Future Components for New Concepts of Printing Presses

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Introduction

The long tradition of printing is a process of continuously optimizing press design. Speaking about innovations of printing presses, today new printing processes like electrophotography or ink jet are a focal point. They are especially interesting for short run applications because of their potential for reducing make ready times. However, high volume printing will have a high market share in the future, and in this segment of the printing business make ready times are not such a high priority as in the short run market. Other press components in this technology become important for the total costs per copy. The aims of all new concepts for these high volume presses are:

- To simplify the various complex components in a press
- To reduce the costs of the press manufacturing process
- To automate the systems for "manless" press operating.
- To maintain the high level of printed quality on today's level.

One of the most complex and therefore most expensive parts of a high quality press is the inking unit. This is due to the technical effort that is necessary to apply a very homogeneous film onto the printing form. So it is highly attractive to look for new concepts in inking units, which simplify the process and design. In part 1 of the paper this problem is investigated.
Another expensive part of mechanical engineering is the manufacturing of the different cylinders and the design of the machine frame. Today, these components are designed with massive weight requirements to minimize the quality problems caused by vibration and other effects. New materials, like metallic foam, may be used to reduce the weight of these components whilst still guaranteeing the other mechanical parameters. In part 2, the possibilities of these new technologies are discussed.

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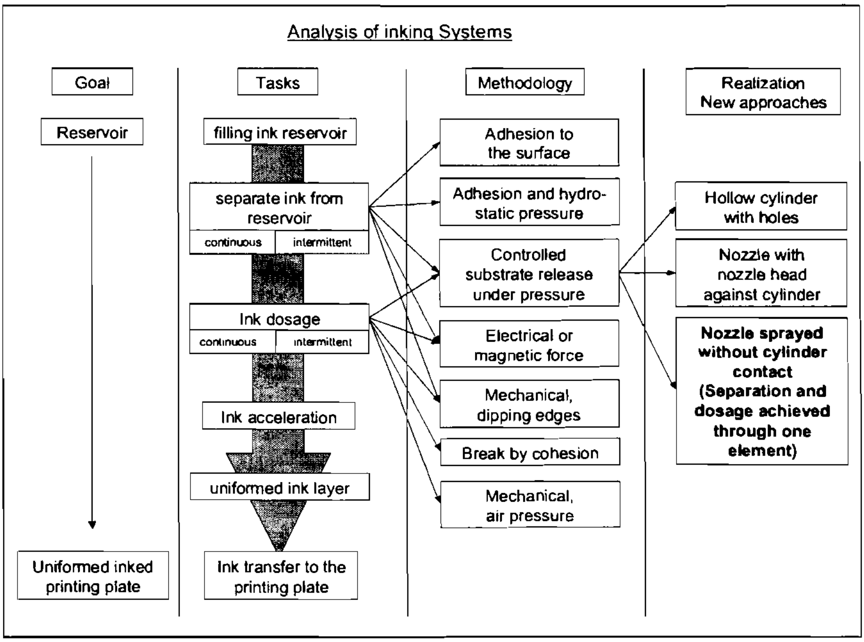
I) New Concepts for Inking Units

The further development of inking units is, among others, of great importance for future printing presses because inking units have a central influence on the quality of the product and the press expenses. Additionally, the sluggishness of the adjusting behavior of inking units is crucial for the setting period and the resulting waste paper, hence it is decisive with smaller circulation. In this field, new technologies which replace the conventional inking process are being sought.

The main tasks of an inking unit are to separate ink from a ink reservoir, to accelerate it to processing velocity, to dose and to harmonize it. Exact dosing and coating smoothness are responsible for the print quality.

The possibilities of ink separation and dosage shall be examined in the following paragraphs:



Picture 1: Analysis of Inking Systems

Ink dosage can be achieved by using different modes of operation (see picture 1). Applied examples are ink feed roller, continuous inking roller, roller squeegee or brush rollers etc. Further research with a swinging plate, a hollow cylinder or an air knife did not achieve the desired results.

Inking Units

In the past, several types of inking units were developed and used. These inking units represent the up-to-date technology and shall be analyzed shortly in the following statements:

Ductor-type inking units and continuous-type inking units are used in nearly all rotary offset printing presses for printing illustrations. They are generally characterized by good and harmonized inking. This is due to the long inking unit and, as a result, the ability to store huge amounts of ink. Continuous-type inking units with approximately 7 nips in the primary line and 20 nips altogether are typical. A disadvantage of this units is the relatively large adjusting sluggishness caused by the long inking unit.

