THE "MATERIAL CONVERSION CLASSIFICATION"

John L Burbidge

Much of the present research literature on Production is of little help to industry because it fails to relate its findings to the types of industry where it is applicable. For the same reason, many attempts at benchmarking fail because they neglect the need to limit the targets they set to particular industrial situations.

There is a need for a classification of industries which brings together types of industry requiring similar production systems which can also accept the same targets for benchmarking. The classification recommended here is the "material conversion classification" (MCC) based on the ratio of material to product varieties. It finds the four main classes of Process, Implosive, Square and Explosive industries. These classes are further sub-classified by "flow type" and "organisation".

These classification systems are not new [1] and [2], but they need restating and elaboration. Together they provide a good foundation for the selection of production systems and for the specification of targets for benchmarking.

1. THE MCC CLASSIFICATION

The "materials conversion classification" (MCC) is illustrated in Figure 1. It finds four main classes, based on the ratio of the number of material varieties

	PROCESS	IMPLOSIVE	SQUARE	EXPLOSIVE
Key:- m = No. mtl. varieties p = No. prod. varieties	m p	m p	m p	m p
Mtl. - Input:- Product - Output:- Mtl. flow type:-	Bulk mtl. Bulk mtl. Line flow	Bulk or Gen mtl. Gen mtl. or comp Batch or line flow	Components Components Batch flow	Gen. or sp. mtl. Assemblies Batch flow
Examples:-	B Cement E Ore treat (mine) F Milk F Sugar F Distilleries C Gases O ₂ , N B Bricks B Timber F Breweries E Tanneries E Paper	E Foundries D Potteries D Glass C Dec. laminates T Spinning, fibres E Brake linings D Printing T Knitting F Bakeries E Rolling Mills E Wire drawing	E Jobbing m/c (some) D Dry cleaning E M/c overhaul T Dyeing textiles T Finishing textiles E Heat treatment E X Ray E Painting E Electro-plating E Metal spraying E Polishing	E Automobile E Electronics D Consumer durables E M/c tools E IC engines E Electrical T Weaving D Clothing & shoes C Chem. dye stuffs D Furniture E Welding

Key:- F = Food C = Chemicals T = Textiles E = Engineering B = Building D = Domestic

FIGURE 1 TYPES OF INDUSTRY

used to the number of products produced.

- (a) **PROCESS industries** are those in which a small number of material varieties is converted into an equally small number of product varieties. Examples are found in factories making cement, spirits and many chemical and food products. Both the raw material and the product generally take the form of bulk material, normally measured in standard units (SUs) of length, weight, area or volume, although packaging may give added product variety in some cases.

This is a unique and homogeneous class because such factories are easily recognised; they can generally be laid out for continuous line flow (CLF); they are normally suitable for automation based on the automatic transfer line; because there are few varieties of material and product, Production Control is simple and statistical forecasting of future sales is more reliable than it is in other industries which make a greater variety of products and use a greater variety of materials.

- (b) **IMPLOSIVE industries** are those in which a very small number of material varieties is converted into a large number of product varieties. Examples are found in foundries (pig iron), potteries (clay), glass works (sand), bakeries (flour) and others. The raw materials are generally bulk materials (e.g. pig iron, clay, sand, flour etc.) and the products are components (e.g. castings, pottery items, glass works products and cakes) or partly processed raw materials (e.g. rolled bar or wire).

This is again an easily recognised unique and homogeneous class. A tendency to use the same processes in the same sequence gives simple material flow systems, leading to simple production control in which material supply can again be based, with some accuracy, on statistical forecasting [3].

- (c) **SQUARE industries** are those in which a large number of material items are converted into an equal number of products. They are normally service industries where the customer supplies the materials which are returned to him after processing. Examples are laundries; dry cleaners; textile dyers and "finishers"; and painting, electro-plating, X-ray inspection and heat treatment sub-contractors.

