

Development of a product-costing model oriented to productive capacity analysis

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Abstract

Purpose of this paper is to present a new cost accounting model to estimate the standard product cost.

This model, named Enhanced Full Manufacturing Costing (EFMC), makes an extensive use of Production Job Orders to collect cost data; through this technique, the traditional cost allocation procedure and cost centres classification is reviewed. It represents an intermediate step between Absorption and Activity Based Costing: it gives the solution for the well-known limits of the former without the economic impacts and the complexity of ABC, which makes the presented model suitable for small-medium enterprises requirements.

Moreover the model identifies the share of standard product costs due to available unused productive capacity: such contribute is strategic for enterprise management because it gives an evaluation parameter for planning effectiveness and it supports decision-making.

Our proposal has been tested on a chemical-pharmaceutical plant: the EFMC implementation has lead to a more reliable estimate for standard product cost and an exhaustive data collection for productive capacity analysis which have been used for line balancing.

Keywords

Cost accounting, absorption costing, productive capacity analysis, small-medium enterprises

1. Critical constraints of traditional cost accounting systems

Cost accounting systems have been intensely developing since '80, due to remarkable industrial scenario changes:

- changes in competitive strategy: focus on customer satisfaction and increasing market globalisation [Johnson T.H.] have shifted competition towards product differentiation;
- changes in production technology: information technology innovations have let companies achieve goals of lowering cost and increasing quality and customer service level, which were considered apparently contrasting;
- changes in management: Just In Time and Total Quality Management techniques have caused tayloristic model crisis with effects on traditional cost accounting systems too.

Above mentioned changes have directly influenced cost accounting design: commercial and management costs incidence together with increasing importance of research and marketing

activities have amplified the indirect costs weight¹; moreover with the new “total” trends, usual economical-financial performance indicators result obsolete, though requiring “more customer-oriented” parameters, such as “lead time, scrapes amount, order processing time, idle time, etc.” [Baroncelli C.F.].

ABC solves the traditional cost accounting systems weakness, thanks to an activity-based approach to product full cost estimate. ABC accords to competition edge model [M.E. Porter], which breaks up business in value-added activities in order to find *critical success factors*. Therefore ABC has resulted to be very effective if implemented in companies that pursue total quality and product differentiation strategies; moreover has demonstrated good performances in managing high complexity environment. Nevertheless, implementing and managing ABC is difficult and expensive: detailed business analysis and data collection cause ABC technique to heavily impact on economical and managerial aspects, especially in those companies which are not adequately structured.

Purpose of this paper is to present a new cost accounting model in order to estimate the *standard product cost*. It represents an intermediate step between Absorption and Activity Based Costing: it gives the solution for the well-known limits of the former without the economic impacts and the complexity of ABC, which makes the presented model suitable for small-medium enterprises requirements.

2. Enhanced Full Manufacturing Costing (EFMC)

We have developed an innovative cost accounting model, Enhanced Full Manufacturing Costing (EFMC), which was tested in a chemical-pharmaceutical plant, NEWCO2. The cost accounting method NEWCO used before the introduction of EFMC was an Absorption Costing model not suitable for cost-management company goals. Company requirement was a new cost accounting system able to guarantee a detailed product cost estimate and performance analysis, avoiding ABC operating costs and radical changes in current cost accounting configuration. We can outline that this kind of requirement is common in several companies and it has pulled EFMC development, which goal is to improve Absorption Costing model to obtain an overall system performance comparable with ABC though tolerable complexity increase. In Figure 1 we schematically present EFMC compared to a traditional Absorption Costing.

