INDUSTRIAL SYSTEM MANAGEMENT

Coding &Classification; Caliach/FourthShift software
And Linear Programming

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A. Coding and Classification System

1. Introduction

The following report offers the individuals a deeper understanding of how classification and coding can be used to group analogous parts in families by identifying them individually and loffing them into a database. Cost and performance benefits can be realised when the use of coding and classification is utilised not just to allocating a part code, but also by informing the design of manufacturing cells, which in turn improves efficient use of resources.

2. Design Process

Design process follows a specific path, which begins with the intended fit, form and use/function of a product/part. In this process all the options available must be considered, manufacturing requirements and environmental factors. There are a number of designs, which are based upon existing design. These are then modified as requirements of the function. As an integral feature of the decision process coding and classification, based on an examination of its design and/or manufacturing characteristics, i.e. attributes, is a technique that is subjectively crafted to generate a wide-ranging code for a new part; (Goetsch, et al., 2005).

3. Attributes

Goetsch, et al. (2005) identified three attribute groups: design, manufacturing and both design and manufacturing. Although some companies create their own coding and classification systems, commercial products are available; one is the German Opitz system, illustrated in Figure 1, which utilises a thirteen digit alpha-numeric coding system, to cover major design and manufacturing related attributes, associated production operations and their sequencing (Goetsch, et al., 2005). Other vendors do exist; for example, Brisch, Gildemeister, Pittler, Zafo, Vuoso, PERA and PGM.

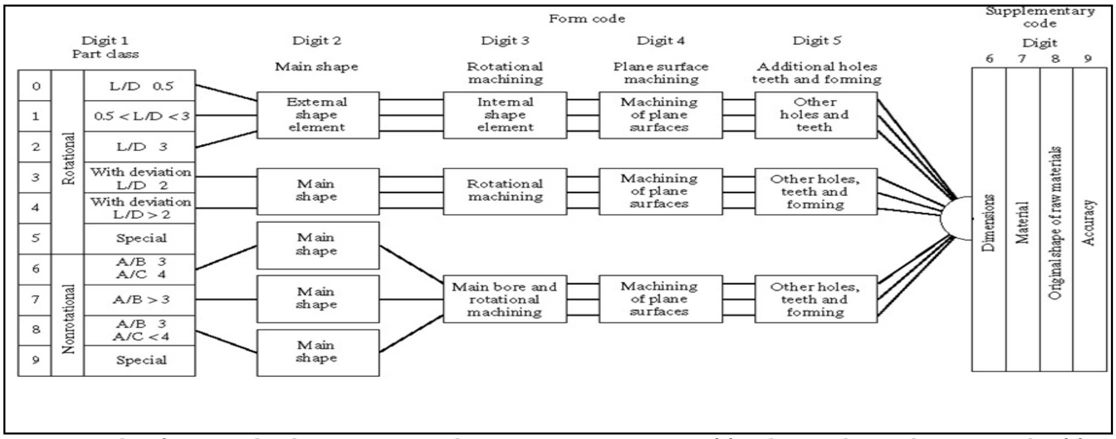

Figure 1: A classification and coding system using the Opitz system, consisting of five digits and a supplementary code of four digits (manufacturing *Processes for Engineering Materials, 4th ed.* Kalpakjian • Schmid Prentice Hall, 2003)

4. Promoting Best Practice

A part is assigned a code number that gives it a unique and distinct encoded geometry carried in a BOM (BUILD OF MATERIALS); giving the company the opportunity to promote a better form of practice as it avoids replication and duplication while informing the manufacturing process. With the use of a database and a part code number designers can locate a part that is equal to the design, dimensions, material and properties which make it a feasible option when manufacturing is considered. Interrogating the database reveals parts, which were previously grouped together, above would relate to a new design. Group Technology is the philosophy behind such a system.