This class is again homogeneous and easily recognised. Materials and products are always the same items; the material flow systems inside the factories are generally simple, and Production Control is again simple because there is no material supply problem. Production Control is concerned mainly with scheduling and loading.

- (d) **EXPLOSIVE industries** finally, are those in which a large number of material varieties are converted into a relatively small number of product types. Most Explosive industries are assembly industries which often make some, or all the parts they use. They generally manufacture in two or more stages (e.g. component processing followed by assembly).

This is the most complex type of industry. The material flow system is intrinsically complex but can be greatly simplified by using Group Technology and be automated to form Flexible Manufacturing Systems (FMS). Production Control can, in this case, also be extremely complex. Traditional methods based on multi-cycle ordering (e.g. stock control - based on re-order levels - or MRP) are unreliable due to their complexity; to the dynamic distortion of the "industrial dynamics" [4] and "surge effects" [5]; and with MRP, due to explosion based on long term sales forecasts, which are always unreliable.

The explosive industries' class is homogeneous because it brings together the assembly industries, which tend to suffer similar problems (e.g. long lead times, heavy stocks, high obsolescence and low flexibility), for which similar solutions tend to be needed (e.g. Group Technology, JIT, single-cycle ordering etc.).

- (e) **GENERAL** In general, this four class MCC classification is reliable in practice and simple to use. Most factories fall mainly into one of the four classes. A few factories may contain more than one (e.g. an Engineering Assembly factory (explosive) with its own foundry), (implosive) and others may be at a transitional point between process and implosive (e.g. a pork pie factory which is planning to introduce sausages, scotch eggs and paté as additional products, using mainly the same materials). In general, however, the MCC is a reliable classification for which the worst that can be said is that it doesn't go far enough for some purposes.

2. MATERIAL FLOW TYPES

The MCC classification is a classification of Material Flow Systems. It brings together industries with similar "maps", showing the routes followed by materials between the places where work is done on them to convert them into products. It does not consider the way in which the materials flow through the material flow system. Figure 2 shows a sub-classification into four main flow types of jobbing, batch, continuous flow and OKP production which contributes to this need. Not all combinations of classes in these two classifications are feasible, but adding this flow classification increases the number of types from 4 to 10.

MCC Class:-	PROCESS - P	IMPLOSIVE - I	SQUARE - S	EXPLOSIVE - E
Flow type	m p	m p	m p	m p
Jobbing J	-	IJ	SJ	EJ
Batch B	PB	IB	SB	EB
Continuous C	PC	-	-	EC
OKP O	-	-	-	EO

FIGURE 2 MCC & FLOW TYPES

- (a) **Jobbing** factories make jobbing products; which are special to each order; are normally ordered in small quantities; and are unlikely to be re-ordered again to exactly the same specification. Such products cannot be ordered "for stock" and must be made "to order" in the quantities specified by the customers. Jobbing production is unlikely to be found in process industries, but it can be a sub-class of Implosive, Square or Explosive industries.
- (b) **BATCH production** is a type of production in which standard parts and products are made intermittently in batches. The products produced must be made to standard designs, either "for stock" or "to order". Batches of different parts share capacity on the same machines and other facilities. "Batch production" can be a sub-class of any of the "MCC" classes. It might be said that batch production is a type of continuous flow production in which manufacture is intermittent because it is faster than consumption.
- (c) **OKP - one of a kind production** is a variant of jobbing production, making large one-off products such as ships, special machine tools, aeroplanes, buildings or small batches of such products [6]. These products usually have a long lead time and their overall regulation can be seen as a case of "project management". OKP companies will normally have departments making components such as machine shops; sheet metal shops; plate shops, cold forge and welding departments; and others, which fit easily into the explosive batch industry category.
- (d) **CONTINUOUS production** is a type in which a single product, with perhaps some variants, is made continuously. Production in this case takes place at the same rate as consumption. Continuous production is widely found in the process industries and can also be found to a limited and reducing extent in the Implosive, Square and Explosive industries, in the form of component processing or assembly lines.
- (e) **GENERAL.** Two or more of these flow type classes may sometimes qualify the same MCC class but most factories can generally be covered by one single two digit class.

