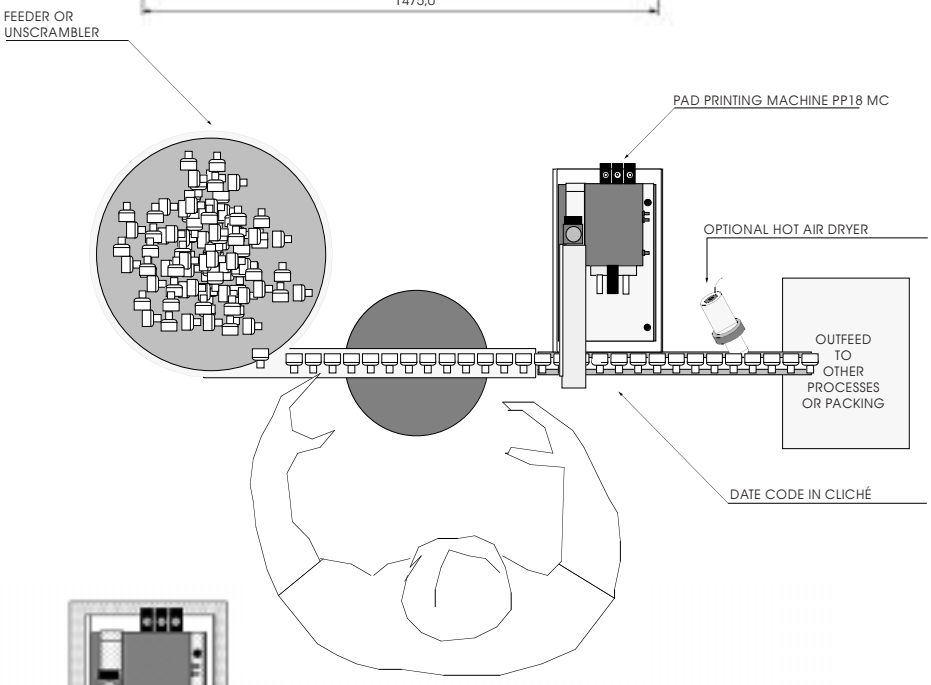

LOADING POSITION
WITH SWINGING
HEAD AND
OPTIONAL VACUUM BED
LOAD
TWO HANDED ACTUATOR
X, Y, AND HEIGHT
ADJUSTABLE
CROSS TABLE
ELECTRONIC
CROSS SLIDE
ELECTRONIC
CROSS SLIDE
PRINT STATION 1
PAD PRINTING MACHINE
PP 18 MC R
PRINT STATIONS 2 AND 3
OPTIONAL HOT AIR DRYER