This disadvantage, however, is eliminated by shorter inking units. Anilox inking units from KBA, MAN-Roland and TKS, short inking units from Mitsubishi and WIFAG or the pump inking unit form GOSS, to name just a few, are all in use today. Anilox inking units, which are the most widely used short inking units in Europe, determine the transfer of ink by checking the dip volume and the degree of admission and discharge of the cells. A considerable problem of these inking units is that the temperature of the ink increases during printing and consequently the viscosity decreases. The result of a reduced viscosity is a change in the cell admission and discharge behavior of the Anilox roller and a changing ink flow. This problem shows that the Anilox technology needs to be developed further. The printing quality and the printing process stability (emulsifying properties) limits the range of application for shorter inking units mainly to printing newspapers. This can be considered another indication for the demand of development of new technologies in this area.

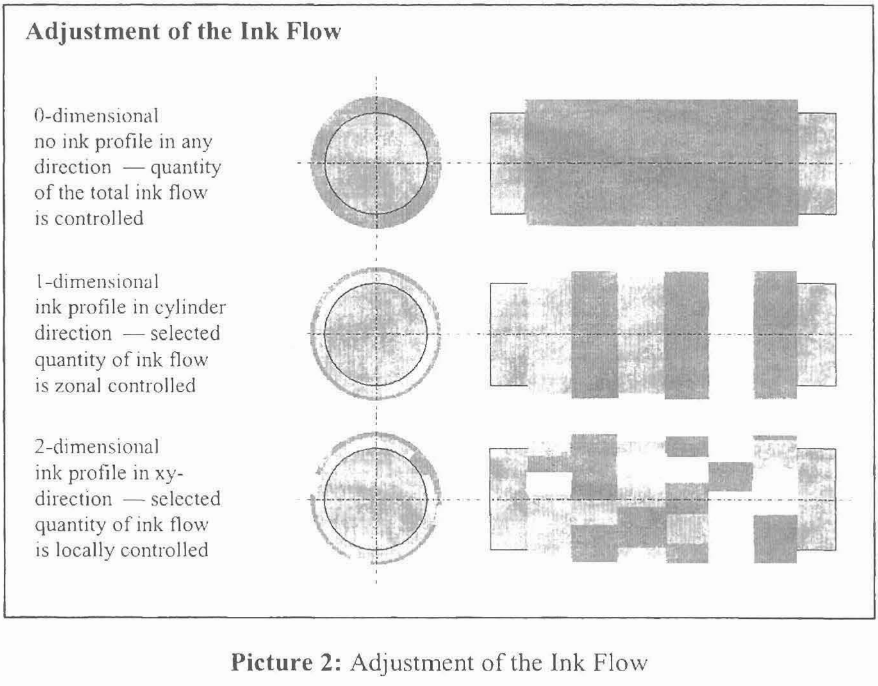
Normal Ink Adjustment

Normal ink adjustment can be distinguished in 0-dimensional and 1-dimensional inking. This means for 0-dimensional inking: the quantity of ink flow is totally controlled. There is no ink profile in any direction. An example for this is Anilox. With roller-type inking units it is possible to adjust the ink flow in zones, one-dimensional, during processing. That means that the ink flow can be adjusted to the ink demand crosswise to the printing direction.

One of the disadvantages of one-dimensional inking is that the ink demand within a ink zone has to be integrated on the entire cylinder circumference. Two-dimensional inking can be considered to achieve an inking variation in printing direction.

Two-Dimensional Ink Adjustment

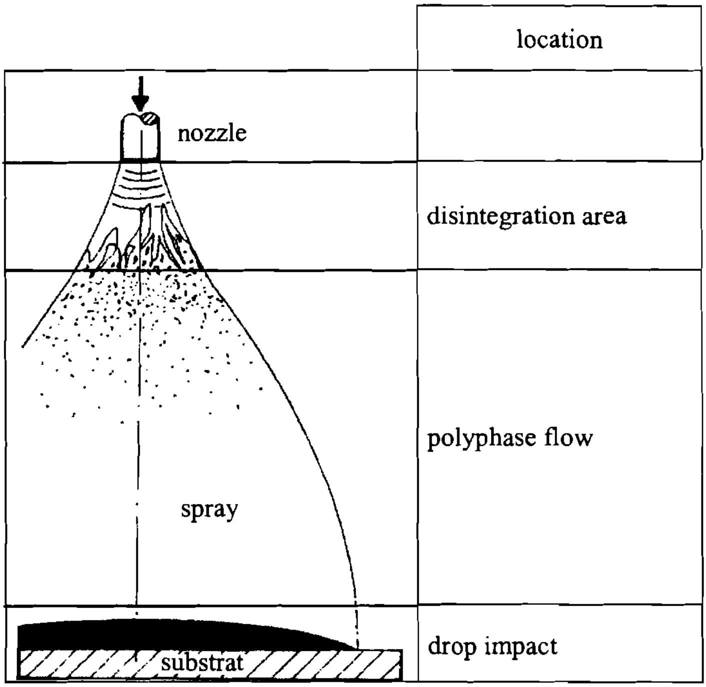
Two-dimensional inking – in addition to the usual regulation of the amount of ink crosswise to the printing direction – is characterized by the possibility of varying the amount of ink in printing direction depending on the ink demand. The special feature of this inking technique is that, when printing a form, the reduction of ink in printing direction (Patzelt, B.; Ruder R.; 1994) can be counter-acted by using different surface coverings per ink zone. The requirements for two-dimensional inking generally correspond to those in normal inking units except for the thickness of the ink layer and the coating smoothness. The thickness of the ink layer must not be judged by examining the whole surface of the application roll since two-dimensional inking variations depending on ink demand are desired. This also has to be considered when judging the coating smoothness.



