CHAPTER V

IMRPOVEMENT FOR INCREASING PRODUCTIVITY AND YIELD

5.1 Improvement Planning and define the responsibility and time

5.1.1 The change area related

As you can see in Figure 5.1, the areas that have changes are Scrap Preparation Section, Preparing the basket section, and melting process. For Scrap preparation section, the company has outsource this section to the subcontractor because this sub contractor has experience in managing the scrap for a long time and the company think outsource this section that it are not expert, it will be reducing the cost from managing the scrap in the scrap yard and receiving the scrap that following the specification.

For preparing the basket section, it related to categorize the type of the scrap and managing the data of stock from subcontractor to the purchasing. In addition, patterns of mixing scrap in the basket are sent to the subcontractor by this section. So this section is the important section that is related to change for improvement.

For melting process, it related to pattern of melting the scrap. The pattern of melting of the scrap is changed if the pattern of the mixing of the scrap is changed. So in melting section, it has to consider the time, energy, additive material and so on for melting process it the pattern of the mixing the scrap are changed.

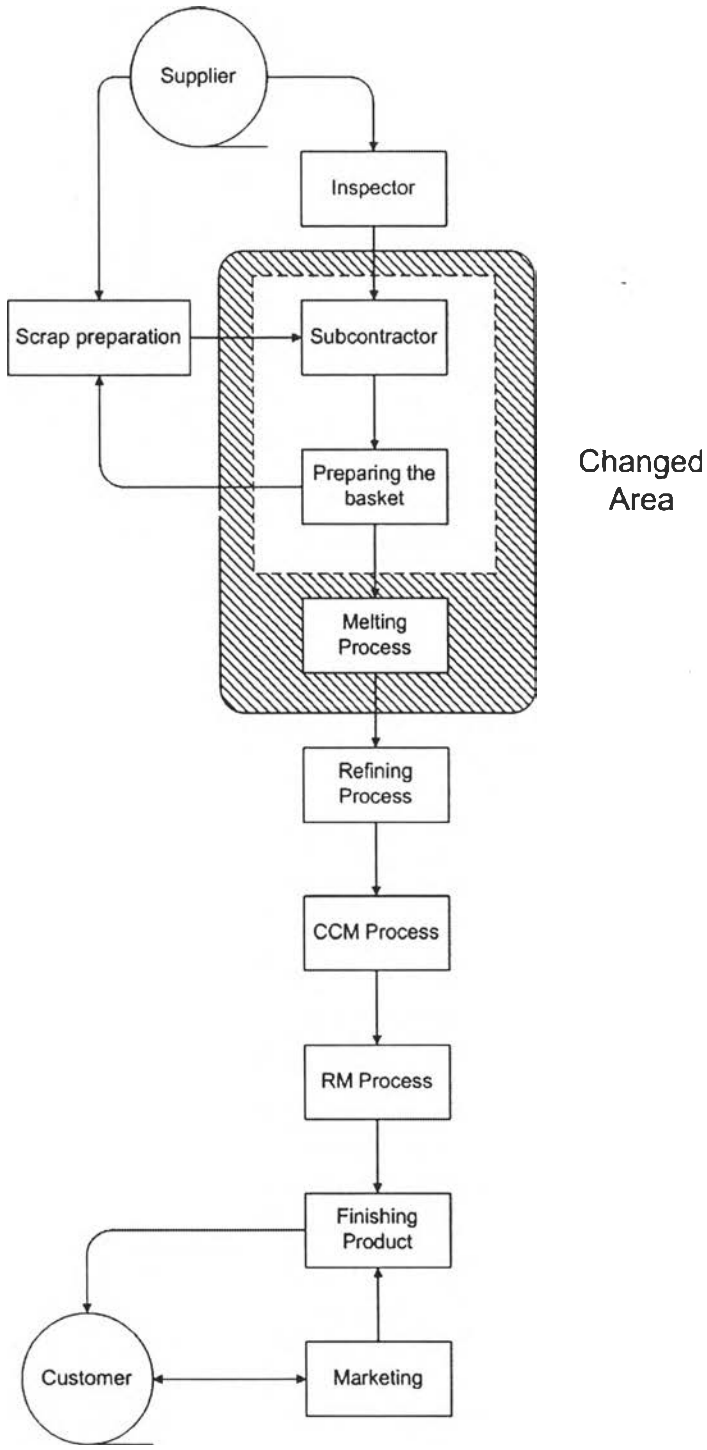

Figure 5.1 New process improvements

5.1.2 Improvement plan

So in improvement, there was meeting the related person and defining the planning and responsibility as shown in the Gantt chart below

