Digital High Volume Printing —Breakthrough for Print-on-Demand?

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Abstract

The following paper presents an evaluation of the future prospects of Print-on-Demand (PoD) technology and, correlated with it, of Direct Digital Print (DDP) systems for high production volumes. After a general introduction to the conditions of PoD production different parameters of the utility features, which are necessary for PoD documents, are discussed. Also a comparison of influences to the cost structure is given.

Introduction

The strong growth of the media market is particularly driven by a very dynamic technology development. Along with new printing technologies especially the Internet is very formative, but also catchwords such as electronic books, database publishing, digital photography etc. stand for completely new media attempts. The idea "Print-on-Demand (PoD)", therefore a concept for the special order of printed material according to demand however is already over 15 years old. Although since then PoD has been able to establish itself within some market segments and despite its convincing basic idea the big breakthrough has not happened.

Above all, typical PoD applications differ from office printing by their higher document volume and the higher demand on print finishing involved (Figure 1).
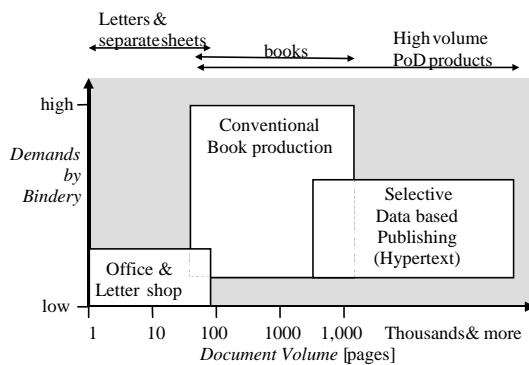

Figure 1. Print Products with different Document Volume

In particular, PoD aims at the production of book-like products which in binding can widely range from loose sheets in a ring binder to leather-bound cases. Beyond the classic book PoD also offers the possibility of printing individual contents and consequently producing new products of Database Publishing. This market is in the process of formation, in which it becomes apparent that concerning these products the features as regards content are in the fore and that the demands on binding are not as extensive.

On the market of available output technologies PoD technologies belong to the field between conventional printing and office printing. Besides that also "electronic books", using new display technologies, could go into competition with PoD. Within these three fields very different cost allocations among technique and consumables are found (Figure 2, see also ref. [1]).
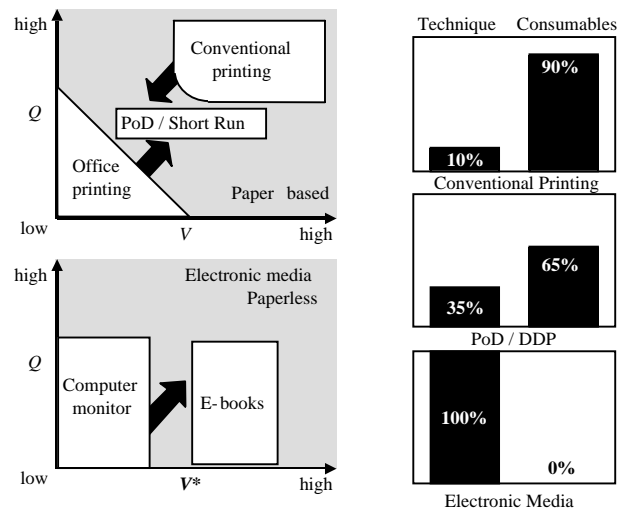

Figure 2. Left: Portfolio of Quality (Q) and Print Volume (V) or Document Data Volume (V*) • Right: Market Volume share of Techniques and Consumables for different Output Media.