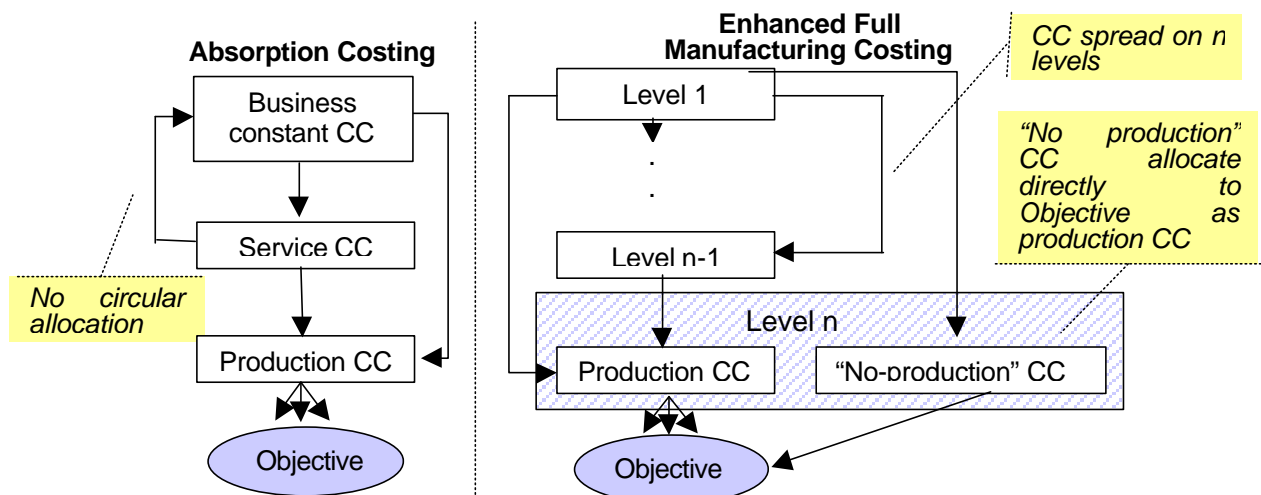


Figure 1: EFMC compared to traditional Absorption Costing.

¹ According to recent analyses [Raffish N.], labour cost is about 5-15%, material cost is 45-50% and overhead is 30-50% of full product cost.

² The name is fictitious due to privacy reasons

EFMC architecture

EFMC makes an extensive use of Production Job Order (PJO) as data collector: manufacturing factors, such as raw material quantity, machine and man hours, equipments, etc., are reported on PJO identifying a partly-finished product in each production flow step (Figure 2). Allocation cost is based on real absorption of manufacturing factors by PJOs and product cost is the sum of all costs distributed to PJOs.

The use of PJO solves also the “joint production” problem, which is the joined and unavoidable production of several outputs by a single flow. In fact focus on partly-finished product and individual production flow step render the EFMC able to distinguish main product cost from those of other outputs.