ID	Project improvement	Start	Finish	Dec 2002 / Jan 2003 / Feb 2003 (8/12, 15/12, 22/12, 29/12, 5/1, 12/1, 19/1, 26/1, 2/2, 9/2, 16/2, 23/2, 2/3)	Resource Names
1	Categorizing the scrap type	1/12/2002	30/12/2002		Melt Shop Section Manager
2	Managing the scrap layout	15/12/2002	30/12/2002		Subcontractor
3	Managing the mixing the raw material from 4 baskets to 2 baskets	15/12/2002	30/12/2002		Subcontractor
4	Making the melting program and continuous melting program	1/12/2002	30/12/2002		Steel Making Manager & Consultant
5	Collecting the data after improvement	1/1/2003	15/2/2003		Melt Shop worker
6	Assessment	15/2/2003	21/2/2003		Steel Making Manager & Consultant
7	Conclusion	21/2/2003	28/2/2003		Consulting

Figure 5.2 Gantt chart of planning improvement the mixing the raw material into 2 baskets

5.1.3 Target of improvement

- To improve yield from 75% to 87%
- To reduce tap to tap time from 83 minute/heat to 72 minute/heat
- To reduce the additive flux utilization from 7,000 kgs/heat to 5,200 kgs/ heat

5.2 Categorizing the type of scrap used

5.2.1 The cause of categorizing new scraps types

According to information about categorizing the types of the scraps, the types of the scraps are categorizing into 5 categories: Po(ex), Po, A, B, and Pig Iron. The density and the chemical composition detail of these scrap are shown in Table 3.2. As can be seen in Table 3.2, the scrap types are categorized broadly following both chemical compositions, density. In addition, there are no defined the size of scrap clearly. The disadvantages of categorizing following Table 3.2 can be shown below:

- The scrap preparation section has to waste time to cut the scrap that is too long size to having the suitable size for the Furnace.

- In addition to lost time due to re-sizing the scrap, the company has to using the equipment and energy to cutting the scrap. It makes the cost of using gas energy to cutting the scrap increases.

- Broad categorizing the scrap lead to difficult mixing the scrap to be the require density. The density required is about 0.8-0.9 ton/m3 and this density makes using the energy for the scrap reducing. The current density of the company is about 0.62 ton/m^3.

- In addition to the difficult mixing the density required, It makes the chemical composition are not meet the specification requirement.

All of these are the causes of why the company has to categorizing the new scrap type to convenience to mixing the scrap to receiving the specification required both density and chemical composition.

5.2.2 The principle of categorizing the new scrap type

The company is still categorizing the scrap type base on the density and the chemical composition of the scrap. However, there are adding the categorizing the scrap base on size to easy to handling the scrap to the basket.. However, the company categorizes the scrap type by using the IRSI standard of U.S.A and the Japanese uniformity standard to be guideline. The example of the ISRI Standard of U.S.A can be shown in Table below:

Table 5.1 The example of the ISRI Standard of Scrap types

ISRI Standard of U.S.A		
Kind	Class	Size (mm)
No.1 HMS No.2 HMS P&S (Plate & Structural Steel)	200 203 231 232	$t \geq 6$ $W\ or\ H \leq 600$ $3 \leq t \leq 6$ $t \geq 6$ $W\ or\ H \leq 400$ $t \geq 6$ $L \leq 600$
No2. Bundles Terne Plate Bundles	209 216	Charging Box Size
Shredded Scrap Shredded Tin Cans for re-melting	210 211	
No1. Bundles No1. Bushelling	208 207	Charging Box Size $Max.(W, H, L) \leq 300$
Machine Shop Turnings Shovelling Turnings	219 221	
Charing Box Cast Mixed Cast Unstripped Motor Blocks	253 257 260	$W, H \leq 1500$ $L \leq 750$

Table 5.1 The example of the ISRI Standard of Scrap types (Cont.)

ISRI Standard of U.S.A		
Kind	Class	Size (mm)
Iron Bornings	223	

Table 5.2 Japanese uniformity standard of scrap type

Japanese Uniformity Standard		
Kind	Class	Size (mm)
Heavy	H1 H2 H3 H4 HS1 HS2	$t \geq 6$ $W\ or\ H \leq 500$ $3 \leq t \leq 6$ $L \leq 1200$ $1 \leq t \leq 3$ $t < 1$ $t \geq 6$ $W\ or\ H \leq 500$ $3 \leq t \leq 6$ $L \leq 1200$
Press	A B (Drum cons) C T (Turnings)	$W + H + L \leq 1800$ and $\max.(W, H, L) \leq 800$
Shredder	A B C	
Bundles Bushelling	Press A B A B	$W + H + L \leq 1800$ and $\max.(W, H, L) \leq 800$
Turnings	Steel Turnings	
Casting	A B	$\max.(W, H, L) \leq 1200$

The scrap types can be categorized following the standard above. In addition, the company adapts the type of the scraps from the standard to apply within the company. For example, Returned scraps from the tundish in the continuous casting process are called recovered Scrap A. So there are many types of the scrap that the company categorizing as shown the detail in the topic below:

5.2.3 Types of Scrap

According to why the company has to change classifying the scrap type in the section above and the principle of classifying the new scrap types following the standard. The company can classify the new scrap types into 15 types. The types of the scrap can be shown below