The traditional production concept with a national printing company, a central mass edition production, and the following physical distribution of books will not be necessary with PoD. A data distribution to local PoD production centers, which use large digital printing systems, or also directly to the "Point of Sale (PoS)", which uses small systems for immediate printing, is possible. In PoD centers small printing systems can be combined in production clusters and can replace a large system as well. For printing only direct digital printing methods (DDP) are possible. The finishing in binding is generally carried out

after the pass ("Back"-Binding), in which for PoD the possibility of individual bindings (edition "1") has to be available. For PoS solutions also conceivable is a "Front"-Binding wherein first the white book is industrially bound and then on the site the contents are imprinted (Figure 3).
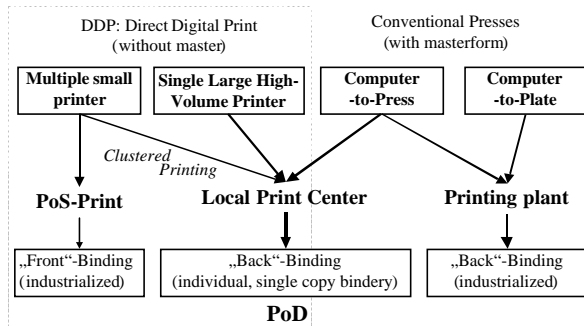

Figure 3. Production Concepts for books

For the further development of PoD technologies the users' (readers') demands are of central importance. However, before going into the actual printing technology the general demands on the whole product PoD-book need to be considered first.

In principle, different user interests find expression in various kinds of products (Figure 4, see also ref. [2]). Here should be taken into consideration that the features of use of documents are objectively assessable in wide fields and that over hundreds of years experiences of how information and knowledge can be optimally absorbed have developed. In the shaping of the different kinds of products is merely apparent how willing the readers are to do without optimal product features in favor of price advantages. Almost every reader, for example, would prefer a hardcover book to a softcover book at the same price. The user's weighing up of content, features of use, and price shows various behaviors that could have their roots in culture: American users have different reading habits than European or Japanese readers.

Therefore the aim for every technology development is the abstract maximum demand for putting the right content and optimal features of use at the user's disposal as economical as possible. Practicable technologies defines at a time the reachable market segment: Thus in the past PoD technologies were especially successful in those kinds of products in which for the reader the content and not the appearance is important, such as technical manuals.

Classic methods of book manufacturing particularly optimized the utility features and set the standard how good books can be. On the other hand the newly arising "E-Book" products as regards content offer completely new functions to the user, whereat the general utility features of these technologies are still very bad.

In this sphere PoD occupies an intermediate position in: On the one hand the utility features of a good book are striven for, on the other hand a selective and individual content generation can be done by the user. Future PoD-

Technologies in this sphere must show the right mix of features in order to be able to open up new market fields.
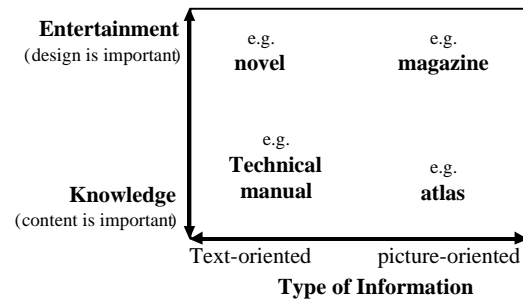

Figure 4. User interest in books

Utility Features

Besides the legibility of information further criteria for the usability of books are important as well, without discussing subjective characteristics such as the haptics of paper etc. The utility features that have to be met by documents can be divided into various groups:

Legibility

The most important demand on the output of a document is optimum legibility. There are two kinds of absorption of information:

1. Image Information

The whole image is absorbed and interpreted parallel by the reader. Relevant for the reader is a clear and good image. Even if the demands on a "good" image are not unambiguous it is possible to define several corner points: At general reading habits the image elements need to be below the optical resolution of the human eye. The spacing between the grey levels needs to be below the threshold of perceptibility and the depictable color space needs to be maximal.