Picture 2: Adjustment of the Ink Flow

There are several approaches to a variable inking crosswise and in printing direction. One possibility is a variable dip roller. Varying ink transmission could be realized by depth-adjustable cells - similar to Anilox rollers- whose dip volume can be adjusted according to the printed form. Another possibility would be to have the ink fountain blade of a continuous-type inking unit open and close in time. Therefore, a number of possible solutions, which are more or less suitable for an alternative and circumference-variable inking in short inking units, are conceivable.

Ink Separation and Dosage using Nozzles

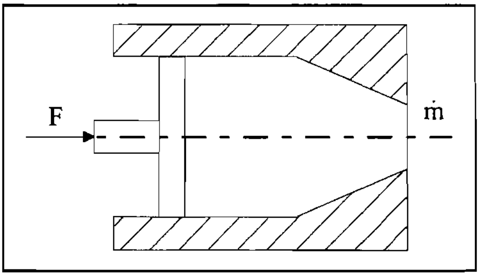


Picture 3: Zones of atomization

Another method of circumference-variable inking is to apply the ink with nozzles. The solution introduced by MAN-ROLAND (1979) uses nozzles that merely fulfill the function of ink separation and dosage. A variation in the amount of ink in the printing direction is not intended. Furthermore, the way the ink is applied as shown there requires a long inking unit in order to harmonize the ink layer. The ink needs to be spread evenly – that is sprayed – to sufficiently coat the application roll. Spraying is generally understood to be the production of drops in a surrounding vacuum or gas phase. The process of spraying is divided into sub-processes: the disintegration process, the polyphase flow within the spray, and the impact process of the drops on the substratum (see picture 3; Bauckhage, Klaus; 1990). Nozzles are often used for spraying. Typical applications are the spraying of fuels, the production of granulated products, coating of surfaces and so on (Walzel, Peter; 1990).

Contrary to the applications already mentioned, the problem with coating ink application rolls with offset inks is the high viscosity of those inks. The influence of shear processes in nozzles on the ink's thixotropic behavior has also not been researched yet. The type of nozzle is decisive for the kind of spray produced. We differentiate between single substance pressure nozzles and airblast atomizers.

Single substance pressure nozzles

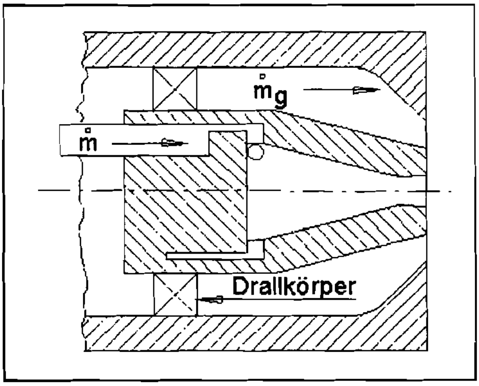


Picture 4: Single substance pressure nozzle

The characteristic feature of single substance pressure nozzles is that they transform the pressure power of liquids into velocity power and a small amount of surface power. The atomization of liquid jets is influenced by surface forces, inertia forces, viscosity forces and aerodynamic forces. Because of jet turbulence high velocity atomizing causes the emerging jet to disintegrate (Troesch, H. A.; 1954). Atomizing highly viscous liquids requires high pressures or in some cases extra power. Schneider, Thomas (1995) explains the interrelationships dependent on velocity of flow, surface tension of the fluid, nozzle diameter and many other factors. Hansmann, Stephan (1996) shows that fluids with a viscosity of $\eta > 20$ Pas are atomized into small droplets by using an ultrasonic standing wave field. A change of the material pressure effects the throughput of single substance pressure nozzles. Consequently, droplet sizes also change, which is a great disadvantage for their intended use.