- SCRAP-HEAVY NEW
- SCRAP-HEAVY OLD
- SCRAP-MEDIUM OLD
- SCRAP-LIGHT NEW
- SCRAP-LIGHT OLD
- SCRAP-COMPACTED
- LIGHT NEW (BUNDLES)
- SCRAP-FRAGMENTED
- SCRAP-CLIPPINGS
- SCRAP-Bar and Rod Mill
- RECOVEREDSLAB/COIL
- RECOVERED SCRAP 'A'
- RECOVERED SCRAP 'B'
- RECOVERED SCRAP 'C'
- HOT BRIQUETTE IRON (HBI)
- PIG IRON

The detail of these scrap type can be shown in the follow these

5.2.3.1 SCRAP-HEAVY NEW

AREA OF USE : Scrap Yard

PROPOSE : Iron charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Screen Analysis	Min	Aim	Max
Thickness: greater than 5 mm.	95%		
Length and width less than 1550 mm.	100%		
Length and width greater than 400 mm.	95%		
Individual piece weight			
Chemical Analysis	**Min**	**Aim**	**Max**
Plain carbon steels Mn> 1.65%		100%	
∑ Residuals (Cu,Sn, Cr, Ni, Mo)			0.3%
∑ Non-metallics			0.3%

Packaging	Loose pieces or bundled. Bulk density at least 600 kg/m^3
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Material must be free of motors, machine assemblies, galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials, and alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/ or Mo 3) No rebar permitted. All scrap must be new from processing and production lines.

5.2.3.2 SCRAP-HEAVY OLD

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Scrap steel products recovered from previously constructed or manufactured steel products. Amaximum of 10% re-bar will be accepted.

Screen Analysis	Min	Aim	Max
Thickness: greater than 6 mm.	85%		
Length and width less than 1550 mm.	100%		
Length and width greater than 100 mm.	85%		
Individual piece weight			500 kg
Chemical Analysis	Min	Aim	Max
Plain carbon steels Mn> 1.65%		100%	
Cu			0.25%
Sn			0.01%
$\sum$ Residuals (Cu,Sn, Cr, Ni, Mo)			0.025%
$\sum$ Non-metallics			1%

Packaging	Loose pieces. Bulk density at least 600 kg/m^3
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Supplier must minimize arising of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo.

5.2.3.3 SCRAP-MEDIUM OLD

AREA OF USE	:	Scrap Yard
PROPOSE	:	Iron unit charge to EAF
CONSUMPTION	:	Depend on scrap mixed
APPROVED SUPPLIERS	:	Various

SPECIFICATION:

Scrap steel products recovered from previously constructed or manufactured steel products. A maximum of 10% re-bar will be accepted.

Screen Analysis	Min	Aim	Max
Thickness: greater than 3 mm.	85%		
Length and width less than 1550 mm.	100%		
Length and width greater than 100 mm.	85%		
Individual piece weight			
Chemical Analysis	**Min**	**Aim**	**Max**
Plain carbon steels Mn> 1.65%		100%	
Cu			0.25%
Sn			0.01%
Σ Residuals (Cu,Sn, Cr, Ni, Mo)			0.025%
Σ Non-metallics			1%

Packaging	Loose pieces. Bulk density at least 600 kg/m^3
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Supplier must minimize arising of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo.

5.2.3.4 SCRAP-LIGHT NEW

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Clean and consistent scrap, with no coating; resulting from the processing of new hot/cold-rolled flat products or coil

Screen Analysis	Min	Aim	Max
Thickness: greater than 5 mm.	100%		
Length and width less than 1000 mm.	100%		
Length and width greater than 400 mm.	95%		
Individual piece weight			
Chemical Analysis	**Min**	**Aim**	**Max**
Plain carbon steels Mn> 1.65%		100%	
∑ Residuals (Cu,Sn, Cr, Ni, Mo)			0.3%
∑ Non-metallics			0.3%

Packaging	Loose pieces. Bulk density at least 400 kg/m^3
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Material must be free of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo. 3) No car body scrap 4) No electrical sheet with Si > 0.5%

5.2.3.5 SCRAP-LIGHT OLD

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Scrap steel products recovered from previously constructed or manufactured steel products. A maximum of 10% re-bar will be accepted.

Screen Analysis	Min	Aim	Max
Thickness: greater than 3 mm.	100%		
Length and width less than 1000 mm.	100%		
Length and width greater than 50 mm.	95%		
Individual piece weight			
Chemical Analysis	**Min**	**Aim**	**Max**
Plain carbon steels Mn> 1.65%		100%	
Cu			0.4%
Sn			0.02%
Σ Residuals (Cr, Ni, Mo)			0.3%
Σ Non-metallics			1.5%

Packaging	Loose pieces. Bulk density at least 600 kg/m^3
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 3) Material must be free of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo.