	Standard needs	Good offset	PoD-Printer	E-Books (TFT)
Resolution	150 dpi	300 dpi	600 dpi	82 dpi
Grey levels*	8 bit	14 bit	2-6 bit	6-8 bit
Color space	Standard CMYK			larger

* Linear (in printing transformation to the eye's logarithmic sensitivity)

2. Text Information

The individual text symbols are sequentially deciphered and interpreted by the reader. Relevant for the reader is to recognize the characters as quickly and certainly as possible. In the context of characters a sufficient character definition means a minimum of interpretation intensive artifacts. Blurred edges, step lines by the eye perceived where the character information is actually a straight line, as well as not to the character belonging ink splashes make the reading more difficult and lead to signs of fatigue at the reader. Additionally, a typographically good composition

demands a free positioning of the characters in steps of under 100 μm (about 250 dpi). Therefore the recognizability of characters mainly depends on the resolution of the output system. In addition to that the characters' contrast to the background is of particular importance. In printing this can be characterized by the reachable optical density (see also ref. [3]).

	Standard offset	Good offset	PoD-Printer	E-Books (TFT)
Resolution*	1200 dpi	2500 dpi	600 dpi	82 dpi
Opt. Density	1.6	1.9	1.4 - 2.0	–

* Theoretically

For the actual usability of output systems the ambient light needs to be considered because it can have a very negative effect on the contrast of displays e.g. of E-books.

It is obvious that offset printing can at the same time fulfill the very high demands for both types of information, image and text depiction. The usually very high resolution by imaging offset printing plates can be directly used at the depiction of text (Figure 5 left), or screening Grey levels of an image can use it. DDP systems that can be used for PoD applications either attain a relatively good image depiction or they are orientated to depict the text as good as possible (Figure 5 right).
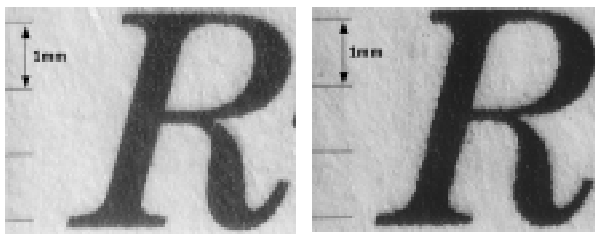

Figure 5. Offset print (left) and 600 dpi PoD-Print (right) on the same paper

With monitor systems the image depiction reaches an acceptable quality, as well as in offset quality. The text depiction is definitely too bad and with it's low resolution it does not even facilitate an acceptable type setting.

The development of digital printing technologies towards higher resolutions is not only impeded by the physical marginal requirements to produce finer image structures. At the same time the RIP technology encounters limits in the calculation of image data on the flight at a higher printing speed. With an increasing resolution data sets show a quadratic growth whereat on the other hand with an increase of the Grey level resolution data sets only grow linearly. Because of that for several suppliers of digital high-capacity printers this is the center of development at the moment. Assuming a doubling of computer performances every two years Figure 6 shows that in about five years calculation performances for image data

in standard offset quality and in about nine years for high offset quality will be available.

Format

In the office sphere the standardization of paper formats caused a huge rationalization effect and lead also to many advantages for users. Despite diverse attempts a standardization of format has not been successful. One has to come into terms with the fact that e.g. publishers and readers will furthermore expect different book formats owing to the effect of recognition. The format flexibility of PoD systems will also be a factor for the success on classic book markets.

Though as a rule the format of text oriented documents is a portrait format since this is adapted to human reception behavior. The format of image documents however is landscape. For this reason new E-books are not in the classic monitor format, but are aligned vertically just like books.
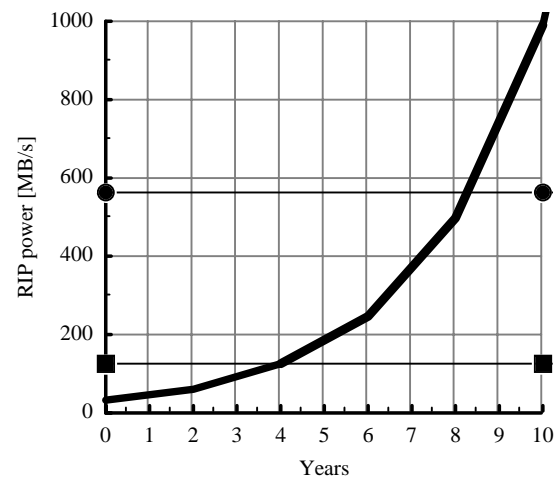

Figure 6. Prognosis of RIP-power for high volume DDP-systems, Today: 30 MB/s • Square: In 5 years standard offset quality (125 MB/s) • Circle: In 9 years high offset quality (560 MB/s). Assuming double computing power every 2 years.