Twin fluid nozzles (Air blast atomizers)

Pneumatic atomizer nozzles use the energy of the atomizing gas $(\dot{m}_g)$ to separate the fluid $(\dot{m})$. The gas accelerates the fluid shortly after it reaches the end of the nozzle. The relative velocity or the pressure head of the gas causes a partition of the fluid. The smaller the dimension size of the fluid droplets before partition, the more effective the process is (Walzel, Peter; 1990). Furthermore, air blast atomizers can be classified according to where the fluid and the atomizing gas are combined. A combination of those two components within the nozzles is called "internal mixing". This type of nozzle requires the material to be pressed into a mixing area with the help of supply pressure. In contrast to this, "external mixing" combines the components after they have reached the end of the nozzle. Because of the undertow caused by the gas, it is not necessary to use additional pressure to press the fluid into the mixing area. The swirl body (Drallkörper) as shown in picture 5 demands a bigger spray angle.



Picture 5: Example of an external mixing twin fluid nozzle
(Source: Ingenieur-Büro für Zerstäubungstechnik)

The application of external mixing twin fluid nozzles, as opposed to internal mixing twin fluid nozzles, is recommended due to the low maintenance and reduced danger of blast atomizers blocking associated with external mixing, as well as the above mentioned disadvantages of single substance pressure nozzles with regards of the change of throughput. However, attention must be paid to the fact that several nozzles, whose spray cones influence each other, have to be arranged alongside each other for the complete inking of the printing width.

The possibility of inking directly to the ink roller is of great interest. Inking directly before the plate cylinder leads to a maximum contraction of the inking unit and as a result a substantial reduction of the reaction times of the printing mechanism to changes in the quantity of the ink. The further test setup can be described as follows: The nozzles are supplied with ink by an ink pump. The ink has a particular pressure in the nozzles. By changing the process parameters (pressure of the jet, quantity being transported by the pump, preliminary pressure of the material, rate of flow through the nozzles etc.) the quantity of ink being transported can be varied. The distance between the individual nozzles determines the width of the ink zones crosswise to the printing direction. The control behavior of the nozzles controls the size of the ink zones in printing direction.

Atomization tests

The tests at the Institute for Print- and Media Technology showed that twin fluid nozzle technology can spray highly viscous offset inks on an application roll. The mass flows of the twin fluid nozzle in use were defined gravimetrically. If the determined flow is related to the demand of ink of solid area (in relation to the width of coating), a potential printing speed of about 3,5 m/s has been calculated. By using bigger nozzles it should be possible to reach even higher processing speeds. Printing tests with the above mentioned test setup were also carried out.

Point-focal inking

A second possibility of varying inking has been introduced by the Heidelberger Druckmaschinen AG (1995). Inking with varying circumference as well as point-focal inking is taken into account. The ink is only be applied onto an inking roll at those patches where ink is actually needed by the following printing plate. That requires an inking which is controlled by the printing style information. Since the image is still produced and transmitted by the printing plate, it is not necessary to achieve a definition-corresponding resolution of the inking. In this case, the use of a twin fluid nozzle only seems possible if extra air nozzles can adjust the spray cone so that neighboring sprays are not influenced. The reactivity of the hydraulic system (ink, ink pipelines etc.) and the opening and closing behavior of the nozzles represent further problems.

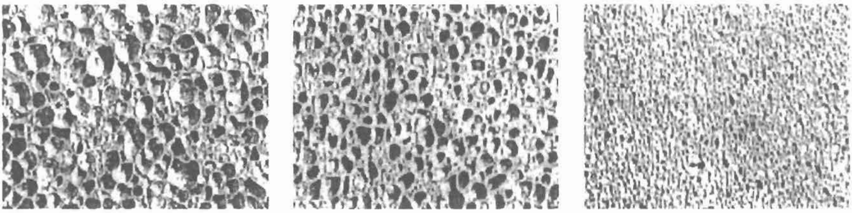
The equalization and removal of the remaining dye film on the inking roll after transmission of the ink to the plate cylinder needs to be taken into consideration when examining both inking possibilities introduced earlier in this text - the circumference-variable and the point-focal inking. This can be done by mechanic doctoring and returning the ink and, especially in the case of point-focal inking, by clearing the remaining ink with the ink needed in the following cycle.

Conclusions

In addition to further spraying tests, the Institute must examine the determination of the surface cover and, consequently, the amount of ink required. The electronically available image data can be used for this calculation. Furthermore, since the formation of paint mists has been reduced substantially due to only a small number of nips, it is possible to reduce the viscosity of the printing ink. It remains to be seen how much a viscosity reduction improves the spraying process.

II) New Materials for Press construction

The possibilities for light weight construction, which have been considered up until now, have always been handicaped due to the inherent reduction in stiffness. New prerequisites have been created by the development of metallic foam materials (Picture 6) making it possible to comprehensively realise the lightweight construction of machines within graphic technology.