5.2.3.6 SCRAP-COMPACTED LIGHT NEW (BUNDLES)

AREA OF USE	:	Scrap Yard
PROPOSE	:	Iron unit charge to EAF
CONSUMPTION	:	Depend on scrap mixed
APPROVED SUPPLIERS	:	Various

SPECIFICATION:

New light scrap or Clippings scrap mechanically compressed into bundles or securely fastened bales of typical size 600x600x900 mm.

Screen Analysis	Min	Aim	Max
Thickness: less than 5 mm.	100%		
Length and width less than 1000 mm.	100%		
Individual piece within bundle:			
Chemical Analysis	**Min**	**Aim**	**Max**
Plain carbon steels Mn> 1.65%		100%	
∑ Residuals (Cu,Sn, Cr, Ni, Mo)			0.3%
∑ Non-metallics			0.3%

Packaging	Compressed bundles. Typical bundle size: 600x660x900 mm. . Bulk density at least 1000 kg/m^3
Other	1) Material to be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Material to be free of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo. 3) No car body scrap permitted.

5.2.3.7 SCRAP-FRAGMENTED

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Supplied as old or new scrap processed through a fragmentizing or shredding process and magnetically sorted.

Screen Analysis	Min	Aim	Max
Length less than 1000 mm Width less than 200 mm	100% 95%		
Chemical Analysis	Min	Aim	Max
Cu Sn ∑ Non-metallic			0.18% 0.02% 0.4%

Packaging	Magnetically separated, loose pieces. Bulk density at least 900 kg/m^3
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Material must be free of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo. 3) No product from garbage processing plants permitted.

5.2.3.8 SCRAP-CLIPPINGS

AREA OF USE	:	Scrap Yard
PROPOSE	:	Iron unit charge to EAF
CONSUMPTION	:	Depend on scrap mixed
APPROVED SUPPLIERS	:	Various

SPECIFICATION:

Supplied as slender cuttings of new scrap, from a shear line or side trimmer, processing new hot-rolled flat products or coil.

Screen Analysis	Min	Aim	Max
Length less than 400 mm	100%		
Length: greater than 100 mm	95%		
Thickness: less than 50 mm	100%		
Chemical Analysis	Min	Aim	Max
Plain carbon steel with Mn < 1.65%		100%	

Packaging	Loose
Other	1) Material must be supplied free of closed containers, ammunition, radio-active materials, dirt, concrete, insulation, oils, rubber, general garbage, and organic materials 2) Material must be free of motors, machine assemblies, wheel rims galvanized and other coated materials, batteries, bearings, tin cans, non-ferrous materials and, alloy steels which could contribute Cu, Zn, Pb, Cr, Ni, and/or Mo.

5.2.3.9 SCRAP-Bar and Rod Mill

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Screen Analysis	Min	Aim	Max
Thickness greater than 5 mm.	95%		
Length and width less than 1200 mm.	100%		
Chemical Analysis	Min	Aim	Max
Plain carbon steel			100%
Cu			0.5%
Cr			0.5%
Ni			0.3%
Nb			0.1%
V			0.1%
Mo			0.15%

Packaging	Loose pieces. Bulk density at least 600 kg/m^3
Other	The scrap may be bar or rod crop or may be coiled or compacted material rejected from the process line. This specification does not include scrapped rod coils (rod finished product)

5.2.3.10 RECOVERED SLAB/COIL

AREA OF USE	:	Scrap Yard
PROPOSE	:	Iron unit charge to EAF
CONSUMPTION	:	Depend on scrap mixed
APPROVED SUPPLIERS	:	-

SPECIFICATION:

Iron unit generated on the company processing line, uprising between slab caster mold and HSM inspection line. Material may be skulls, crops, cut cobbles, and scrap coils from coil box.

Screen Analysis	Min	Aim	Max
Thickness	1 mm		100mm
Length			1580mm
Width			600mm
Individual piece weight			500kg

Packaging	-
Other	Material should be kept free of dirt, concrete, insulation, oils, rubber, general garbage, and organic materials

Note: Pickup points for this scrap :

- Tundish Bay – caster tundish skulls
- CCM crop shear – caster shear crops
- HSM coilbox – coilbox refect coils
- HSM crop shear – HSM crops
- HSM bay – HSM cobble cuttings
- Inspection line and laboratory – sample crops

5.2.3.11 RECOVERED SCRAP 'A'

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : -

SPECIFICATION:

Material generated on the company processing line, uprising between EAF and slab caster mold. Uprisings can be slag or skull and must go through the metallic recovery process and then be screened to the desired size within this specification.

Screen Analysis	Min	Aim	Max
Size range Individual piece weight	250mm 100%	 As per size constraint	1500 mm
Chemical Analysis	Min	Aim	Max
Metallic content (as per contract)	80%	85%	

Packaging	-
Other	Material should be free of dirt, concrete, insulation, oils, rubber, general garbage, and organic materials.