Also important for the user is the actual information area, which is directly connected to resolution and format. It is a measure for information quantity that can be depicted on one page. The more information can be arranged on one page the clearer a medium can become to the user. Here particularly E-books are clearly behind the printed media.

B/W page: 29,7 x 21 cm	Standard offset	Good offset	PoD-Printer	E-Books (TFT)
Info area*	17 MB	78 MB	4,4 MB	81 kB

* Addressable pixels

Binding

The binding of a book takes on a very important handling function. By it the pages are held in a fixed order and are moreover protected from destruction. In book

manufacturing is known a multitude of technical possibilities with several advantages and disadvantages. Main criteria for the quality of bindings are strength, the behavior at opening and lying, as well as the register precision of the book.

While in industrial binding an extensive mechanical expenditure is possible for high run length, PoD production with the smallest number of editions however is even still today confronted with the problem of developing useful binding machinery. Because of different page content and possibly formats for every product a mechanical preparation of the finishing units is necessary. Automatization of this is confronted with economic limits. Today only inline binding units for perfect-bound books of simple quality are on the market. Here as a rule the case making is done in a separate pass. Further developments in these fields strongly depend on to what extent new, optimal work principles for simplified binding processes can be found. By then in practice one will have to cope with compromises:

1) Accept less binding qualities
2) Keep the needed conversion low by standardized, uniform products
3) Carry out many production steps manually
4) Accept comparatively high prices

The technical possibilities for binding PoD products will be a bottleneck for the growth on the classic book market because here the usual standard is taken as a benchmark. With it the demands are regionally very diverse, in America the demands on quality are clearly below those in Japan or on European markets.

Making Content Accessible

On the basis of the paper-based technologies used classic books have offered only a few individual possibilities for use regarding the reader's comprehension of content. The selection of the documents was effected by the fixed offer of bookstores or libraries that could not be influenced. Books partly had tables of contents and keyword indices or individual references within the text.

Here computer technology offered a completely new dimension in dealing with documents. Search functions, links, programmed support functions, larger memory capacities, and access to network on any external resource offer possibilities that until today have not really been seized or converted into new products. E-books have the chance to establish completely new forms of use for documents, whereat still many questions ranging from copyright to the proof of genuineness of information need to be settled.

Also for PoD systems chances for new products will arise, which can go far beyond the usual possibilities of classic books. In principle, every function mentioned in regard with E-books can be realized by PoD products, in which the necessary dialogues and selection processes go off via computer, after that the output of information is digitally printed offline. Here the individual user selection does not only concern the content of book to be printed, but also its layout (character size, typeface, etc.) or even the appearance (format, binding method, etc.).

The basis technology, which offers a far-reaching access to the content of documents and their spread out printing through PoD systems, is the Internet that the reader can access and that can also offer the possibility of distributing electronic documents. Though so far no explicit market with all it's necessary running functions occurred. At the moment on the one hand a regular, open access to the document contents is lacking. Business models that consider the copyright of contents are only scattered and do not at any rate exist among several publishers. Otherwise only non-profit contents are available. These problem effects E-book technologies as well as PoD. The paper-based PoD document has a few advantages over the E-book: As before the reader gets document data on paper, so that an electronic misuse is impossible, and through delivery of the printed document exists direct contact also in regard with the statement.