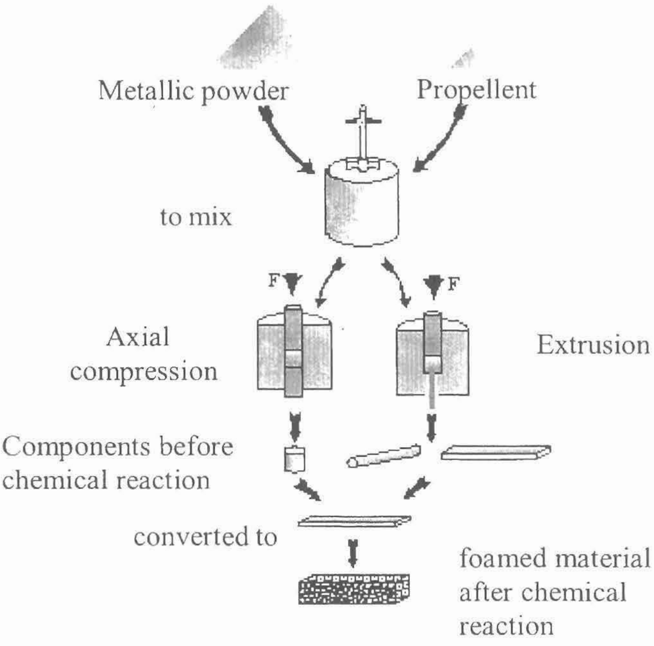


Picture 6: Innovative Material - Metallic Foam

New manufacturing techniques developed at the beginning of the nineties, made the reproducible manufacture of metallic foam possible. The results for aluminium foam are particularly promising. The varied connections of shafts, axles and bolts to e.g. cylinders, rollers, reels, levers and similar machine parts, which are necessary in machine building, as well as the connections between frame elements and crossbars etc, can be subdivided according to their type of power transmission (friction, form, and material contact). Due to the structure of metallic foams and the resulting advantages and disadvantages, it is necessary to take some action with regard to constructional adjustments. The following investigations and results refer to the application of aluminium foam.

The Process of Manufacturing Aluminium Foam

Metallurgic fusion and powder metallurgic fusion processes have to be used in the production of aluminium foam. The powder metallurgic fusion production process (Banhart, J.; Baumeister, J.; Weber, M. 1993) forms the basis of the test results presented below (picture 7). During the procedure, the powdery raw material is displaced by a propellant. Titanium hydride, for example, can be used as a propellant. The mixture is then compressed to a semi-finished material. This compression can be done by pressing e.g. isostatic pressing, extrusion or by using rollers. The external appearance of the resulting semi-finished material is no different than that of conventional metal, but when heated to above the melting temperature of the metal, the material becomes a foam like substance, due to the release of gas from the propellant. The foam structure can be fixed by controlled cooling to below its solidification temperature. The construction of components of the most varying configerations is possible using this process.



Picture 7: Powder metallurgic fusion production process
(Source: Baumeister, J. 1991)

Parameters of aluminium foam:

Size of Holes: 1 – 6 mm
Density: 0.9 – < 2.7 g/cm^3
El. module: ≈ 20,000 N/mm^2

Possible Application for Machines within Graphic Engineering

In comparison to other machines used in graphic engineering, printing machines have a very large mass. This creates problems with high material expenditure and energy use (a large number of mostly rotating parts with large masses and positive and negative acceleration), transport, stability, high production expenditure and demands placed upon foundations. The relative mass ratio (mass of the machine / mass of the processed material) is very unfavourable. It is the realization of technical processing parameters, however, which is limited most of all by the large masses demanded by the format dependant size of printing machinery.

Possible Solutions

Smaller masses with equal or increased rigidity and, as a result, improved technical processing parameters, can be achieved by:

- coating existing cavaties with foam (increasing the static rigidity)
- cross-sectional dissolving, and then coating the resulting cavaties with foam material(smaller mass while keeping or increasing the static rigidity)
- utilising the material and frictional damping capacity (energy absorption) of metal foams (increasing the dynamic rigidity)
- increasing the natural frequency of components

The following charts (pictures 8,9 and 10) show a variety of proven construction principles for web guide rollers, frames and cylinders, as well as suggestions on how the aluminium foam can best be applied to the aforementioned machine parts.