Note: Pickup points for this scrap: EAF slag – In pots or in pit.
LHF slag – Ladle bay
Steel 'ice cubes' – Ladle bay
Tundish skull – Tundish bay

5.2.3.12 RECOVERED SCRAP 'B'

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : -

SPECIFICATION:

Material generated on the company processing line, uprising between EAF and slab caster mold. Uprisings can be slag or skull and must go through the metallic recovery process and then be screened to the desired size within this specification.

Screen Analysis	Min	Aim	Max
Size range Individual piece weight	20 mm	As per size constraint	200 mm
Chemical Analysis	Min	Aim	Max
Metallic content (as per contract)	80%	85%	

Packaging	-
Other	Material should be free of dirt, concrete, insulation, oils, rubber, general garbage, and organic materials.

Note: Pickup points for this scrap: EAF slag – In pots or in pit.

LHF slag – Ladle bay

Steel 'ice cubes' – Ladle bay

Tundish skull – Tundish bay

5.2.3.13 RECOVERED SCRAP 'C'

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : -

SPECIFICATION:

Material generated on the company processing line, uprising between EAF and slab caster mold. Uprisings can be slag or skull and must go through the metallic recovery process and then be screened to the desired size within this specification.

Screen Analysis	Min	Aim	Max
Size range Individual piece weight	20 mm	As per size constraint	80 mm
Chemical Analysis	Min	Aim	Max
Metallic content (as per contract)	80%	85%	

Packaging	-
Other	Material should be free of dirt, concrete, insulation, oils, rubber, general garbage, and organic materials.

Note: Pickup points for this scrap: EAF slag – In pots or in pit.
LHF slag – Ladle bay
Steel 'ice cubes' – Ladle bay
Tundish skull – Tundish bay

5.2.3.14 HOT BRIQUETTE IRON (HBI)

AREA OF USE : Scrap Yard

PROPOSE : Iron unit charge to EAF

CONSUMPTION : Depend on scrap mixed

APPROVED SUPPLIERS : Various

SPECIFICATION:

Screen Analysis	Min	Aim	Max
Nominal size. Any standard briquette size can be considered.			
Chips: less than 12 mm.			5%
Chips/Fines : less than 6 mm.			2%
Chemical Analysis	**Min**	**Aim**	**Max**
Total Fe	92%		
Metallic Fe	86%		
Metallization	92%		
Carbon		1.5%	
Phosphorus			0.09%
$\sum$ Residuals (Cu,Sn, Cr, Ni, Mo)			0.01%
SiO_2			3%
Al_2O_3			1%
CaO			5%
Total Guague			3.5%

Packaging	Bulk density to be approximately 2.5 MT/m^3
Other	Individual briquette density > 5 MT/m^3 Keep dry in transit.

5.2.3.15 PIG IRON

AREA OF USE	:	Scrap Yard
PROPOSE	:	Iron unit charge to EAF
CONSUMPTION	:	Depend on scrap mixed
APPROVED SUPPLIERS	:	Various

SPECIFICATION:

Screen Analysis	Min	Aim	Max
No size limitation. Any standard pig iron size is acceptable.	-	-	-
Chemical Analysis	**Min**	**Aim**	**Max**
Carbon (C)	3%		4.5%
Silicon (Si)			1.25%
Manganese (Mn)			1%
Phosphorus (P)			0.16%
Sulfur (S)			0.08%

Packaging	Bulk density to be approximately 2.5 MT/m^3
Other	Individual briquette density > 5 MT/m^3 Keep dry in transit.

All scrap types above are shown the detail of each types such as the area of use, propose, consumption, approved suppliers, the limitation of the chemical composition not required, the bulk density and so on.

However, at present, the scraps that have been in the scrap yard for the product MS code 00001 are follow these:

Heavy Old Scrap (S183, S187)

Compacted Light-Bundle Scrap (S400)

Tin Can Bundle (S406)

Shredded (S517)

Recovery Slab/Coil (S900)

Recovered 'A' Tundish Skull (S922)

Recovered 'A' Slag Pot Skull (S923)

Pig Iron (I116)

All of these are the scraps that the company has during this thesis study. However, the scraps may be change each time, it depend on there are which type of the scraps when the company operates. The symbols shown behind the scrap types above are the code that company has been set up for the new type of the scraps. The detail of the coding the scrap are shown in Section 5.2.4. In addition, the detail of the scrap types that the company has can be shown in Table 5.3

Table 5.3 The detail of the new scrap types for product MS code 00001

Type of Scrap	*Density*	*Chemistry Composition*				
	t/m^3	*%C*	*%P*	*%S*	*%Mn*	*%Si*
S183	0.432	0.25	0.01	0.02	0.30	0.15
S187	0.431	0.25	0.03	0.07	0.30	0.25
S400	0.615	0.25	0.03	0.09	0.30	0.20
S406	1.333	0.05	0.01	0.02	0.30	0.25
S517	1.111	0.25	0.03	0.04	0.40	0.25
S900	1.043	0.040	0.020	0.020	0.30	0.25
S922	1.600	0.040	0.020	0.020	0.40	0.20
S923	1.600	0.040	0.020	0.020	0.30	0.20
F111	1.000	-	-	-	-	-
I116	3.333	4.50	0.16	0.08	1.00	1.25