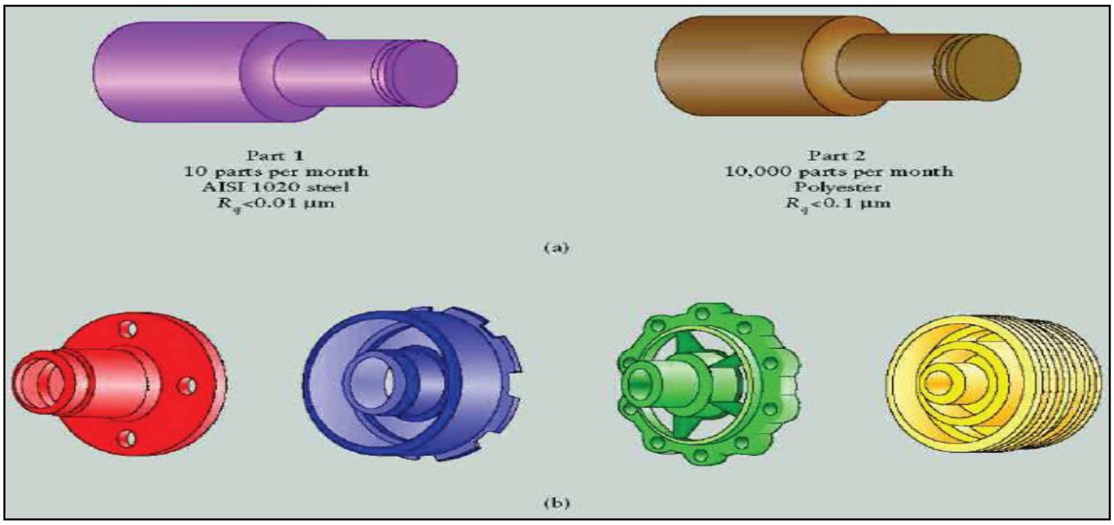

Figure 2: Grouping parts according to their geometric similarities

(Manufacturing *Processes for Engineering Materials, 4th ed.* Kalpakjian • Schmid Prentice Hall, 2003)

5. Reducing Costs through Standardisation

The methodical approach of Group Technology embraced provides the designer with a database through which individual components; family of components can be reviewed to identify existing parts. Hirsch (2006) believes cost reductions are achievable through the standardisation of parts, where by identifying similar parts with characteristics which enable their use in more than one application, eliminates repetition and reduces the cost base.

Designers using a coding and classification tool with the use of standardisation allows them to set variables to control the grouping of products, this in encouraged in the design. This enables planners to achieve high levels of resource utilisation (Bauer, et al., 1991) because, as GT requires each part to be recognized by a code which also represents intended processing requirements, it helps to simplify a company’s inherent production planning and control mechanisms (Heizer and Render, 1993). The Opitz System theory is further illustrated in Figures 3, 4 and 5.