Web Guide Rollers	
Construction Principles	**Possible Applications**
Hollow cylinder (with axle bolts or continuous axles)	- fill in with foam material - reduce wall thickness and fill in with foam material - full foam
Requirements	**Reasons**
Small masses	- sagging due to mass of component (with large rollers) - acceleration (a lot of rollers in one machine) - breaking procedures (adhesion of the web to the roller, eventual web break
high static rigidity	- sagging due to web tension
high dynamic rigidity	- natural vibration at high speeds - external excitation through the web

Picture 8: Web Guide Rollers - Construction Principle / Possible Applications

Frames		
Construction Principles		**Possible Applications**
Walls (and supporting Structures)	- box walls - profile walls - solid walls	- sheet steel design and pack with foam material - reduce cast wall thickness and pack with foam material - full foam („sandwich“)
Cross Bars	- open - closed - full	- steel plate design and coat with foam material

Picture 9: Frames - Construction Principles / Possible Applications

Cylinders		
Construction Principles		**Possible Applications**
Printers/ Printing units	- solid cylinders - open cylinders	- dissolve the cross-section and fill with foam material - reduce wall thickness and fill with foam material
Rollers	- componets and gears with non-uniform motion (translatory and oscillating)	- cross-sectional dissolving and fill with foam material

Picture 10: Cylinders - Construction Principles / Possible Applications

Problems

The following problems are those that have arisen during the analyses of what was previously known about aluminium foam.

Homogeneity
Inhomogeneities, which could have negative effects on translatory and rotationally moving components, are expected to occur as a result of the foaming process. Unbalances, especially in rotational elements, normally lead to problems in the realisation of technical processing procedures.

Adhesive Capacity at Points of Contact
There are legitimate grounds for supposing that, after the foaming process, the metal foam will offer insufficient adhesive power at points of contact. Furthermore, it is possible that the foam could dissolve when put under dynamic stress.

Damping Characteristics
Frictional damping in the foam structure and at the contact points, as well as material damping of the foam, can be expected when foam coated machine parts are put under dynamic stress.

Natural Frequency of Components
An increase in the natural frequency of foam coated components is expected, which will lead to a sub-critical construction. This means an especially rigid light weight construction.

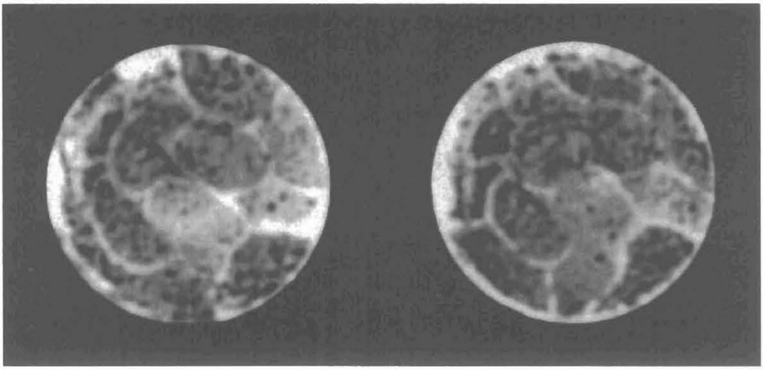
Surface Characteristics
Wear resistance, friction coefficient and permissible compression are all important factors to be considered when the foam structure is being used on action pairs carrying out technical processing procedures. At this point in time, however, there are no results available regarding this subject.

As can be seen from the problems stated above, there are a lot of requirements to be met for the appropriate use of metal foams with the appropriate materials. It is possible to deduce from this, though, that the positive parameters can be used and the negative parameters can be compensated for by alternative construction designs.

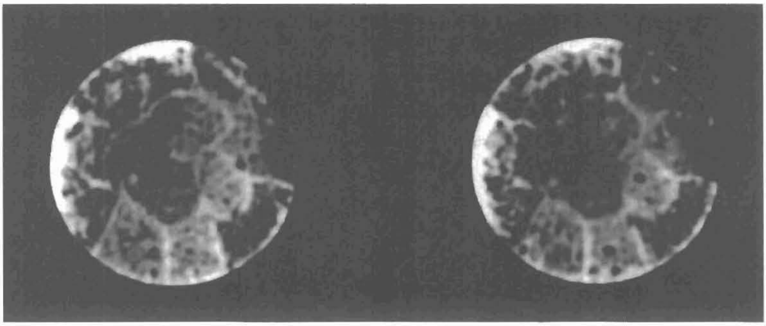
Results

The following test was carried out on foam filled and foam coated rotationally symmetrical components. The foaming process was carried out in co-operation with a foam manufacturer.