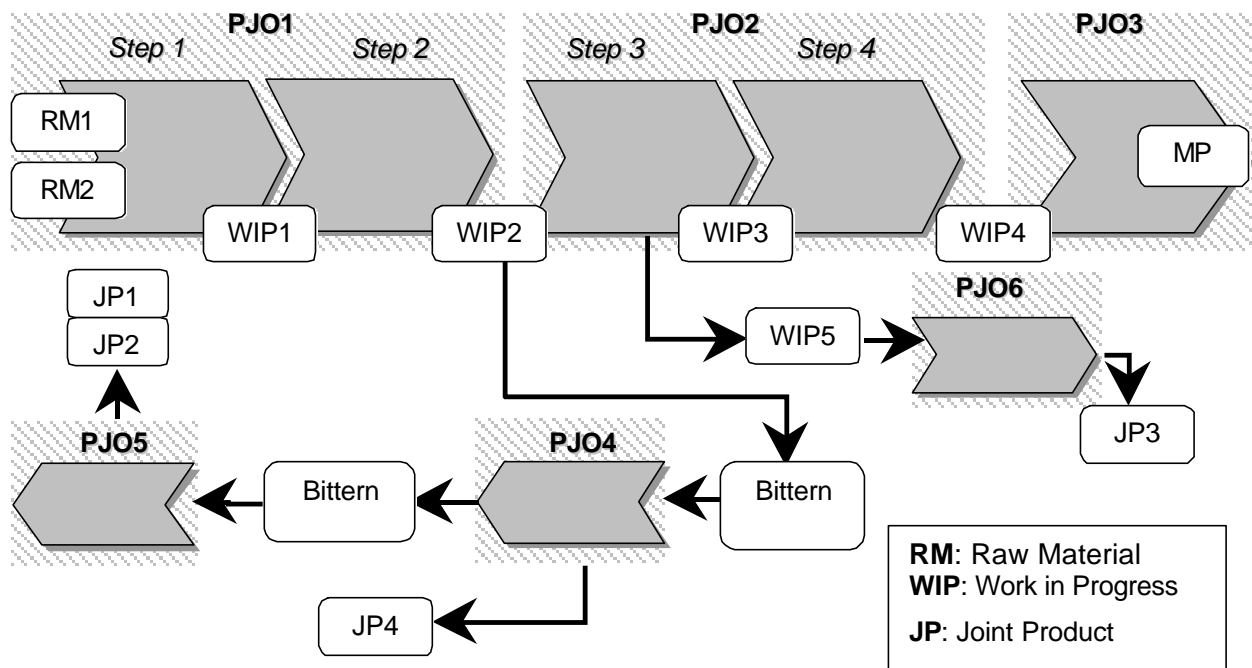


Figure 2: PJOs and production flow steps in NEWCO

In Absorption Costing production cost centres allocate to objective; even in EFMC, but to face automation increase – manual workers have especially supervision and control tasks - production centres are divided in:

- Production line centres: maintenance costs, machines consumptions and amortization constitute the cost amount; apportionment is machine-hours based, including set up, down time, etc.
- Divisions: other product cost items, as indirect labour, consumable stores, etc. constitute the cost amount; apportionment is man-hours based.

For each production flow step direct costs are distributed to corresponding PJO, whereas indirect costs are absorbed as machine-hours if supplied by line centre and as man-hours if supplied by division. Cost absorption is based on an exact rate for cost centre - line centre or division – and it is possible to collect important data about production flow performance.

In the EFMC not only production centres allocate costs to PJO, but also a few service centres do it. On the contrary in traditional cost accounting systems service centres attribute costs to production centres, but this procedure implies considerable mistakes: in service centres we can find cost items which vary on the number of batch, therefore not suitable for an apportionment based on man or machine hours. Those centres, named “no-production”, allocate to PJO as

production centres thanks to activity based drivers. In NEWCO, Control Quality and Material Management are no-production centres and they use respectively tests and moved pallets number as cost drivers.

Cost centres map

Generally speaking a cost centre is defined as an “autonomous equipped centre with a single person in charge and a traceable output”; in order to obtain the cost centre map, these are distributed on different levels in relation to techno-operative link with objectives – i.e., a production centre allocates directly to objective, whereas a service centre allocates to a production one. Such map is often simplistic and not suitable to industry reality: inside a single centre, different cost items lose distinctiveness; moreover circular allocation problem is often so complicated to solve that is usually ignored.

EFMC proposes an original procedure to design cost centres, which are grouped together in basis of appropriate cost items (Figure 3). Cost items should be:

- Overheads: for fundamental resources, as utilities, estates, etc.;
- Business service costs: for common infrastructures managing (refectory, medical service, etc.);
- Business constant costs: for supporting production;
- Industrial constant costs: for plant managing (i.e. maintenance service);
- Conversion cost: for productive activities.