Coding in Opitz system

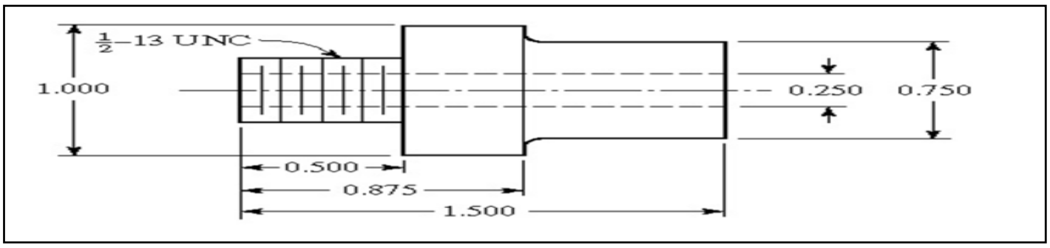

Figure 3: Shown how the part modified

Part Class		Main Shape External	Rotational Machining Internal	Plane Surface Machining	Additional Holes and Teeth
0	L/D<0.5	Smooth, no shape elements	No hole, no breakthrough	No surface machining	No Auxiliary Hole
1	0.5<L/D<3	Stepped to one end or smooth: No shape elements	Smooth or stepped to one end: No shape elements	Surface plane and/or curved in one direction	No gear teeth: Axial, not on pitch circle diameter
2	L/D>3	Thread	Thread	External plane surface related by graduation around a circle	Axial, on pitch circle diameter
3	-	Functional groove	Functional groove	External groove and/or slot	Radial, not on pitch circle diameter
4	-	Stepped to both ends: No shape elements	Stepped to both ends: No shape elements	External spline (polygon)	Axial and/or radial and/or other direction
5	-	Thread	Thread	External plane surface and/or slot, external spline	Axial and/or radial and/or on PCD and/or other directions
6	-	Functional Groove	Functional Groove	Internal plane surface and/or slot	With gear teeth: Spur gear teeth
7	-	Functional cone	Functional cone	Internal spline (polygon)	Bevel gear teeth
8	-	Operating thread	Operating thread	Internal and external polygon, groove and/or slot	Other gear teeth
First Digit		Second Digit	Third Digit	Fourth Digit	Fifth Digit

Step 1: The total length of the part is 1.75, overall diameter 1.25,
L/D = 1.4 (code 1)

Step 2: External shape - a rotational part that is stepped on both with one thread (code 5)

Step 3: Internal shape - a through hole (code 1)

Step 4: By examining the drawing of the part (code 0)

Step 5: No auxiliary holes and gear teeth (code 0)

Code: 15100

Figure 4: Example of coding

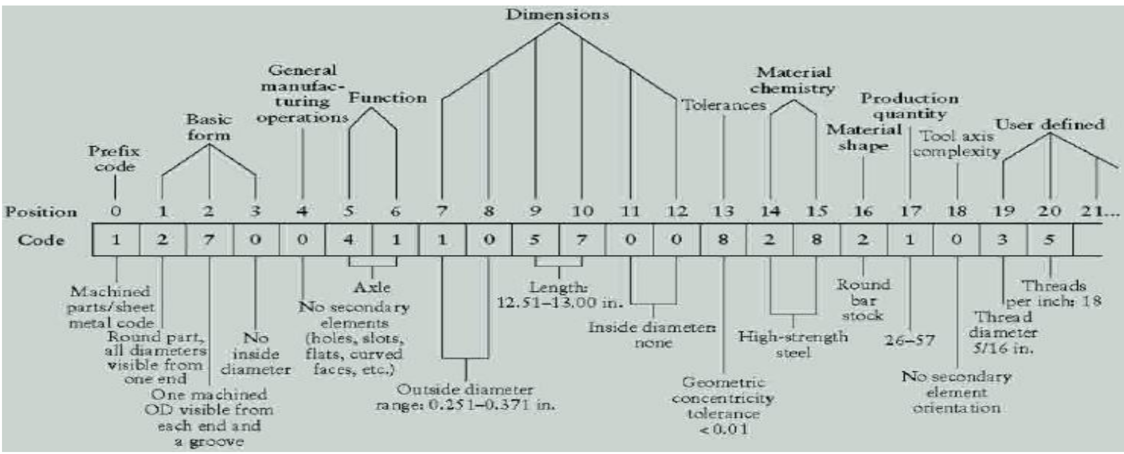

Figure 5: Shown how the typical multiclass coding for machined part

Source: Organization for Industrial research

6. Product Based Manufacturing

Significantly, GT enables product based manufacturing (Bauer, et al., 1991), which is pre-disposed to complement, lean principles; where by parts with similar processing characteristics are produced within a cellular disposition containing groups of resources. Cells accommodate all of the machine shop resources necessary to complete a part. Various machines serve families of parts as a group entity; thus minimising set-up times, improving routing and machine loading, material handling and production time (Heizer and Render, 1993). Whereas in process based environments, machinery is organised in groups according to function; for example, all drilling machines or lathes in one location only (Bauer, et al., 1991).

A company gains significant benefit from the unhindered flow of material through a cell, by time saved in transporting parts between machines.

However, cell production loading and flexibility in the use of a labour force are critical components for management to consider as they influence the success of any manufacturing operation. As Bauer, et al (1991) points out, at the strategic level management should endeavour to have sufficient inherent manufacturing flexibility to facilitate a varied mix of related marketable products. Clear linkage exists between this strategic level and the Just in Time philosophy. JIT concentrates on matching a product with its perceived market; product design to facilitate manufacturing and GT concepts to enable flow based manufacturing of defined families of products and assemblies (Bauer, et al., 1991).