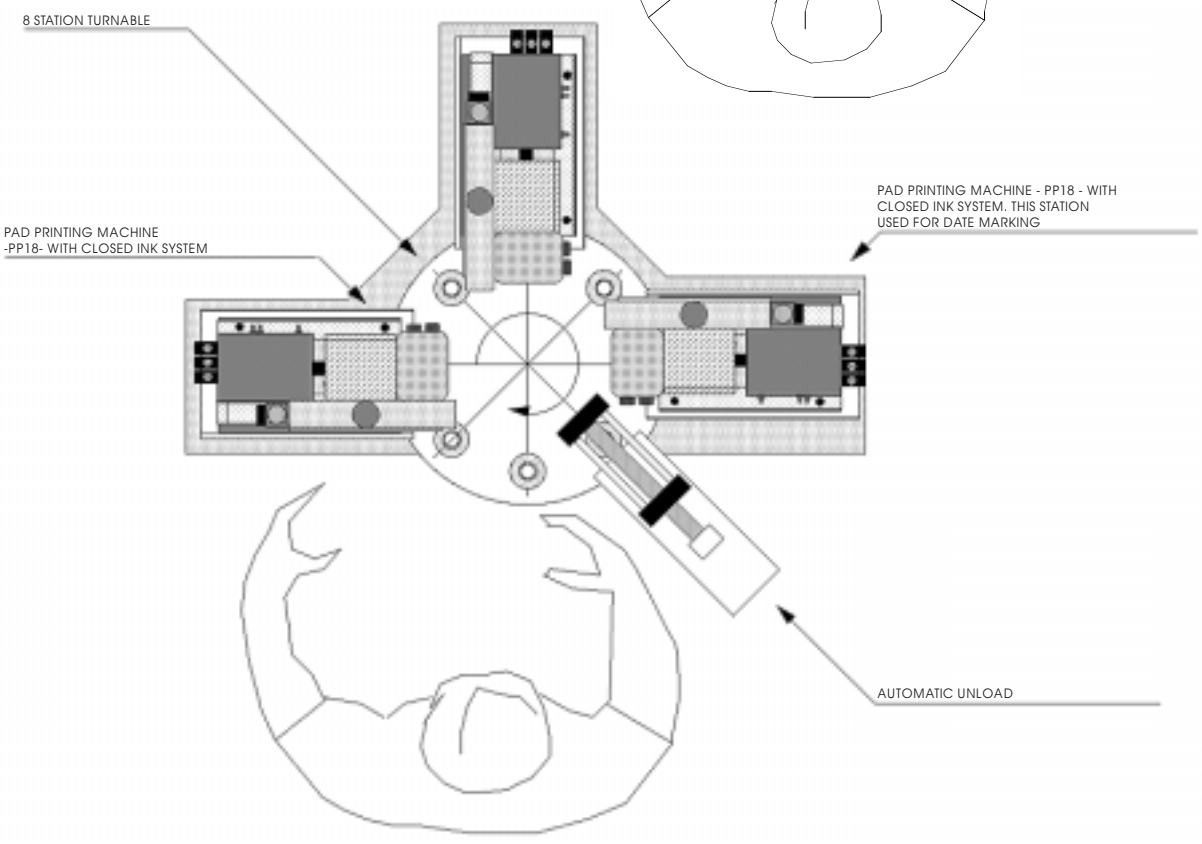

MACHINE 3
MACHINE 2
MACHINE 4
MACHINE 1
CROSS TABLE WITH X, Y AND ANGLE ADJUSTMENT
ELECTRONICALLY CONTROLLED CARRIAGE POSITIONING SYSTEM, ACCURATE TO ± 0,02 mm
SPECIAL MACHINE STAND MADE FROM 80 mm SQUARE SECTION STEEL
EXTRA SUPPORTS
`X``Y``Z` ADJUSTABLE CROSS TABLE AND SUPPORT


8 STATION TURNTABLE
CLOSED INK SYSTEM PAD PRINTING MACHINE PP 18
CLOSED INK SYSTEM PAD PRINTING MACHINE PP 18
PAD PRINTING MACHINE PP 18 FOR DATE MARKING
AUTOMATIC UNLOAD


PARTS UNSCRAMBLER OR VIBRATION FEED EQUIPMENT
PAD PRINTING MACHINE PP 18 MC
PAD PRINTING MACHINE PP 150 MC WITH TURNABLE C88/18-5
PAD PRINTING MACHINE PP18 M
CONVEYOR SYSTEM
`X``Y` ADJUSTABLE CROSS TABLE
MACHINE STAND


500
1475,0


FEEDER OR
UNSCRAMBLER
PAD PRINTING MACHINE PP18 MC
OPTIONAL HOT AIR DRYER
OUTFEED
TO
OTHER
PROCESSES
OR PACKING
DATE CODE IN CLICHÉ


8 STATION TURNABLE
PAD PRINTING MACHINE
-PP18- WITH CLOSED INK SYSTEM
PAD PRINTING MACHINE - PP18 - WITH
CLOSED INK SYSTEM. THIS STATION
USED FOR DATE MARKING
AUTOMATIC UNLOAD

Drive types

Pneumatic
The pneumatic drive is the most commonly used drive type for the following main reasons:
- The basic use of a cylinder (up/down, forward/backwards).
- The simple concept makes the machine easy to design (and service!).
- Manufacturing is cheaper as standard elements (cylinders etc.) are available from stock.

The pneumatic drive is often combined with synchronous belt drive or spindle.

Electromechanical
The electromechanical drive is mostly used with small or medium-sized models and results in very quiet machines. Because of the relatively complicated technique (the motor drive has to be turned into a linear movement by gear and cam), the prices for these machines are higher than similar pneumatic drive machines. These machines are often not as user-friendly as pneumatic machines.

Hydraulic
Hydraulic drive is used only with very few and very large machines. The largest print capacity can only be reached through hydraulic drive. The costs for this machine type are, based on the small quantities manufactured, very high.

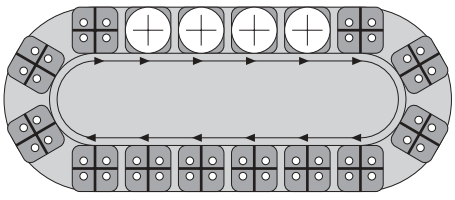
Servo pneumatic
A new concept is the combination of commonly used techniques (for example ink tray movement) with servo-pneumatic drive for the pad movement.
As this drive is very fast, fast printing speeds can be combined with high accuracy. These machines are fully electronically controlled and are freely programmable. So far, they are only used for multi-colour printing, as they offer the possibility to print each individual colour as often as needed within one printing cycle. But these advantages have to be compared to the extremely high purchasing costs in excess of DM 100,000.

Accessories

Handling for positioning of parts to be printed
Most of the described machines can be combined with multiple accessories, which are offered by many manufacturers. These accessories are product and/or machine related. Most accessories are suitable for the assembly of automatic feed or ejection stations. Also, products can be printed on more than one side as turning arrangements can be added between the individual stations.

Carré table
This oval or square shaped table is most often used. Models of 2, up to 8-colour-printing are available. Depending on the number of colours, 5 up to 18 or more jigs/part carriers are chain-driven either electrically or pneumatically. The jigs are positioned during the printing cycle, to receive an exact registered print. The distance between the individual stations mostly varies from 88.9 mm and 152.4 mm (3.5" and 6").

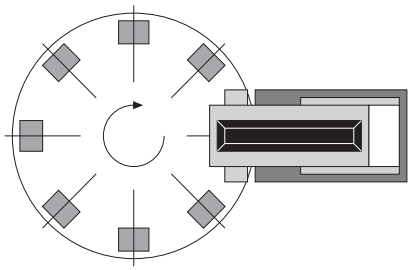
printing stations



Application field: Multi-colour printing of small or medium-sized articles.
Machine types: machines on stand, table models, assembly machines.
Addition of automatic feeder and automatic ejector is easy.
Printing speed: approx. 800 - 1,500 prints/h.