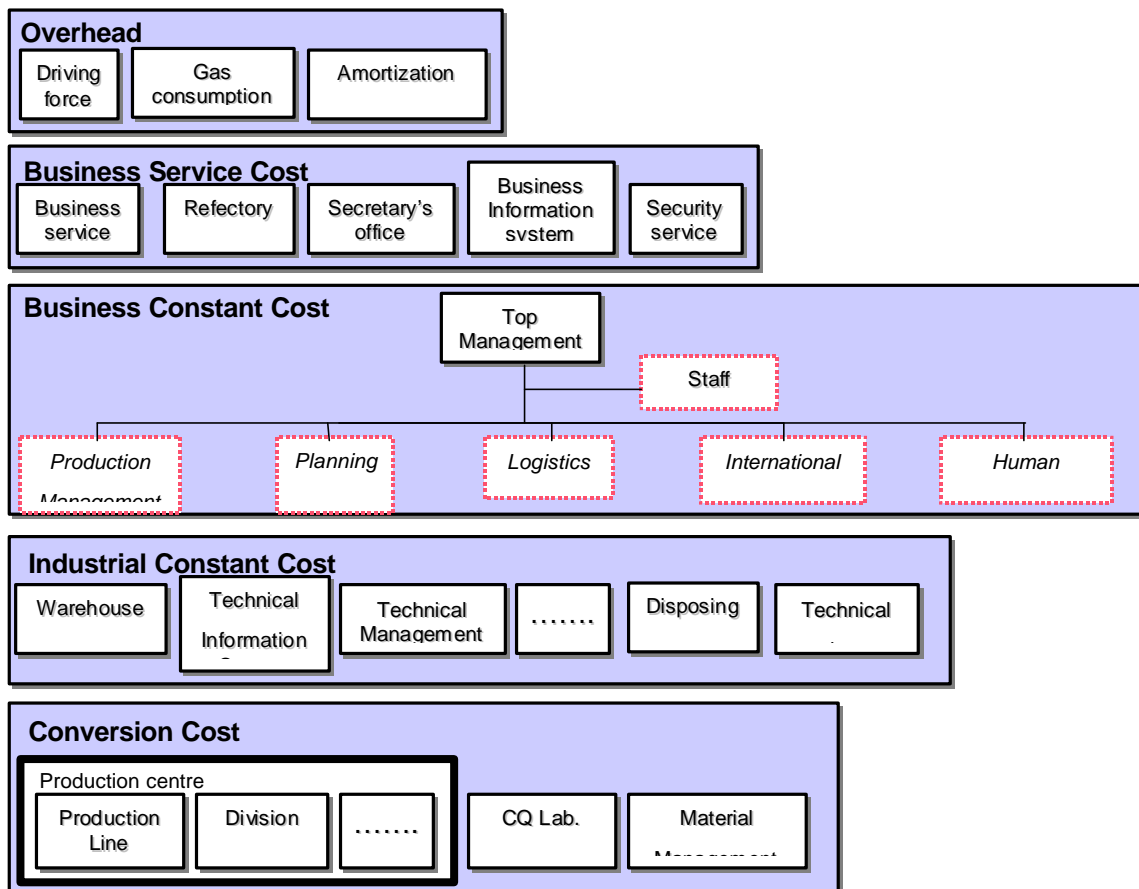


Figure 3: example of cost centres classification in NEWCO

Cost centres including the same items are distributed on different levels; last level is reserved for production and non-production cost centres that have a direct link to objective (Fig. 4).