At the tactical level, a company's management system should focus on the creation of precise, time phased requirements plans that complement a MPS supported by JIT manufacturing techniques. This enables the development of a flow based manufacturing process, simplistic cell activity and improves customer/supplier relationships (Bauer, et al., 1991).

At the operational, shop floor level, cell activity is managed effectively to meet the planned orders from a resource planning system (Bauer, et al., 1991).

7. Encouraging Manufacturing Flexibility

Encouraging manufacturing flexibility should be a fundamental principle in strengthening a company's customer base. Drucker (1973) held the opinion that the purpose of a business is to create and maintain customers with its primary responsibility being to serve them. But high investment in equipment may dissuade management from introducing a coding and classification system, through a belief that resources might become under utilised in a cellular environment. However, Pareto type histograms are useful statistical analysis techniques to help a company identify any potential issues (Purcheck and Oliva-Lopez, 1978).

8. Work Groups

Grouping coded and classified parts and their supporting resources into a cellular environment, under the guiding principles of GT, facilitates the development of complementary work groups (Bauer, et al., 1991). According to Drucker (1989), a good structure has the most significance in determining a company's organisational performance, affecting not only productivity, but also morale and workplace job satisfaction. Unlike a process-based layout, a product-based environment encourages greater responsibility amongst team members and their supervisor. Delegated responsibility to teams, working in small production cells, enables all aspects of the production of each product group to be organised (Bauer, et al., 1991); ensuring enhanced performance through increases in the levels and ranges of skills required.

9. Change Effects

To implement a Coding and Classification system a company will realise the problems quite early. This process will affect the manner in which tasks are deligated and existing processes run. Coding and classifications will definitely benefit all manufacturing production, but management vision and cultural tendencies within the workforce will be affected. All manufacturing processes strive to obtain efficiency, this ideal spans from the initial design to final product, making way for new processes. As the new change is implemented the strategies leaders use will help create a broad cultural change which each individual will be a part of helping to generate efficiency and revitalise areas.

10. Commercial Design Retrieval Systems

In addition to CAD Find other similar 2D/3D design retrieval systems exist. Two are briefly explained.

11. CATIA

IBM produces an integrated suite of CAD, CAE and CAM applications under the name CATIA. The applications provide product development from concept to in-service, facilitating collaborative engineering across a multi-disciplinary extended enterprise environment; and, enable product re-use to accelerate development cycles. CATIA can be utilised within a variety of industries including aerospace, automotive, industrial machinery, marine and plant design (IBM, 2009). Ms Vicky Drew, Marketing Manager at IBM (07710820841) advises that costs will vary depending on individual requirements but are in the range £3k - £20k.

12. Solid Edge

Siemens produce a modular 2D/3D integrated mechanical design management application for engineering companies called Solid Edge. The application provides core tools to capture, store and retrieve designs throughout the design process. The product has a parts library and is interoperable with other systems in an extended enterprise and, using wizards, enables file migration from current 3D systems. Solid Edge is used in the automotive, marine, construction, machinery and nuclear industries (Cutting Edge Solutions, 2009). Ms Michelle Jenkins, Account Manager for Solid Edge (01993 871001) advised the set up and support costs vary from £2k - £15k.

13. Summary

Coding and classification technology influences companies to organise the parts through out the spectrum of the manufacturing cycle from initial design to final manufacture. Coded parts, classified into groups, encourage their standardisation with consequential cost reductions. Similar part characteristics suit a process based cellular manufacturing environment, which is pre-disposed to both lean and JIT philosophies; thus, enabling companies to improve material flow and throughout times and reduce handling costs. Manufacturing flexibility serves the customer encouraging reorganisation of structure and giving work groups more responsibility and job satisfaction. Through strong leadership, introducing coding and classification techniques invokes change effects, which revitalise work areas and generate efficiencies.