5.2.4 The benefit of scrap types re-arrangement

In the section 5.2.3.4, the scrap types before improvement categorize into 5 types and the new types of the scrap that company categorize into 15 types. The benefit of re-arrange the scrap types are solving the problem or disadvantages of categorizing the scrap type before improvement. In addition, it makes the company can mixing the scrap pattern to receiving density at 0.8 – 0.9 ton/m^3. The benefits of scrap type rearrangement can be shown below:

- Reducing Time from making the size requirement of the scraps
- Reducing Cost form making the size requirement of the scraps
- Having ability to mixing the scrap at the density 0.8-0.9 ton/m^3 that saving the energy for melting the scrap
- Having ability to mixing the scrap at the chemical composition requirement easier than before improvement.

5.2.5 Coding the Scraps

Due to having classifying the new scrap types, the company sets up the coding of these scrap types including the other raw material. The principle of coding the raw material of the company based on 3 characteristics. These are:

- Types of material
- Suppliers
- Specification of the raw material

However, there are demonstrating only the scrap types coding in this thesis. The detail of coding the material can be shown below:

5.2.4.1 Definition

Raw Material - A bulk item charged to the EAF or/and LHF for the purpose of forming or contributing to the chemical composition of the steel or slag. These items include Home Scrap generated during the production process that can be re-cycled as a raw material.

Scrap - Recovered plain carbon steels, processed to defined sizes, containing Mn no more than 1.65 %, Limitations are also defined for elements such as Pb, Cu, Cr, Ni, Mo, and so non-metallic. May be purchased or re-cycled from the production line as home scrap.

Material Code - A 4 digit alpha numeric code used internally at the company to uniquely identify a particular raw material or waste material code allows traceability of the material to a specific heat.

Raw Material Specification - An internal technical description of an individual raw material detailing all chemical composition, sizing, packaging, and special instructions deemed necessary to ensure production of final steel products to customer requirements.

Waste material - Material other than 'Home Scrap' discharged in the plant during the course of production. A portion of this material might be re-covered as scrap, suitable for re-cycling as a raw material, with the balance being classified as rubbish.

Rubbish - Materials from which all re-usable scrap has been recovered and thus of no further use to the production process. Efforts to further sort rubbish into salable items such as wood, paper etc are encouraged, but not as part of the quality system.

5.2.4.2 Material Codes

Material codes include both raw and waste material. A common structure is defined as follows

Material Code Structure

The plant site uses a series of raw material and waste material codes to allow classification and traceability in a common manner However, in this thesis, I will describe the raw material only scraps

These codes are 4 digits, alpha-numeric as follows:

LNNN, where

Materials Codes

L = A : Alloys

C : Carbon

F : Flux

D : HBI/DRI

I : Pig Iron

S : Scrap

NNN = Sequential number between 000 and 999

These codes are allocated as follows:

a) Scrap [S000-S999]

- Purchased Scrap

Code	Material
S000 to S099	Purchased Heavy New
S100 to S199	Purchased Heavy Old/Medium Old
S200 to S299	Purchased Light New (Busheling)
S300 to S399	Purchased Light Old
S400 to S499	Purchased Compacted Light (Bundle)
S500 to S599	Purchased Fragmented
S600 to S699	Purchased Clipping
S700 to S799	Purchased Turning
S800 to S899	Purchased Quarantined

S900 to S999	Spare

- <u>Home Scrap</u>

<u>Code</u>	<u>Material</u>
S900 to S 919	Home Recovered Slab/Coil
S920 to S929	Home Recovered 'A'
S930 to S939	Home Recovered 'B'
S940 to S949	Home Recovered 'C'
S950 to S989	Spare
S990 to S999	Home Quarantined

All of these are the coding the scrap of the company. It makes the company can be used the scrap or the other material by not confusing and knowing the specification of the product certainly.

5.3 Define the improvement of scrap mixing pattern

The company defines the improvement of mixing the raw materials from 4-basket pattern into 2 basket pattern can be shown in the figure 5.2

5.3.1 The principle of managing the scrap mixing pattern

Managing the scrap mixing pattern can be considered by many factors but the main factors are 4 factors that be shown below:

- Finding the Scrap for operating
- Cost of the scrap pattern mixing
- Density of the scrap pattern mixing
- Operating Cost of scrap pattern mixing

5.3.1.1 Finding the scrap for operating

At first consideration, the company has to know how many scrap the company can finding for operating. For example, In January, the company expected that it can find the scraps for operating as shown in table 5.4

Table 5.4 The expected scrap has in the company in January

January	
Scrap Types	*The quantity of the scraps (tons/month)*
S183	12000
S187	2700
S400	3000
S406	830
S517	21000
S900	1500
S922	1000
S923	1200
I116	10000

The company has to consider the scrap that it has or finding for operating. When the company know how many the scraps the company has. The next considered factor is price of mixing the scrap.