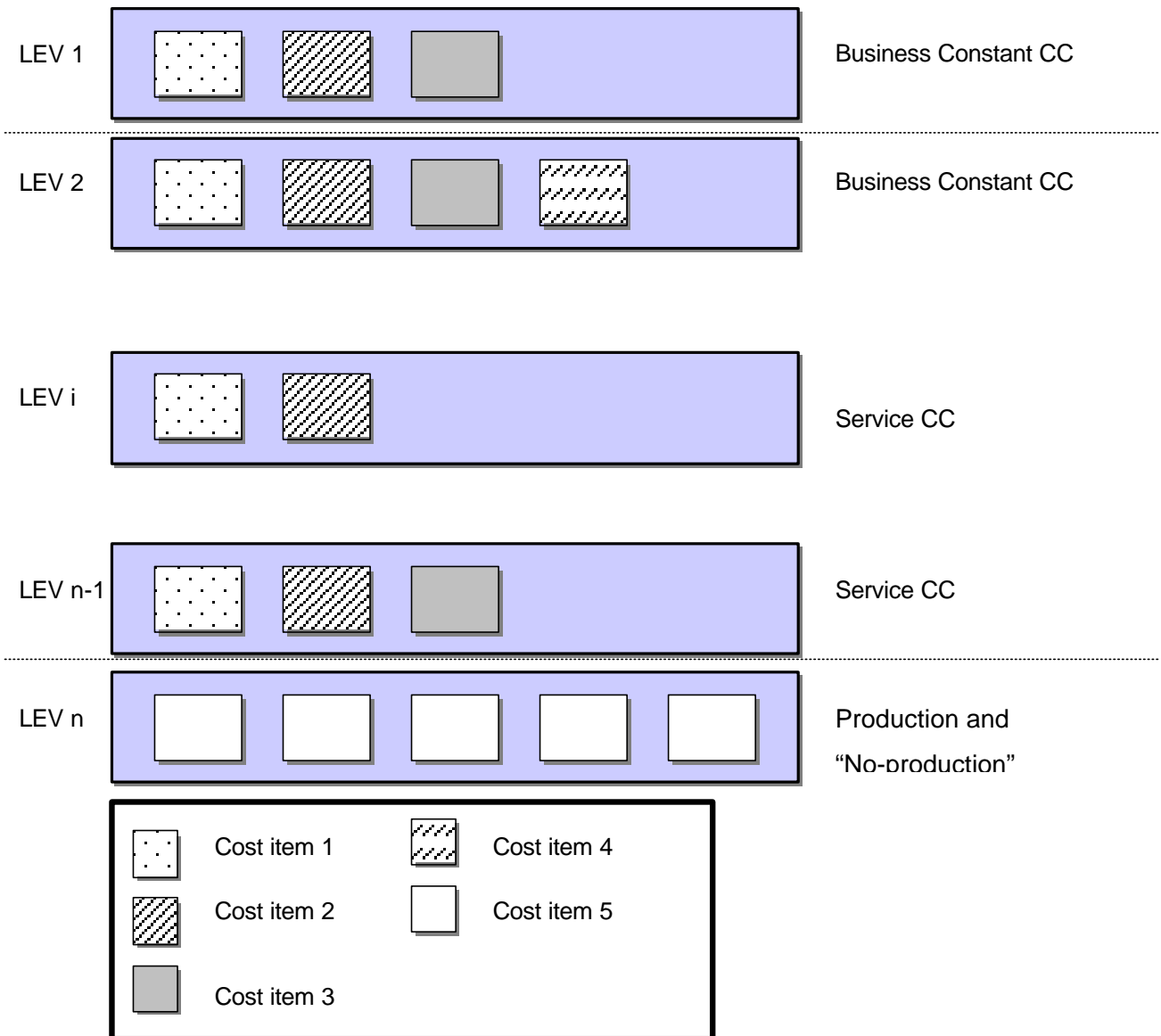


Figure 4: cost centres spread on different levels

The simple but more refined cost centres classification and the original spreading procedure improve allocation effectiveness: cost items identification makes allocation easier and the better identification of cost centres reduce circular allocation requirement.

Finally, in order to completely eliminate circular allocation it is possible to duplicate those centres in the inferior level that mutually allocates costs with those of the superior. These duplications are then spread on opportune level.

Our proposal implies an increase in levels and cost centres number, but it does not require analytic and difficult procedure, so that complexity growth is lower in comparison with return.

Product cost structure

Cost amount for last level centres is further more detailed; this makes easier to identify appropriate drivers for each cost item. In Table 1, for example, we describe last level centres in

NEWCO using drivers related to cost items. Apart from accuracy increase, that technique guarantees a large number of data: i.e. it is possible to know maintenance and energy cost for all production line.

Last level centres	Cost items	Drivers
Division	Direct labour	Direct man-hours
	Cleaning labour	Cleaning man-hours
	Indirect labour	Indirect man-hours
	Variable industrial constant cost	Machine-hours
	Fixed industrial constant cost	Machine-hours
	Other industrial constant cost	Machine-hours
Production line	Energy cost	Machine-hours
	Maintenance cost	Machine-hours
	Amortization	Machine-hours
Material Management	Logistic cost	Used Pallets
CQ laboratory	Quality control cost	Tests number

Table 1: last level centres in NEWCO with drivers related to cost items

It is now possible to build the P matrix: p_{ij} measures the amount of service provided by a last level cost centre j to perform a PJO i ; man or machine hours, material, etc. To evaluate standard cost, the requirement for a PJO - assumed by Master Production Schedule and the Bill of Materials - can be used to evaluate standard cost. The PJOs costs sum is now the product cost.

3. EFMC for available unused productive capacity measure

Overall Master Production Schedule requirement is the Planned Productive Capacity (PPC) and it is equal to:

$$[PPC] = m^T P$$

where m is the Master Production Schedule vector. The ratio between PPC and Standard Normal Capacity (SNC) is the used capacity percentage.

In Table 2 we report used capacity for NEWCO SpA; on those data we made an analysis, which was used in line balancing.

In accordance with the previous data, in Murillo plant electrolysis line is over-absorbed and Inox reactors are nearly saturated, so that Master Production Schedule should not be kept. On the contrary, all the other production lines – particularly ionic exchange line – are considerably unused.