3. TYPE OF ORGANISATION

One other classification which has a profound effect on the production system and on its performance is the method of organisation adopted.

Organisation is concerned with the way in which the people in an enterprise are formed into organisational units or teams for supervision and control. In

production there are two main types of organisation:-

- (1) **"Process organisation"** is a type in which organisational units specialise in particular processes. e.g. All lathes and lathe operators together; under one foreman; all milling machines together, and so on.
- (2) **"Product organisation"** is a type in which organisational units complete products, assemblies, components or parts and are provided with all the machines and other facilities they need to do so. e.g. One organisational unit or Group makes a list or "family" of gears. Others complete other sets of parts.

It should be noted that "Process organisation" and the "Process Industry" type are names for two entirely different concepts, even though they both use the word "process" in their names.

There are again two main types of Product organisation:-

- (1) **"Continuous line flow" (CLF)** in which production operations are carried out in line, always in the same sequence. Examples can be found in most "Process industries" and to a limited extent, with mass production products in "Explosive industries".
- (2) **"Group Technology" (GT)** [7] in which different sets of machines and other processing facilities each complete all the components in their own particular "family" or list of components.

The effect of adding this classification of organisational types to the "MCC plus flow type" classification of ten types (illustrated in Figure 2), is illustrated in Figure 3. It is postulated that although Process organisation was generally used in the past and can still be used today, it is always possible to change to Product organisation if one so wishes. [8] Because Product organisation is much more efficient, Process organisation is obsolete.

As long as Process organisation is still used in industry, the ten types in Figure 3 with the "-PO" suffix, will still be needed and the full classification will include 20 types.

4. THE MCC CLASSIFICATION AND THE CHOICE OF PRODUCTION CONTROL

If one knows the type of industry in a company, one has a clear idea of the type of system which should be used to regulate material flow. Consider first

INDUSTRY TYPE MCC + flow	PROCESS ORG (PO)	or PRODUCT ORG.	
		CLF	GT
PB PC	PB/PO (X) PC/PO (X)	PB/clf PC/clf	- -
IJ IB	IJ/PO (X) IB/PO (X)	- -	IJ/GT IB/GT
SJ SB	SJ/PO (X) SB/PO (X)	- -	SJ/GT SB/GT
EJ EB EC EO	EJ/PO (X) EB/PO (X) EC/PO (X) EO/PO (X)	- - EC/clf -	EJ/GT EB/GT - EO/GT

Key: - = Impossible, or very unlikely.
(X) = Possible but obsolete.

FIGURE 3 INDUSTRY TYPE AND ORGANISATION

the Process industries. In both the "continuous flow" and "batch flow" modes, these provide the simplest case for the regulation of material flow. Simple statistical forecasting, based on Moving Annual Totals (MAT), can be used to forecast future sales and material requirements. A supplementary control of stocks makes it possible to adjust output to match changes in demand.

The Implosive industries next, in both the Batch and Jobbing modes, are also simple to manage and require similar types of Production Control system. Supply of the small number of material varieties can be based again on statistical forecasting. Production programmes for manufacturing can be based on the regular periodic accumulation of orders received, with smoothing to eliminate excessive variations in demand rate between periods.

The Square industries, in both the Jobbing and Batch modes, require only simple Production Control methods. Programming for Manufacture can again be based on the regular periodic accumulation of orders received, with smoothing to eliminate excessive variations in demand.

The Explosive industries require the most complex Production Control systems. They need sales programmes for finished products; which are converted with "smoothing" into production programmes to regulate assembly; which are exploded to find the requirement for parts and materials. Similar systems can be used to regulate production in most Explosive industries.

It will be seen that if one knows the MCC class of industry of a company, one has made a major step forward towards finding the best type of Production Control system.

5. THE MCC CLASSIFICATION AND BENCHMARKING

The measures appropriate for benchmarking tend to be similar for different companies with the same MCC classification. The values assigned to benchmarking targets for these measures will tend to fall into narrow bands for each MCC class.