Rotary table

Rotary tables are used for large production runs. As the complete rotary table is moved, all positions are automatically fixed. It is therefore possible to integrate various processing machines at stations not needed for printing. Rotary tables are available with 6, 8 or 12 work-part carriers. Because the mass which is moved is quite large, the indexing time is longer on rotary tables than with conveyors.



Application field: 2-colour printing or 4-colour printing with 2 machines on large and heavy articles.

Machine types: stand-alone machines, table-top models, in-line machines; addition of automatic feeders and automatic ejectors is possible.

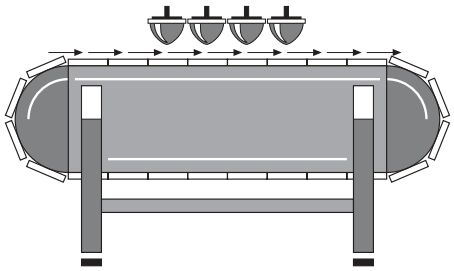
Printing speed: approx. 700 (large table top) up to 2,000 prints/h (miniature table top).

The printing image has to be indexed at an angle. The machine set-up is easier if 2 or 3 small machines are used instead of 1 large multi-colour machine. A solid base (special stand) is necessary.

Linear conveyor

Linear belts always move parallel to the machine; the printed parts always return under the belt. These belts are often set-up in a modular form and can, therefore, be manufactured for a specific product.

They are variable in length and width. Differing numbers of jigs can be fixed. The distances between the individual stations vary from 88.9 mm up to 203.2 mm (3.5" up to 8").



Application field: Multi-colour printing up to 16 colours, for medium-sized to large articles; ideal for interlinked systems of many machines.

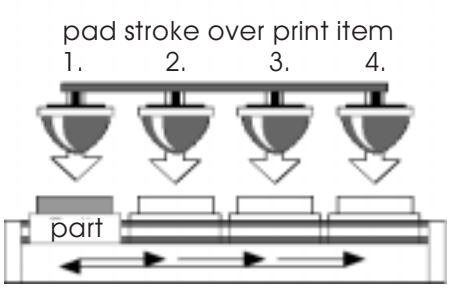
Machine types: stand-alone machines, in-line machines; addition of automatic feeders and automatic ejectors is easy; long drying distance under the linear belt. Printing speed: approx. 700 - 1,500 prints/h.

Shuttle

This type of accessory has become frequently requested over the past few years due to the following advantages:

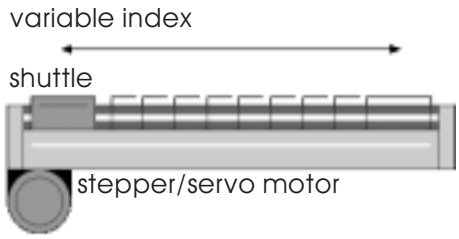
- Only one jig needed (low cost)
- Very simple and quick set-up
- Easy integration of pad cleaning

The parts to be printed are transported on the shuttle from print station to print station and are quickly returned to the starting point. If necessary, a further stop station for receipt and removal of products can be added. The economical quantity of printed parts for a shuttle ranges from 5,000 to 30,000 parts/print run. Quantities over 50,000 parts/print run can be achieved more economically with a conveyor.



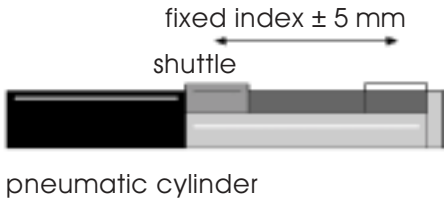
Two shuttle designs are available:

Electronic drive/electronic control
These shuttles mostly run with linear motors and a separate electronic control. Via the keyboard various stop stations can be programmed. A correction of the register accuracy is also possible via the keyboard. This version is specially suitable for steadily changing parts to be printed in multi-colour printing as well as high quality demands. As the length of the shuttles is variable, several machines can be interlinked with one shuttle.



Model train manufacturers are specially attracted to this version. Steadily changing parts with multi-colour print jobs in small print runs can hereby be printed completely, and the set-up expenditure stays small.

Pneumatic drive
For shuttles, this is the cheaper version, as the control design is much simpler. The shuttle runs via cylinders to the given limit (a correction of +/- 5 mm is possible); the index is fixed by the cylinder stroke, which uses the linear motion. Pneumatic shuttles are available in 2, 3 and 4-colour versions.



The 2-colour version is very economical. All versions are suitable for the same application fields as the electronic controlled shuttles, but they are preferred by printing shops due to their economy.

Technical details
In the details of the basic components necessary for all machines, are a large amount of various solutions.

Ink well system

Open ink well (technically outdated)
With an open ink well, the die plate lies on a lower level of the ink tray and is held at the side by screws. Therefore, only die plate sizes related to the ink tray size can be used. At the same time, the die plates should have the same height, so that doctor blade and ink coating system do not have to be adjusted. Also, as the ink flows to the sides of the die plate, the ink consumption is very high. There is an advantage in that almost the complete die plate surface can be used for the printing image. Photopolymer or thin steel plates can only be fixed very poorly.