Glossary of Acronyms

BOM	Bill of Materials
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAM	Computer Aided Manufacturing
COTS	Commercial of the Shelf
GT	Group Technology
IBM	International Business Machines
JIT	Just in Time
MPS	Master Production Schedule

B. Caliach/Fourth Shift MRP software experience

1. Introduction

Although both Caliach and Fourth Shift ERP technology claim to offer the well-publicised benefit of management empowerment, the actual benefit depends on the individual circumstances, with an initial cost/ benefit analysis.

This report aims to discuss the advantages of an ERP system in a manufacturing environment. It will also highlight the likely user problems in the scenarios identified.

2. Establishing the Functional Baseline

The functional baseline for all ERP systems should follow the lines of better resource management, operational control, increased cost savings or better customer relationship and supply chain management, but the scope of operations differ from organisation to organisation. And functionality will have to be tailored according to the type of industry, size of the organisation and the complexity of operations.

For example: Caliach and Fourth Shift are aimed at organisations with annual turnover between £5m to £100m. Oracle, on the other hand, is aimed at larger organisations with turnover between £5m and £1bn.

When establishing the functional baseline or operational focus of an ERP system a thorough cost/ benefit analysis on the earmarked operations for the change should be carried out. These cost savings or possibility of increased sales as a direct result of the ERP implementation then needs to be compared against a benchmark return on investment. It is important to factor in a risk margin of appropriate viability as a stress test to ensure that any shortfall will not turn a beneficial venture into a costly mistake due slight altercations to plan.

It is also important for organisations to evaluate possible ERP implementations against their mission and vision. It is also important that adequate funding is available to withstand possible budget overshoots and training requirements. ERP systems will be useless and will not be well received by users if adequate training is not provided.

3. System Interaction

The main advantage of an ERP system is the interaction between different organisational functions and the reference to one centralised pool of data/ data warehouse. It is vital that all users of particular a data file or record has access to all necessary information, and that any updates are real time. One advantage of Caliach is that, being a closed loop system; it gives full data visibility to all relevant users.

However the way different systems interact should be modified according to circumstances. For example a large organisation like General Electric cannot simply integrate all its different operations together. If this were done without forethought into the actual required management information, chaos would result. And the system may even be overwhelmed with traffic.

Therefore it is vital an organisation, as it expands with ERP, has a blueprint for systems interaction, especially when very different operations are being linked. This blueprint should be based on the required management information. The other main issue that should be addressed in systems integration is data security and access levels. Finally, training the users is essential: if the users lack operational knowledge of an ERP system, there is a high likelihood that the full potential of the system will not the realised.

4. Informing Decisions

All ERP systems will have fundamental functional bases, but these will need to be customised according to management information requirements. ERP systems are planning tools, not simply a matter of automating tasks.

Thus, the success of the ERP system will depend on how the management framework is integrated with the manufacturing process. The management information framework will need to be supported by an appropriate communications protocol, which is understood by all relevant users. The protocol will be essential when the ERP is used to set manufacturing instructions and in retrieving performance data.

Also, since the main purpose of ERP systems is the provision of a holistic view of the business for planning and feedback purposes, it is important that all information is up to date. The problem of data duplicity will have been hopefully eliminated by the time of the ERP implementation therefore records will be linked using proper database rules of relational linkage.

Finally, it is vital that all users are aware of any limitations of the ERP systems. This will enable the users to question large variances or anomalies rather than accepting them at face value and making misinformed decisions.

5. Supply and Demand

Organisations need to be responsive to changes in demand. It needs to ensure that excessive production capacity does not result in wasted resources. At the same time it needs to ensure that the existing systems can accommodate higher demands.