Plant	Production line	PPC [hours]	SNC [hours]	Absorption %
Cese Plant	Spin drying	397	5,472	7.25%
	Drying	1,337	5,472	24.42%
	Reacting	1,661	16,416	10.12%
	Division	1,335	6,281	21.25%
	Machine	3,394	27,360	12.41%
Murillo Plant	Spin drying	10,104	27,360	36.93%
	Spin drying for inflammable	1,195	16,416	7.28%
	Concentrating	4,964	11,088	44.77%
	Dissolving	264	21,888	1.21%
	Electrolysis	5,750	5,544	103.71%
	Drying	4,355	21,888	19.90%
	Inox reacting	44,475	49,248	90.31%
	Reacting	3,671	16,416	22.36%
	Ionic exchanging to purify	1,192	5,472	21.78%
	Ionic exchanging	0	10,944	0%
	Division	34,415	43,835	78.51%
Machine	75,969	186,264	40.79%	

Table 2: used capacity report in NEWCO

We have set out an optimisation model to find out those areas to invest in productive capacity in order to balance the line and to increase productivity. Objective is maximizing annual main production in batch number (x):

$$\begin{aligned} & \text{Max } x \\ & \text{subject to:} \\ & \sum_i m_i p_{ij} \leq C_j \quad \forall j \end{aligned}$$

where:

m_i is the Master Production Schedule vector m element in function of x

p_{ij} is a matrix P element

C_j is production line j capacity.

After having solved the problem with current SNC we have evaluated MPS feasibility; the result has showed that production shall decrease by six batches.

Then we have iterated the solution each time improving the performance in the bottlenecks – i.e. buying an electrolytic cell and two inox reactors. Finally we have been able to reach an optimal level of improvements obtaining following outcomes (Figure 5):

- productivity is increased by 30.4%;
- labour utilization goes from 78.5 to 97.2%;
- machine utilization goes from 40.8 to 49%.

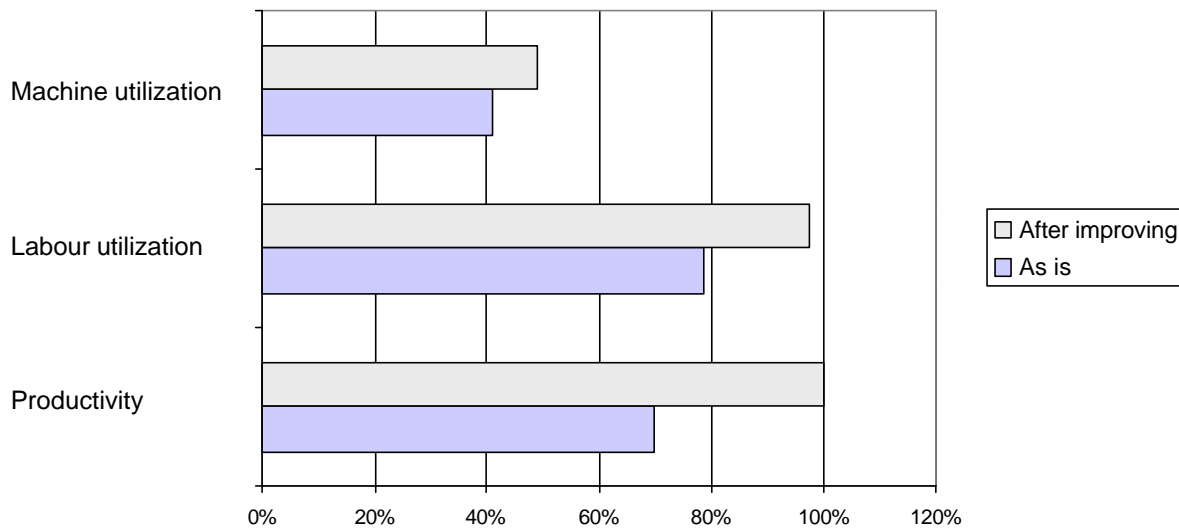


Figure 5: improvements in NEWCO

Concluding remarks

EFMC is a cost accounting model based on cost centres; it has been designed and implemented for small, medium enterprises in order to calculate standard product cost. The following characteristics identify the suitable scenario for EFMC application:

- Standard products and Work Orders knowledge make EFMC suitable for flow line and continuous process;
- EFMC is manufacturing oriented. Extending it to other product costs penalizes the model performance; indeed administrative costs allocation requires typical ABC procedure and drivers – bill number, time for reporting, etc. -, that clearly conflicts with the aim of carrying on with cost centres structure. EFMC is then suitable for enterprises in which marketing and administrative costs are low. In alternative EFMC is an intermediate step to ABC in unstructured or not adequately equipped companies.

EFMC test in NEWCO has showed that our proposal avoids traditional Absorption model errors thanks to a more detailed cost allocation procedure; moreover unused capacity cost is now identified and correctly allocated to the product.

Concerning last remark, unused productive capacity measure is useful to collect data for decision-making, as sizing and critical analysis.

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