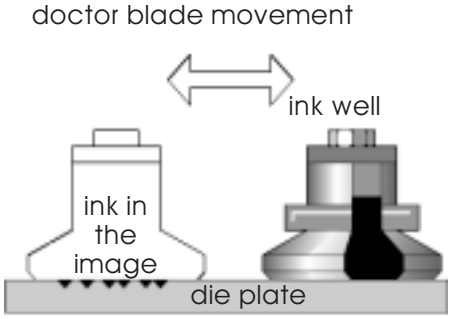
Open ink tray/ Wedged ink tray
This type has become the leading system with many manufacturers. The die plate is pushed into the ink tray from the front or the side and fixed from below by two jamb strips. The ink is filled at the rear.

Advantages:
- Less ink consumption
- Quicker die plate change
- Less cleaning time
- Thin steel or photopolymer plates can easily be fixed with an adapter or magnetic plate.

With the use of ink trays with an open side, longer die plates with numerous designs can be slid through. This way, the design change is very fast. These ink trays also allow the use of coding sticks, as they have to be movable at the sides. On multi-colour machines, these ink trays reduce the set-up costs immensely, as only one die plate with all colours is slid through.

Closed ink well system

Closed ink well systems with ink cups were only developed in the last few years and have revolutionized pad printing in the industrial sector. Almost all the disadvantages of the conventional, open ink trays have been overcome. The printing ink is in an ink cup, which also functions as a doctor blade. An ink tray is not needed. The die plate must be larger, as the ink cup needs a park position. All manufacturers are currently trying to improve this system. The only real problem is that through normal daily use, the ink works its way out of the bottom of the cup.



Advantages:

- No smell annoyance of the solvents or inks.
- Almost 100 percent production quality over a longer time period, as the solvents of the ink inside the cup can no longer evaporate easily.
- After machine stoppages, the print is immediately good (tests have proven that after a machine stop of over 4 weeks, the first print with a one component ink was very good without re-thinning of the ink).

Disadvantages:

- Ink cups are more expensive than doctor blades
- In comparison with open ink well systems large images are not yet possible.

From an economical point of view, this system has succeeded well for large-quantity production and has helped the pad printing technology to become more recognized.

The established manufacturers are competing with a variety of versions to win over more customers: different materials for ink cups, contrasting hold-down devices, e.g. held-down by pneumatic cylinder, held-down by magnetic inserts etc.
All types of die plates can be used, but photopolymer and thin steel plates still have a shorter durability.
For this reason, the 10 mm steel plate has regained favour, but its surface has to be specially even to avoid ink leakage. For large, long printing images, square ink cups are being developed, which are already in use as prototypes. A disadvantage is the extremely high cost, as these cups cannot be manufactured economically.

Semi-closed ink well systems (drawer system)

This type is an alternative to the ink cup, specially for larger print images, which cannot be achieved with an ink cup. The ink tray is constructed like a drawer, the die plate runs out of this drawer so that the pad can pick up the ink.

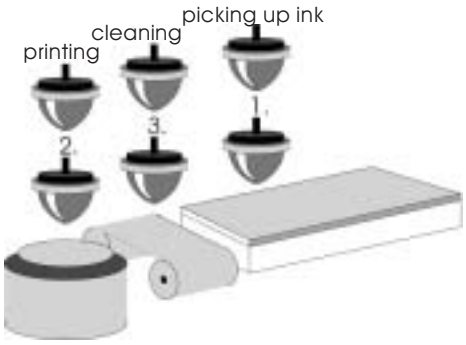
Doctor blades (open ink systems)
Polished and sometimes hardened feather-band steel blades are normally used as doctor blades. Differences result from the treatment, for example the direction of polish. Longitudinally-polished doctor blades can be used immediately while horizontally-polished doctor blades have to be stripped first, so that during the doctor blade movement a groove forming on the die plate is omitted.
The doctor blades are available from 0,18mm (for photopolymer die plates) up to 1,0 mm (armour plate) thickness. The latter should avoid a sinking in of the die plate on the printing image, with large surface images. The blade edge can be arranged at different angles (steep, blunt, one-sided, two-sided or with lamella). Good results can be achieved with a one-sided angle of approx. 18°. The doctor blade must be used at an angle opposite to the scraping direction. The angle is also dependent on the angle of the blade holder and therefore on the machine type.
In the machine, there are also two different blade systems available:

Self-adjusting doctor blade system
The blade holders are freely moving over the die plate. The pneumatic cylinder is pressurised with air and forces the doctor blade onto the plate surface ensuring even pressure. This system is very simple and reduces the set-up time tremendously.

Adjustment by screws (technically outdated)
Many doctor blade holders have adjustment screws along the front. As this system is fixed, the adjustment has to be made by the screws. This is very complicated and time-consuming.

Automatic pad cleaning

As with the closed ink system, the request for automatic pad cleaning came from the industrial users of pad printing. Much has been done by the manufacturers in the past few years. The pads of single or multi-colour machines are cleaned by adhesive tape. When the pad prints onto the adhesive tape during production, it is cleaned effectively and carefully by the adhesion of the tape. The dirty tape is then automatically advanced. This improves the quality tremendously, when used in combination with the closed ink system.