5.3.1.2 Cost factor of scrap pattern mixing

According to the scrap that the company has, the next consideration factor is cost of scrap pattern mixing. The company is necessary to consider the minimum cost of mixing pattern to receiving the specification required. At this time the company has to consider the cost of each scrap types and the quantity of each scrap used and then calculating the cost of scrap pattern mixing.

5.3.1.3 Density of the scrap pattern mixing

The density of the scrap pattern mixing that the company requires are 0.8-0.9 ton/m3. According to the research of the Japanese company, at this density, the company saves the energy from melting process as shown in the figure below:

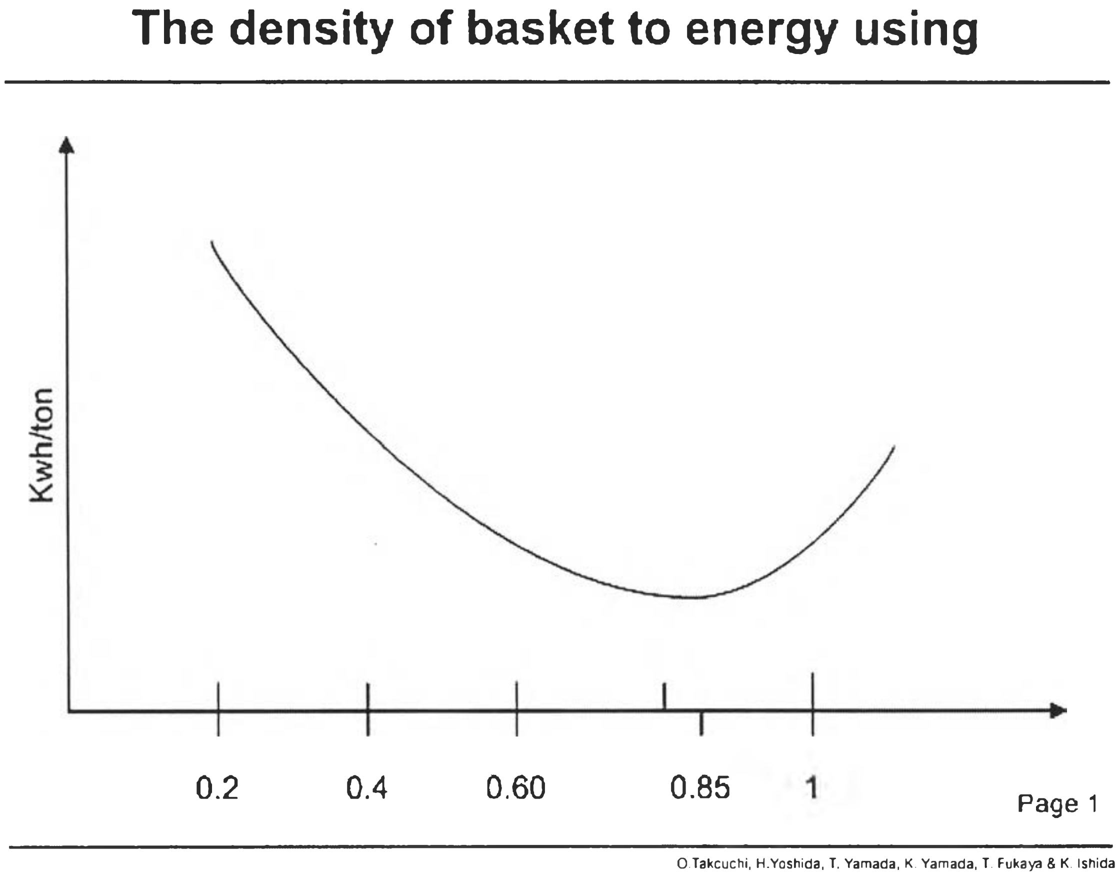

Figure 5.3 The relationship between the energy for melting scrap and density of scrap

However, in consideration density of the scrap mixing, it depends on the scraps that the company has. If the company has a little quantity of some type of the scrap, it may be make the company cannot make the density required (it may receiving the density less than or more than requirement). In some case, if the company doesn't have the quantity of scraps enough, the company needs to mix the other pattern that receives density more or less than 0.8-0.9 ton/m^3 for having ability to operating continuous.

5.3.1.4 Operating Cost of scrap pattern mixing

Operating cost of scrap pattern mixing is the one importance of the main factor. In mixing the scrap each pattern, the quantity of additive flux or other that add to receiving the specification are not equal. So it the company mixing the scrap at minimum cost but the company has to increase the high quantity of the flux, carbon and so on. It may be increase the total cost of production. Therefore, this subject is so importance.