Homogeneity
The rotationally symmetric, foam filled component shows clear signs of inhomogeneities (see Computer Tomographic picture 11). This can probably be traced back, to the fact that the semi-finished material already shows inhomogeneities in the distribution of the propellant. It can also be assumed that the cooling process was not sufficiently controlled. As a result of this, the large differences in mass between the gas (hydrogen) and the metal (aluminium) cause the foam structure to collapse. One can expect that the foaming process will be continually optimised, but it is not expected that absolute homogeneity will ever be achieved.



a) Sufficient Homogeneity

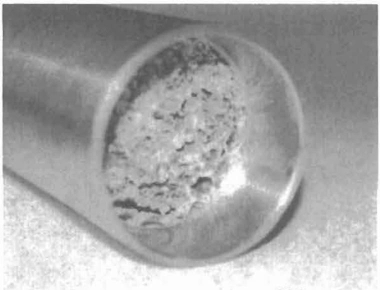


b) Inhomogeneity caused by Cavities

c) Inhomogeneity caused by Accumulation of Material

Picture 11: Computer Tomographic Pictures

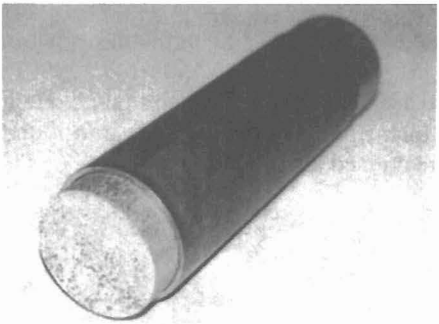
This front view of a foam filled cylinder, Picture 12, shows the inhomogeneity in aluminium foam. This leads to considerable unbalance in rotationally symmetric components. Inhomogeneities which can be compensated for by counter-balances are tenable. Double-sided unbalances of approximately 100g occur in foam coated cylinders with the dimensions: length 680 mm and diameter 60 mm.



Picture 12: Front View of a Foam Filled Cylinder

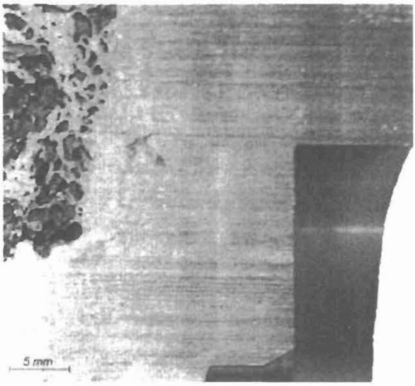
Adhesive Capacity at Points of Contact

No metallic bond between the aluminium foam and the steel casing was discernible. It was possible to separate the aluminium core from the casing by exerting relatively little force in an axial direction (picture 13).



Picture 13: Adhesive Capacity between the Foam and the Core

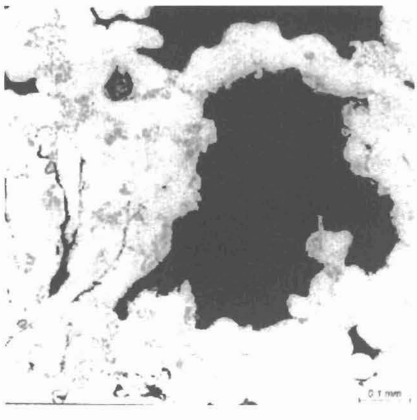
The result of this was the idea to create a metallurgic bond (Picture 14).



Picture 14: Longitudinal Section: Metallurgic Bond Aluminium Foam / Aluminium

When coating machine parts (massive metallic components whose cross section ensures form contact)with foam material, a form contact and metallurgical material contact bond is achieved.

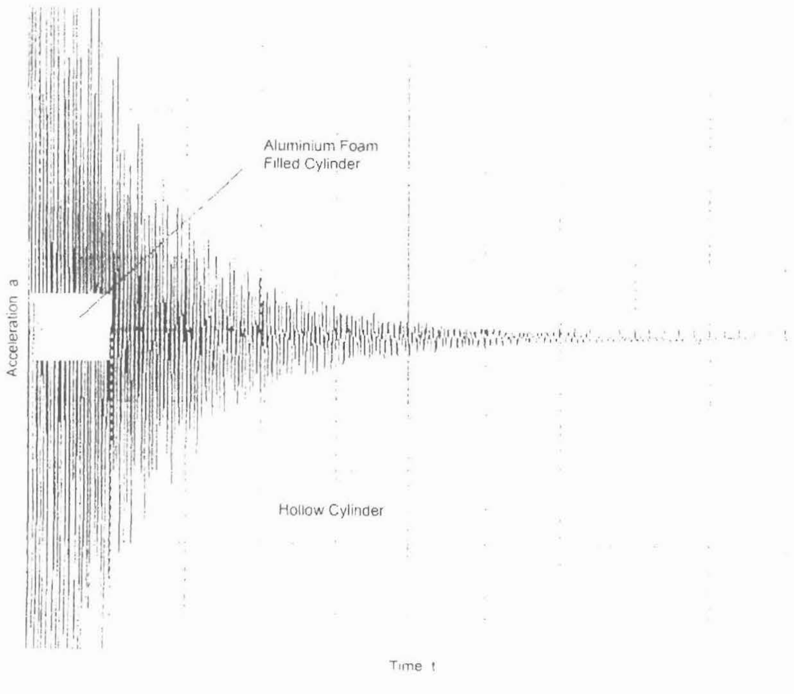
In practice, this is an alloy made up of aluminium, copper, magnesium and lead (Hübler, C.A.; Hahn, M.; Schneider, J.; Weidner, J.; 1999) This ability to bond will considerably increase the aluminium foam's range of application. Picture 15 shows a microscopic picture of the structure in its transitional phase between the foam and the above mentioned alloy.