Ink spatula (open ink systems)
They are mostly used together with wedged ink trays. Generally, the ink spatulas are made either from aluminium or plastic. The adjustment of ink quantity and thickness of the ink film is easy. The cleaning expenditure is very small.

Ink roller (open ink systems)
On some machines ink rollers are used instead of ink spatulas. There are no advantages or disadvantages when comparing these two systems.

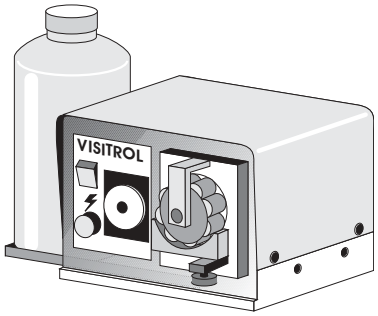
Ink pumps

In production processes, in which printing machines are running multiple shifts over a long time with the same ink, pumps are sometimes used. They guarantee constant ink viscosity and ink volume in the ink tray.

These ink pumps cannot be used with two-component inks, as this ink will, even with the steady flow, dry out after 8-12 hours and the cleaning expense would be very high. The price of an ink pump is about the same as a medium-sized pad printing machine. With the advent of closed ink systems, they have lost their significance.

Thinner pumps

Thinner pumps keep the ink viscosity constant and are used with open and closed ink system. Thinner pumps are generally low-cost. By variable timing, single drops of thinner are automatically added to the ink system. For good results, tests have to be made during one shift, for example, to find the optimum dosage.



Pad mounts or couplings

The printing pad is attached to the machine by a pad mount. In an ideal set-up, this mounting is "x" and "y" adjustable. This way, the pads can be moved to any desired position over the die plate that is ideal to pick up the printing image. In the mounting, the pad holder is inserted. The printing pads are normally mounted to the pad holder with screws. The pad holders can be rotated by a joggle joint and complement the adjustability of the coupling. To compensate for different pad heights, these pad couplings are available in various length. The market offers different mounting systems including a simple magnetic pad holder.

Pad stroke

On older, mostly mechanical machine models, the pad stroke adjustment is difficult because the control stroke inside the machine has to be adjusted. On modern machines, the pad stroke is manually adjusted on the machine's outside on a scale or a control switch; the adjustment is controlled by contactless limit switches.
A further possibility for pad stroke adjustment is by digital means. The distance of the pad stroke is controlled by either an incremental encoder or an absolute encoder without the use of a limit switch. In this case, the pad stroke is adjusted by either a rotary potentiometer or directly on the display. This is a big improvement, as the adjustment can be done during the printing cycle.

Speed

The machine's speed is given as prints/hour and reaches approximately 1,000 to 3,600 prints/hour on standard machines. With mechanical machines, only the overall cycle time can be changed. On pneumatic machines, particular speeds can be regulated individually.
This means that
- the pad stroke upwards or downwards and/or
- the doctor blade movement forwards and backwards
can be adjusted faster or slower separately. This is advantageous for complicated print jobs, for example the pad can lower slowly (to pick up and transfer ink better), but at the same time move forwards faster, so that the ink cannot dry on the pad. With manual printing these machine speeds are relative. The governing factor is how fast the operator can feed and offload the machine.

It should be mentioned that some machines are driven by power takeoffs from other systems, the speed is dependent on the system speed.

Functions

Simple pad printing machines may have only one or two functions, but modern machines are now equipped with electronic controls. By simple pneumatic control, the pad stroke or the doctor blade movement can be run individually. This makes the set-up much easier, as it can be done step by step.

The most commonly used functions are:
- Single print (single/permanent step)
- Double print (single/permanent step)
- Doctor movement only
- Pad stroke only

Numerous other functions are helpful during printing, for example:
- Single print with double ink pick-up
- Single print with double ink transfer
- Single print with dwell time before ink transfer
- Start at printing position (with ink)
- Combination with Conveyor/Turntable/Shuttle
- Round-print functions

Because these functions are already included in basic machines, these machines are very suitable for difficult print jobs as well as additions in the future.

Accessories

There is a large scope of pre- and post-treatment units available, which all help to improve the printing results, or which enable a print otherwise impossible. Certain plastics (for example Polyethylene) can only be printed after a pre-treatment or some materials need a post-treatment (for example Delrin, Hostaform) to achieve ink adhesion.

Pre-cleaning

The most simple method to clean parts which are covered by a dirt layer is to wipe them with alcohol or to mechanically remove the dirt by brushing. Parts which are covered with an oil film or silicone, cannot be printed on without pre-cleaning. Some parts are so sensitive that even sweat from fingers will have a negative influence on the ink adhesion. In this case, it is recommended to wear thin cotton gloves when handling the parts.

Drying

For high printing speed, multi-colour printing, for parts which accept ink badly or for slow-drying inks, a cold or warm air blower can be used to speed up the drying process. Installations can vary as follows:

- air is directed at the pad as it moves forward carrying the wet ink
- air is directed at the pad from the front of the machine
- air is directed at the ink on the parts to flash dry the ink

When using open ink systems, the blower must not be aimed directly at the ink tray, as the thinner would evaporate too quickly and re-thinning would be necessary too often. There should also be no airflow near the personnel operating the machine. Pneumatic machines are mostly all constructed with outlets for cold air blowers, so they can easily and economically be retrofitted.