On the other hand, apart from direct access to the contents, for PoD production a just as open and standardized working method must be available. While the manufacturing of classic book products is possible within a closed process between publisher and PoD system, where the workflow can be coordinated with each other directly, the individual user controlled printing of documents depends on a transparent exchangeable workflow that can be run through the Internet. Books need to be capable of being produced immediately without any further expenditure by all PoD systems of the various producers. Here especially the finishing is to be looked at integratedly, which leads to relatively complex demands that cannot be solved by simple job tickets.

Because of the lacking manufacturing processes the need of standardization of E-books is considerably lower. Despite this fact an "Open-E-Book" group has already established itself with the aim to organize an open exchange of documents among various E-book concepts (see also ref. [4]).

The initiative of the Institute of Print and Media Technology at the Chemnitz Technical University to develop an open standard together with the leading manufacturers of PoD technologies in a PoD workflow consortium, however is still slow-moving at the moment (see also ref. [5]).

Costs

On contemplation of the costs for books very often the true cost structure is not considered sufficiently. Predictions derived from that, e.g. concerning the chances of PoD product, have not proven to be well founded.

About 50% of the price of a book are covered by the costs of commerce. Although first experiences with Internet book sale show that costs of business and logistics expenditures can be saved partly at the same time also new costs for maintenance of these electronic systems etc. arise. Especially for individual and low-volume products, just like

in all other trades, it is to be expected that the expenditures on customer attraction and service will increase.

About 40% of a book's retail price belong to the publisher. There the principal part lies in the work as regards content (author's royalties and licenses, program work etc.), costs for warehouse and logistics are the smaller part. In classic book manufacturing just 6% of the retail price go to technical manufacturing, the last 4% to paper.

According to the basis of costing in PoD production the advantage of saved costs for logistics, which is always looked at, therefore reduces itself considerably. Several company-internal exemplary costings have shown that for many publishers' PoD production costs, which are above the double unit price of a classic offset edition, are not economical anymore if not other specific reasons lead to PoD.

Of course it is not foreseeable if the whole net product chain in book manufacturing will change because of the possibilities of electronic documents. However, it is to be expected that the share of costs for the display technology cannot significantly go beyond the current share. The in Figure 3 shown variants on PoD production will therefore only in greater proportions be successful on the market if the technical costs involved are in the scale of today's books.

Especially the mechanical expenditure on binding of books will be that central high-volume PoD printing systems with an adapted finishing have significant cost advantages over small output systems. Nowadays a PoD production line of 1 Mio $ investment costs can produce about 10 books/min, while a concept for a small local book production, e.g. directly at the bookstore, starts out from 100.000$ investment costs and 10 books/hr.

In comparison with that the costs of E-books are very high. At the moment according to the system margins of 400$ to over 1.000 $ are given as retail prices. Their electronic contents are supposed to be about 20% cheaper than a correspondingly printed paper version. At an average book price of 20$ an E-book would be profitable for the consumer from the 100th book on.

Conclusion

The general view to the future of PoD gives not the expectation of a "big bang" but of a steady increasing rate of growth. The main support for this may be the Internet, which gives the possibilities for new, individual information products. These new types of documents may become the specific PoD product, really incomparable to conventional books. In this formation PoD is more a Technology of Database Publishing, closer connected to the E-Books than to the problems of classical printing.

Technological demands for PoD in the next time will be the development of enhanced techniques for book binding, which has to find serious improvements in quality and pricing. Also a transparent Workflow standard, which gives an open connectivity between all PoD components, becomes more and more a focal point for the further works.

The basic digital printing technology is expected to give better resolution and Gray values parallel with the development of the computer power. So further quality improvements on the way to offset quality are sure.

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Biography

Arved C. Hübler, born in 1960, studied physics at the universities in Heidelberg/Germany and Berlin. After his doctor degree he join the Bertelsmann Media Group. At least he became the technical director of Mohndruck in Gütersloh, the largest printing facility in Europe. In 1997 he became professor at the Chemnitz Technical University where he founded the Institute for Print and Media Technology.
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