Picture 15: The Structure in the Transitional Phase between Foam and Alloy (Weise, A. 1998)

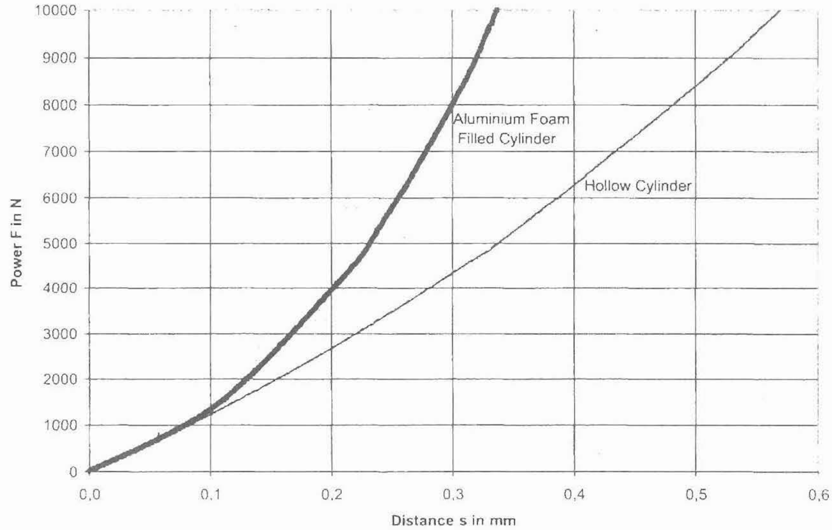
Damping Capacity

In tests, one hollow and one foam coated cylinder of equal geometric dimensions were externally excited. Picture 16 shows the decaying curves of both machine parts. The positive influence of the aluminium foam on the damping capacity is clearly visible



Picture 16: Acceleration - Time - Characteristic Curve of Hollow and Foam Filled Cylinders

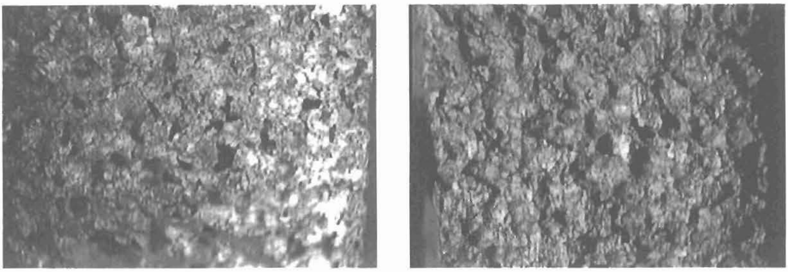
Increase in Rigidity
Hollow and foam filled cylinders were simultaneously and without support subjected to the pressure of an area load. Picture 17 clearly shows that under the influence of aluminium foam, rigidity almost doubles.



Picture 17: Force - Path - Curve of Hollow and Foam Filled Cylinders during Compressive Stress

Surface Characteristics
In a series of experiments, foam filled cylinders with diameter 30 mm and width 10 mm were put on a running web with line compression for 6 hours. A web speed of 12 m/s and an arc of contact of 2°, amounted to surface force of 8 N.

Despite the relatively short test time, Picture 18 clearly shows that a smoothing and distortion has taken place. These test results clearly show that without surface refinement, the surface structure of the foam at the action pair has only a limited use.



Picture 18: Microscopic Photographs Before and After the Tests

Natural Frequency of the Components
At this point in time, it is not possible to comment on the natural frequency of components because the tests are still being carried out.

Conclusion

New manufacturing techniques developed at the beginning of the nineties made the reproducible manufacture of metal foams possible. The test results are based upon aluminium foam produced by the powder metallic fusion process.
In contrast to other machines within graphic engineering, printing machines have a very high mass. The relative mass ratio (machine mass / mass of the finished product) is very unfavourable. Added to this, are the limits set on the realisation of technical processing parameters. These limits are a result of the high masses which are demanded by the format dependant size of the machines.
The following problems have arisen during the theoretical analyses of what was previously known about aluminium foam: homogeneity, adhesive capacity at points of contact, damping capacity, surface characteristics and natural frequency of components .
As a result of this, there are high requirements for the appropriate use of foamed metals.
The first test results were presented proportionally to the problems listed above.

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