There is no published research which has attempted to establish benchmarks for different measures in different types of industry. It is submitted here that such research would be valuable to industry.

As an example of what is needed, Figure 4 shows a speculative range of values for each MCC class for "Rate of Stock Turnover". In this case, the type of ordering system (multi or single cycle) also has an important effect on stock turnover and the "MCC + flow type + org type" classes have been further divided into multi and single cycle sub-classes.

	PROCESS ORG (PO)			PRODUCT ORG - (clf)			PRODUCT ORG - (GT)		
	Code	Multi-cycle	Single-cycle	Code	Multi-cycle	Single-cycle	Code	Multi-cycle	Single-cycle
Process	PB/PO	8 - 15	25 - 40	PB/clf	20 - 25	50 - 55	-	-	-
	PC/PO	50 - 60	80 - 90	PC/clf	60 - 65	100 - 120	-	-	-
Implosive	IJ/PO	12 - 15	20 - 23	-	-	-	IJ/GT	20 - 23	25 - 27
	IB/PO	14 - 16	25 - 27	-	-	-	IB/GT	26 - 28	32 - 35
Square	SJ/PO	14 - 18	18 - 21	-	-	-	SJ/GT	20 - 23	31 - 33
	SB/PO	17 - 19	20 - 23	-	-	-	SB/GT	17 - 20	26 - 28
Explosive	EJ/PO	3 - 5	6 - 9	-	-	-	EJ/GT	6 - 10	18 - 22
	EB/PO	4 - 7	10 - 13	-	-	-	EB/GT	10 - 14	28 - 32
	EC/PO	30 - 35	45 - 50	EC/clf	30 - 35	45 - 50	-	-	-
	EO/PO	14 - 18	16 - 20	-	-	-	EO/GT	10 - 14	28 - 32

KEY: Code = scc code; Multi-cycle = multi-cycle ordering system; Single-cycle = single-cycle ordering system; clf = continuous line flow; GT = Group Technology.

FIGURE 4 "SPECULATIVE" BENCHMARKS FOR "RATE OF STOCK TURNOVER (turns p.a.) BY MCC CLASSIFICATION CLASS

Note: These rate of stock turnover figures are speculative. They are not based on research and are intended only to indicate the kind of distribution expected by the author.

6. SUMMARY

The "Material Conversion Classification" (MCC) was originally designed to find classes of industry which need the same or similar Production Control systems. Its extension to include sub-classes for flow type and organisation type makes it suit this purpose consistently.

It is submitted here that this classification, with perhaps some further sub-classification in particular cases, should bring together classes of factory for which common benchmarking targets can be specified within narrow bands.

REFERENCES

1. 1962. Burbidge, J.L. *The Principles of Production Control* (4th Edition 1978) Macdonald and Evans, Plymouth, UK.
2. 1968 Idem. *Group Technology*. Turin International Centre, Turin, Italy.
3. 1994 Idem. *The use of PBC in the Implosive Industries*. *Production Planning and Control*. Vol. 5, No. 1. Taylor and Francis, London, UK.
4. 1958. Forrester, Jay W. *Industrial Dynamics*. Harvard Business Review, Harvard, USA.
5. 1991. Burbidge, J.L. *Period Batch Control with GT - the way forward from MRP*. BPICS 26th Annual Conference. 14-16 Nov. BPICS, UK.
6. 1993. Burbidge, Falster and Riis. *Reducing delivery times for OKP products*. *Production Planning and Control*. Vol. 4, No. 1. Taylor and Francis, London, UK.
7. 1988. *Group Technology the state of the art*. Proc. IIS Seminar. Elektivni Proizvodni Sistemi, Dubrovnic, Novi Sad University, Yugoslavia.
8. 1992. Idem. *Change to GT. Process organisation is obsolete*. *IJPR*. Vol. 30, No. 5. Taylor and Francis, London, UK.