EERP assists this matching process as follows:

There will be stricter control of stock levels since inventory levels will be directly matched to production schedules. Further, linking the production demands with the systems of the supplier (use of SCM) reduces supplier response time thereby eliminating the need to hold excessive inventory in house

The production scheduling will have access to capacity estimates and work loads of all linked production units. This helps in distributing the workload and in capitalising on unused capacity since the planners will be given an overall view of the organisations production capacity at a particular moment in time

Production schedules will be better matched to demand trends since EERP systems will most likely be linked to CRM systems that give better insight to consumption patterns. Thus changes to resource requirements will automatically be communicated to relevant suppliers, and

Since EERPs are linked to manufacturing systems with better planning data, there is likely to be a much smoother production flow with minimum disruption.

6. The Human Element

Installing a state of the art EERP will be of no benefit if its human users are not motivated to use it. The lack of motivation derives from a number of factors including:

- Lack of consultation during development
- Belief among the users that the EERPs over complicate simple tasks and take more time
- And most importantly if there is inadequate user training with sufficient user documentation

Human users need to be given an education of the breadth and depth of the system. Without the breadth they will be unaware as to how their actions affect the other relevant functions. And without the depth they will not be able to comprehend their main task, which mostly result in avoidable errors.

The users should also be given sufficient time to adjust to the new systems and also be given direct access to training documentation. And to make it all work there should be vehement support from the top management of the organisation together with relevant EERP champions.

The input of users is vital once the EERP goes live since they are the ones who will detect the errors and problems with the EERP. To successfully manage these errors the users should be encouraged to document error logs as and when they happen. This is where impressions count because once these errors are reported the responsible parties should take immediate steps to make the relevant corrections. Otherwise the users will start to resort old tested methods, which makes their work easier with minimum error.

In conclusion, the human element will never be error free therefore it is vital that there are strict controls, which are implemented, communicated and documented. This at least minimises the risk of material errors being made over a prolonged period.

7. Inventory Management

The purported advantages of EERPs with relevance to inventory management are:

Reduced inventory levels therefore lower associated costs

Reduced wastage due to inventory being matched to production schedules

Better supply chain management, as all relevant supplier details will be held in once data location. Centralised storage of supplier details, when compared to purchases ledgers in the financial systems will enable management to compare price and terms between similar suppliers: if properly used this will be a crucial negotiation tool in the future

Lower risk of stock outs thus ability to meet demand and increase revenues, if this was a problem in the past

The inventory management module forms a core part of the EERP system especially in manufacturing intensive organisations, therefore making the above benefits very attractive.

However the main benefits can only be derived if the organisation implementing the EERP is able and willing to make the necessary manufacturing process changes. Further, success of inventory management via ERP will usually be dependent on the implementation of well functioning supply chain management system, which requires supplier commitment.

8. System Shortfalls

With the rapid technological advancements the problems of traditional ERP systems have been mostly rectified. Earlier ERP systems just provided a method by which data can be amalgamated. But with rise of the information age and the development of new data formats management are able to carry out complex data mining.

But with the increasing standardisation of data communication technology and security standards some of the earlier versions of ERPs need be upgraded. This need for continuous improvement is unfortunately a continuous need. Therefore organisations need to understand that core benefit of ERPs (increased resource control resulting in increased flexibility to match demand and supply) will only last as long as the technology can be kept up to date. However, selecting upgrades should be based on thorough cost/ benefit analysis.

The other shortcoming is that most ERP systems are based on sequential planning, with production being based on demand schedules. This makes making changes at a later stage in the planning process more difficult and may even result in unnecessary wastage of inventory. This may easily materialise in situations where systems are given a great degree of autonomy to determine production levels.

At the risk of sounding repetitive, the other major shortfall with ERP systems is that management interest fizzles out over a time period. This will have a direct impact on how the end users perceive the ERP system. If top management loses interest, maybe due to change of management, then the users will not be far behind. Eventually the ERP system might even be a hindrance rather than a benefit.

Finally, most modern supply management and customer relationship management technology comes out piecemeal. Therefore organisations with ERP systems, which wish to continue to enjoy the benefits, may need to acquire these technologies and integrate them into their existing ERPs at great expense. Therefore management may need to set aside sizeable funding regularly to maintain ERP systems.

9. Summary

In conclusion, the successful of ERP systems depends on the continuous management support to the effort. The management support needs to be communicated to the end users via training schemes.