Hot air

With slow-drying inks or multi-colour printing the parts can be warmed prior to printing, to achieve a quicker drying of the ink film.
On parts that are difficult to print onto, a post-treatment with hot air can improve ink adhesion. Some materials can only be printed in combination with a hot air post-treatment. The temperature and length of the post-treatment is stated in the technical data sheets of the inks.

Corona or flame treatment

Printing on some plastics like polypropylene or polyethylene is only possible with pre-treatment by corona discharge or flame treatment. Through some of the latest developments in the printing technique, there is now a special ink available for polypropylene, with which no pre-treatment is necessary; but no solution for printing on polyethylene has yet been found.
Corona units work with a high frequency, high voltage discharge up to 20,000 volts. Flame treatment units produce an open flame, over the parts to be printed, which can be regulated in strength and duration. Both units have the same effect: The surface tension of the plastic is increased to obtain ink adhesion.
The corona units are more expensive, but are preferred due to the reduced fire risk of working with flammable liquids next to an open flame.
The advantage of the flame treatment is that it can be also used for post-treatment and in the same way as hot air. It is advisable to purchase these units from the pad printing machine manufacturers, as bad handling of these units can cause malfunction of the pad printing machines. They can also do tests before purchase, to find out which unit is most suitable.
Furthermore, parts from polypropylene can be pre-treated with a primer (adhesion agent), to achieve the necessary ink adhesion.

Ionisation

Various types of plastic can induce very strong electrostatic charges, which will show up as dust occlusions or uneven edges on the printing design. With the use of an ionisation unit, these symptoms can be reduced. Best results can be achieved in combination with an air blower, as it will remove all dust particles.

Extraction

In order to reduce the solvent fumes for the operators using open ink systems, extraction units can be installed.
Caution has to be taken, as sometimes this will have undesireable effects:

- The thinner consumption can multiply, as the vapour cover over the ink tray is removed.
- Because of increased re-thinning, production rates will fall.
- The outgoing air has to be directed in such a way that no draft is created.

Conclusion

From the great variety of machine types and accessories described in this chapter, a suitable machine for each part to be printed should be found. However, one should never forget that this product may one day be replaced by another.
In order to use this machine for new products, it is preferable if the same machine can be combined or expanded with further accessories.

It is also important to decide if a conventional or closed ink system should be used.
Many manufacturers try to construct the machines in such a fashion that they can be used with both systems by modification or retrofitting.
The present trend in developing new machines is for manufacturers to try to come up with a "universal" pad printing machine (the "do-it-all" machine), for highly developed industrialized countries.

In the next few years, new generations of machine will include further functions and will be even more universally applicable.

This means that a machine including:
- automatic pad cleaning
- integrated viscosity control (thinner addition)
- all functions operated by the electronic control
- open or closed ink system selective
- control with one interface

can be used as a standard pad printing machine for manual operation, but can also be integrated in simple or more complex special constructions or be integrated into existing production lines.
For the new, not yet developed Eastern countries, as well as Asian markets, the simple and rugged universal standard machines will be successfully used for the next few years.

Machine Set-up

As a preliminary, it should be mentioned that pad printing is not yet a profession needing an apprenticeship although steps in this direction have been taken. During a screen printing apprenticeship, the subject of pad printing is hardly mentioned. As pad printing is mostly applied in the plastics industry, users often lack qualified personnel and teaching materials.

Pad printing can be learned quickly and easily: this has been proven when looking back at the last 20 years. It can be picked up even by untrained employees in a short time. Of course, one should avoid starting with 4-colour machines and difficult images, as some experience is necessary for these jobs. Problems will always arise in the beginning, but most times they can be overcome when certain rules are followed.

Preparation

The right choice of film, plate, pad and ink is a basic requirement for good printing results. If any compromises have to be made, best results will not be possible.

Any compromise in
- pad shape
- pad hardness
- repro
- die plate type
- die plate depth
- image position
- suitable ink
- matching thinner

will lead ultimately to unacceptable results. All the above mentioned items will depend on the machine type used. Some further factors are important, which cannot always be influenced:
- the room temperature (best is 18 - 20°C)
- the air humidity (preferably between 60 - 70%).

Set-up

Here are some hints, which will make the machine set-up easier.

Pad

To find the most suitable printing pad, the positive film can be pressed on the pad with a stable glass plate. This shows in a very simple way, how much the pad has to be pressed. To center the pad's position over the image, we suggest that the pad is blown with air or wiped with alcohol, to see its impression on the die plate afterwards. The correct index of the pad can be adjusted at the same time.
If the pad is a little too large, it can be cut with a sharp knife (for example the doctor blade) to the required size. This may for instance save the high costs associated with a special pad. When cutting the pad, it is important to remember that the slanted sides should be kept almost at the original angles. This ensures stability and will therefore not reduce the print quality too much.
When several but separate images are printed together, several printing pads can be fixed onto a wooden board (pad mounting). This way, a much better printing result can be achieved than when using a very large printing pad.