ERP implementation is not a single moment activity but rather a continuous process that changes with environment dynamics. However all these changes need to be assessed through cost/ benefit analysis. All ERP system based decisions need to based on business sense and not on riding the latest technological fads.

Organisations also need to understand the limitations of ERP systems and consultants need to highlight these to ensure that clients do not expect advantages that are not realisable.

Finally, ERP systems entail a possible overhaul of existing systems and processes. Therefore it is vital that change management goes hand in hand with ERP implementation. And once the system goes live, it is essential that adequate controls are in place to ensure that user and the system function to plan.

C. Linear Programming using MS Excel Solver Function

- **Part 1:**

1.1 Minimize cost

CHEMICAL:	**BW**	**Colour**
Cost per tonnes ($):	2500	3000

CONSTRAINTS:	**Min (t)**
BW	30
Colour	20
Total	60

$x_1 \geq 30$

$x_2 \geq 20$

$x_1 + x_2 \geq 60$

PRODUCTION	
BW **(x_1)**	40
Colour **(x_2)**	20
BW+Colour	60
Total costs ($):	**160000**

$= 2500*x_1 + 3000*x_2$

Graphical solution 1

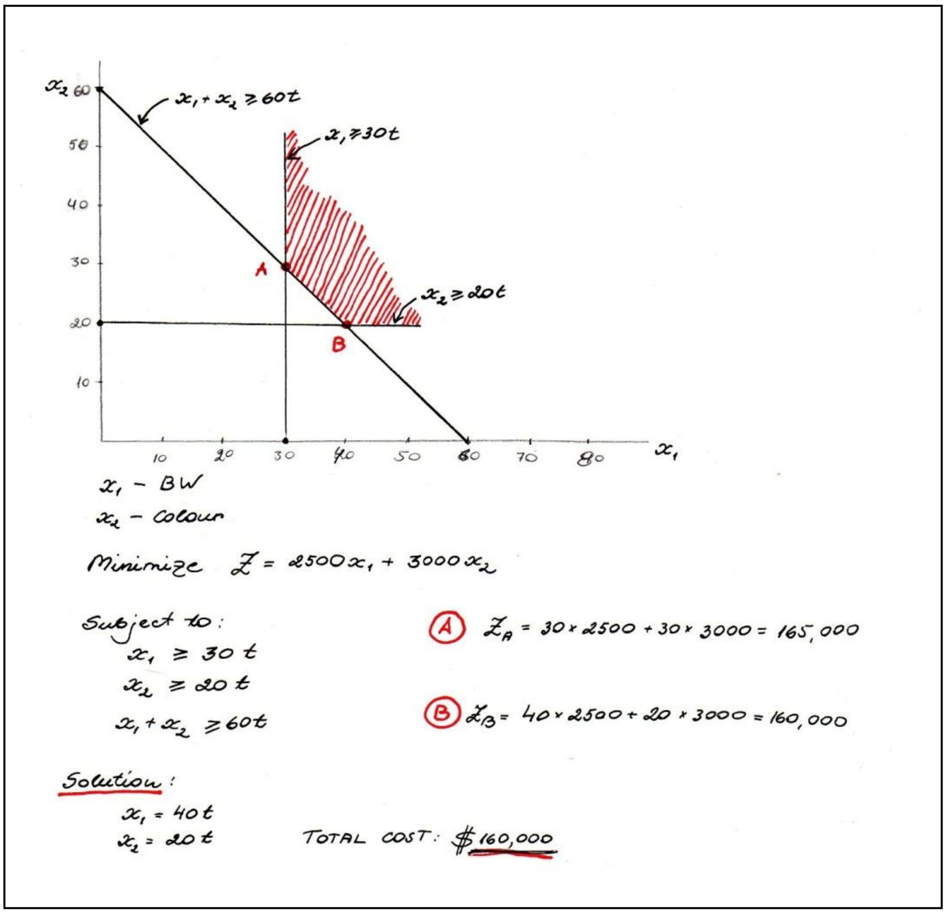

Figure 6

1.2 Different type of P/T

JOB:	Tutor	Assistant
Income per hour (£):	10.00	7.00

CONSTRAINTS	Min	Max
Tutoring	3	8

RESOURCES:	Available	Usage	Left over
Time	20	20	0

WORKING as	
TUTOR (h)	8
ASSISTANT (h)	12
TOTAL INCOME (£):	**164**

Graphical solution 2

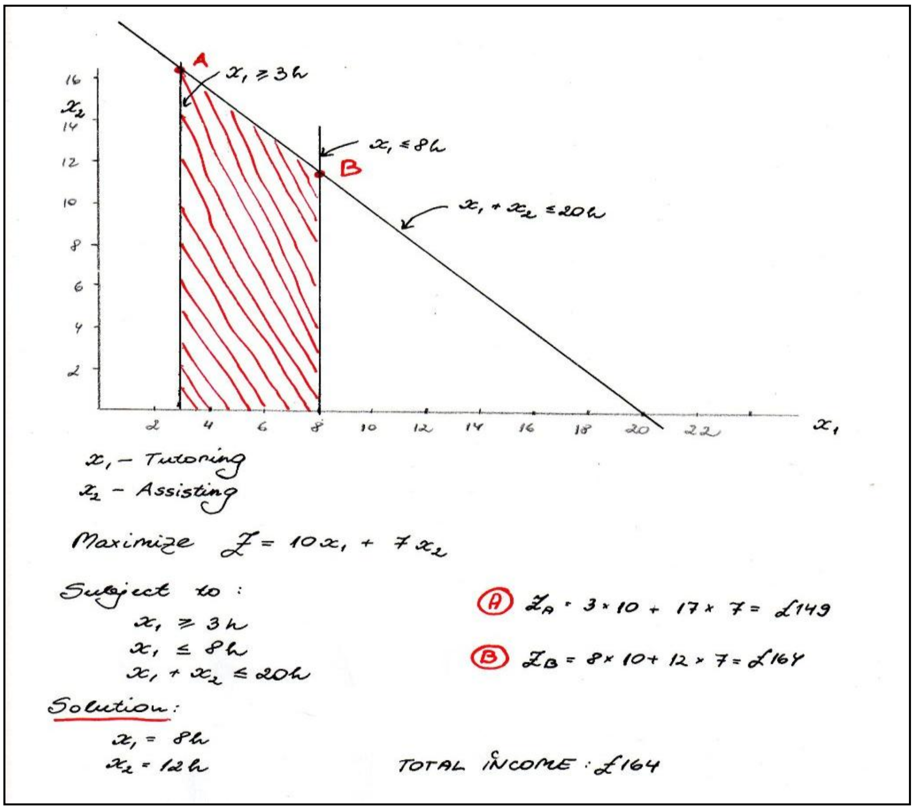

Figure 7

- **Part 2:**

	1	2	3	4	Total hours available per month
Stamping	0.07	0.2	0.1	0.15	700
Assembly	0.15	0.18	0	0.12	450
Finishing	0.08	0.21	0.06	0.1	600
Packaging	0.12	0.15	0.08	0.12	500

Product	Sheet metal (ft2)	Min demand	Max demand	Profit (£)
1	2.1	300	3000	9
2	1.5	200	1400	10
3	2.8	400	4200	8
4	3.1	300	1800	12

Available sheet metal = 5200 ft2

PRODUCTS:	**1**	**2**	**3**	**4**			
Profit per unit	9	10	8	12			
RESOURCES:					**Available**	**Usage**	**Left over**
Stamping (hr/unit)	0.07	0.2	0.1	0.15	700	400	300
Assembly (hr/unit)	0.15	0.18	0	0.12	450	363	87
Finishing (hr/unit)	0.08	0.21	0.06	0.1	600	388	212
Packaging (hr/unit)	0.12	0.15	0.08	0.12	500	338	162
Metal (ft2/unit)	2.1	1.5	2.8	3.1	5200	5200	0

PRODUCTION	
1	500
2	1400
3	400
4	300
PROFIT (£):	25300

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