Die plates

Each die plate should be checked for faulty spots with a magnifying glass before use in the machine. If there are any visible flaws in the area of pad contact, these flaws will be definitely transferred onto the printed part. The die plate should be replaced in order to save expensive set-up time. Photopolymer die plates have to be hardened sufficiently so that, in case of small impurities on the surface, they will not be damaged by the doctor blade or the ink cup.

Ink

It is best to mix the whole ink quantity required for one day in a plastic container with a lid. For weighing, a digital letter scale is most suitable. The small quantities very often needed should never be poured directly from the can into the cup, as it is too easy for too much to run out. It is best to use a spatula, with which the correct quantity can be taken out of the original can. The addition of thinner is not always the same and varies with the basic viscosity of the ink.
If leftovers of the print-ready ink are poured back into the original can, the proportion of thinner becomes larger and larger. Leftovers from two-component inks should never be poured back.
The cap of the thinner bottle is very useful for achieving the right dosage. As it is very difficult to remove the thinner from the mixing cup, it should be measured with extra care. The mixture must be stirred well, before it is put into the ink tray or the ink cup. The ink tray should be filled up to 80 %, to prevent too much ink building up in the front and to ensure that no ink runs from the ink tray edge into the printing image after the doctor blade movement.

Printing machine

An X-Y-worktable is very helpful to position the product quickly and precisely. The printing position can be adjusted by using a transparent foil or tape, which is placed over the part. Adjustable ink trays can also be of help, in case the printing image on the die plate has to be adjusted at an angle.

Pad positioning

The pad positioning can, when parts are extremely curved, cause a bad distortion of the printed image. By repeated x-y-shifting of the pad in the machine, the distortion can be reduced or obliterated. The pad should only lightly touch down on the die plate and the product. An over-pressing of the pad can cause distortion and can reduce the pad's working life.

Printing problems

From the points mentioned previously, it is obvious that numerous individual components will influence the printing result.
The following list can only be a small help and is not at all complete. It can also not take into consideration the special influence of each individual work place. It can only serve as an aid for a better understanding of the possible reasons for certain faults.

The most important requirement in establishing the reason for faults is to recognize the fault itself and narrow down the possibilities.

Fault diagnosis

Experience shows that the reason for faulty prints is almost never a mechanical fault of the printing machine. These faults are almost always obvious and can be easily described and repaired by a technician from the manufacturer.
Because of these obvious reasons this case will not be mentioned here. To remove the faults related to printing, it is most important that the faults be described in accurate detail. Application engineers will have problems if the customer only gives very general information on the phone.
Even the best engineer will be unable to give advice if he is only told the fact that the machine is not printing or that the print is very bad.

What types of faults appear:
During printing:
- Pad will not pick up ink
- Pad will not transfer any ink onto the part or only small parts of the ink

Most common faults on the product:
- No ink opacity
- Position is inaccurate (multi-colour printing)
- Distortion of the printing image
- Blurred print
- Ink run is not clear
- Ink on ink is poblematic when multi-colour printing
- Ink does not correspond to proof
- Ink splashes (thead) on the edges
- Sceen spots are visible/not visible
- Fine lines run into each other
- Lage areas are not completely printed
- Small air inclusions ae visible
- Printing image is smeaed
- Poor ink adhesion on the parts
- Requied ink brilliance is not reached

There are further numerous faults possible, but they are very specific for individual reasons:
Faults occurring prior to printing are for example:
- Insuficient pre-treatment
- Parts to be printed will not accept ink

Faults occurring after printing are for example:
- Ink changes after some time
- Ink cannot be lacquer-coated
- No ink adhesion on the parts

Fault removal
The most important thing is to narrow down the faults, as described above, as much as possible. Only then can the problems be corrected with the right measures.

Fault finding
Basically the fault can be diagnosed fastest when individual components are replaced one at a time. If the same print caused no problems the day before, one can be sure that the die plate did not become deeper or more shallow overnight. The fault should then lay either with the pad or the ink. If a suitable pad (preferably unused) is on hand, it could be quickly replaced.
If the result with the new pad is not better, the ink may be the cause. Many mistakes can be made when mixing inks.
Particularly with single-component inks, which are poured back into the ink can, the thinner ratio can become too large. If more thinner is added to the ink the next day, the amount of ink pigments is steadily reduced and, therefore, transfer and opacity problems will arise.
Further faults which will result from this are: blurred prints, ink run is not clear, large areas are not completely printed, printing image is smeared. With this example, it is clear that many faults can follow from a small mistake.

Cause of fault
As described in Fault Finding, the cause of the fault has to be determined. This is not always easy, as there are often several reasons for a fault.

Reservations against pad printing

Sometimes staff will have to curb their reservations against new technology. These reservations could have various reasons:

Inks
Most problems arise from a refusal to use inks. Usually, staff with experience in hot stamping, labelling or other technologies, have an aversion to inks. The most common reasons are:
- Soiling of hands and clothes
- Unpleasant smell
- Cleaning of ink tray and machine parts

Remedy
The company should offer adequate clothing and gloves for the cleaning process. Cleaning containers, in which the accessories can be cleaned with a brush, are very handy and helpful.
Suitable cleaning solutions are offered by all manufacturers. An elegant solution is washing machines, but this will cause other problems with the cleaning solutions as often extra protection is necessary. For the cleaning process, a small external room, preferably with air extraction, is most suitable.

To avoid the excessive smell of ink with open ink systems, it is normally sufficient to place the machine in a large enough room. As approx. 50 - 100 ml of ink are used per day, and the thinner quantity is about 10 %, the smell annoyance should not be too much. How strong the smell of the solvents will become during normal printing process depends mostly on the staff. If all ink and solvent containers are immediately closed after use, not too much thinner or cleaner can evaporate.

Machines
Staff also sometimes have an aversion to new machines. But as the operating of pad printing machines is quite simple and safe, these reservations can be overcome. It is recommended to visit machine manufacturers with the staff, so that they can form their own opinion about the new machine.
Even the dimensions and the weight of a pad printing machine are not overly considerable; it is a rather compact and handy machine. The printing pads are soft and nothing can happen when a finger is put under the pad in a machine.
As almost any product can be printed onto, even things like pens can be put directly under the pad and printed without prior preparation. The machine's process is very obvious and the operation can be picked up quickly and simply.

Hints for beginners

For total beginners to the pad printing technique, there are a few useful hints which will make dealing with the new technique easier.

For staff new to pad printing
Everyone starting in the pad printing field will have to move slowly into this technique. To begin with, easy prints should be chosen, if possible:
- single colour
- simple materials (PVC, Polystyrene)
- light, white background
- small printing images, which can be printed with a round, pointed pad
- a steel die plate is preferable as it cannot be damaged easily by operational faults
- suitable ink should be mixed exactly according to the technical leaflet

An introduction by the manufacturer should take place either at the manufacturer's or at the purchaser's workshop, with the product for which the machine was purchased. This expenditure will soon become worthwhile, as some know-how can be picked up. In this way, staff contact is established with the technicians who may have to solve problems by phone at a future date.
If the first prints are not satisfactory, the components should be changed one after another (pad, die plate, ink), to narrow down the fault.

Distributors
Some years ago, it was still very easy to compare various offers, as machine manufacturers of this new technology were few. Since then, the number of manufacturers, dealers and importers in the world market has multiplied repeatedly. It is almost impossible to get a total overview.

For beginners, whether for a small shop in a garage or a large production company, the most important criteria is that the manufacturer has overall experience in the particular application relevant to the user.
An application is sold, not only a machine. The price should therefore not be decisive.
When looking at the various machines on offer, it becomes clear that a comparison is not very easy. Various printing sizes are mentioned (printing area in cm^2, diameter, length by width, printing length or other units and dimensions).
Of course, each manufacturer will claim to have the correct specifications.
It is easy to manipulate figures, as with the use of a flat and soft printing pad, very large areas can be accomplished even with a small printing force. But quality prints cannot be achieved with these pads.
An unequivocal criteria is the doctor blade stroke. The most common machine size has a doctor blade stroke of 100 mm. The doctor blade stroke is even with the die plate depth. The die plate width can vary from 50 - 500 mm, mostly in steps of 50 mm.
Now, if a die plate size of say 100 x 200 mm is taken into consideration, the printing image can be 75 x 160 mm at the most. But this printing image can only be printed by staff with experience, as the set-up is quite complicated.
Another prerequisite is that the machine has a large enough printing force, so that an adequately large pad can be used. Naturally, smaller machine models have a limit for pad height.
It is advisable to get the next larger machine, even though a smaller machine could, theoretically, do the job, according to the technical data.
The same problem applies to the maximum print numbers. They are stated in prints per hour. These numbers can be reached, but in reality, the pad stroke to and fro is adjusted for the shortest distance, to reach the highest speed in the shortest possible distance. It is doubtful that any staff would be capable of processing up to 2,000 parts per minute manually. This corresponds to 1.8 sec per part. Such a speed can only be reached with full or partial automation.
Should double-printing become necessary (which is often the case in pad printing), the actual amount of prints is quickly reduced to below 1,000 parts per hour. The actual amount of prints in relation to an eight-hour shift, would average approximately 600 to 800 parts per hour.
If the plan is to print further products using the pad printing process, it is advisable to invest a little more at the beginning, to purchase a basic model which can easily be upgraded with individual accessories later.

Costs

The actual printing costs in pad printing vary extremely and lay between DM 0.02 for a simple, single-colour print for advertisements, and up to DM 1.50 for a costly multicolour decorative print.

The materials like inks, pads and die plates are inexpensive. The printing expenditures are mostly depending on the type and number of print. Compared to other printing techniques, pad printing takes the lead, as the costs are much lower than screen printing or hot stamping, for example.

Outlook

In the past few years, pad printing technology has gained momentum and has improved greatly in terms of reliability, due to the development of closed ink systems and automatic pad cleaning. It certainly will, in the course of the next few years, gain an even more important share of the market in decorative processing techniques.

Not only the conversion from other printing techniques, but also the increasing demand for more highly decorative items in everyday life have been the main cause for the growing importance of pad printing. Furthermore, industry standards require identification numbers, manufacturing dates etc. on an ever increasing number of even the smallest products.
Additionally, the classic benefits of pad printing e.g. the ability to print even the smallest lettering on uneven products, at relatively high speed and at low cost, cannot be understated.

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