The examples of combination of the scrap to matching the specification can be shown in the table 5.5

Table 5.5 The first example of combination of the scrap to meeting the specification and density

Scrap type	*Basket 1*		*Basket 2*		*Total*	
	(tons)	*m3*	*(tons)*	*m3*	*(tons)*	*m3*
S183	15.00	34.74	17.00	39.38	32.00	74.12
S187	5.00	11.61	1.00	2.32	6.00	13.93
S400	5.00	8.13	0.00	0.00	5.00	8.13
S406	0.00	0.00	0.00	0.00	0.00	0.00
S517	35.00	31.50	33.00	29.70	68.00	61.20
S900	0.00	0.00	3.00	2.88	3.00	2.88
S922	1.00	0.63	0.00	0.00	1.00	0.63
S923	2.00	1.25	0.00	0.00	2.00	1.25
F111	0.500	0.50	0.000	0.00	0.50	0.50
I116	24	7.27	10	3.03	34.00	10.30
Total	87.50	95.62	64.00	77.30	151.50	172.93
Density	0.915056438		0.827916319		0.876102277	

Table 5.6 The second example of combination of the scrap to meeting the specification and density

Scrap type	*Basket 1*		*Basket 2*		*Total*	
	(tons)	*m3*	*(tons)*	*m3*	*(tons)*	*m3*
S183	17.00	39.38	17.00	39.38	34.00	78.75
S187	7.00	16.25	0.00	0.00	7.00	16.25
S400	5.00	8.13	3.00	4.88	8.00	13.00
S406	1.00	0.75	0.00	0.00	1.00	0.75
S517	35.00	31.50	30.00	27.00	65.00	58.50
S900	0.00	0.00	3.00	2.88	3.00	2.88
S922	1.00	0.63	0.00	0.00	1.00	0.63
S923	2.00	1.25	0.00	0.00	2.00	1.25
F111	0.500	0.50	0.000	0.00	0.50	0.50
I116	20	6.06	10	3.03	30.00	9.09
Total	88.50	104.44	63.00	77.16	151.50	181.59
Density	0.847412136		0.816526815		0.834289343	

According to Table 5.5 and 5.6, it shows the first example and the second of mixing scrap pattern. As be shown in the table, the first example mixing pattern can be mixed at the density about 0.87 ton/m3 and the second pattern can be mixed at the density about 0.83 ton/m3. Both of these pattern can be mixed in the density range that saving the energy (0.8-0.9 ton/m3). However, mixing the scrap pattern is necessary to concern the other factor such as chemical composition or cost. So the next step of consider is the chemical composition that specification require. From both of these pattern, the chemical composition of first pattern and the second pattern can be shown in Table 5.7 and Table 5.8

Table 5.7 The chemical composition of mixing from the first example pattern

Matallic Input		*Input Ratio*	*C*	*P*	*S*	*Mn*	*Si*	*Weight*
type		%	%	%	%	%	%	(tons)
S183		21.19	0.15	0.01	0.02	0.3	0.1	32.00
S187		3.97	0.25	0.03	0.07	0.3	0.2	6.00
S400		3.31	0.25	0.03	0.09	0.3	0.15	5.00
S406		0.00	0.05	0.01	0.02	0.3	0.2	0.00
S517		45.03	0.15	0.025	0.04	0.4	0.1	68.00
S900		1.99	0.04	0.02	0.02	0.3	0.15	3.00
S922		0.66	0.04	0.02	0.02	0.4	0.1	1.00
S923		1.32	0.04	0.02	0.02	0.3	0.1	2.00
I116		22.52	3.300	0.150	0.050	1.000	1.250	34.00
Scrap Mix	***ratio***	100.00	0.86	0.05	0.040	0.50	0.366	151.00
	(tons)	151.00	1.30	0.08	0.06	0.76	0.55	

Table 5.8 The chemical composition of mixing from the second example pattern

Matallic Input		*Input Ratio*	*C*	*P*	*S*	*Mn*	*Si*	*Weight*
type		%	%	%	%	%	%	(tons)
S183		22.52	0.15	0.01	0.02	0.3	0.1	34.00
S187		4.64	0.25	0.03	0.07	0.3	0.2	7.00
S400		5.30	0.25	0.03	0.09	0.3	0.15	8.00
S406		0.66	0.05	0.01	0.02	0.3	0.2	1.00
S517		43.05	0.15	0.025	0.04	0.4	0.1	65.00
S900		1.99	0.04	0.02	0.02	0.3	0.15	3.00
S922		0.66	0.04	0.02	0.02	0.4	0.1	1.00
S923		1.32	0.04	0.02	0.02	0.3	0.1	2.00
I116		19.87	3.300	0.150	0.050	1.000	1.250	30.00
Scrap Mix	***ratio***	100.00	0.78	0.05	0.041	0.48	0.337	151.00
	(tons)	151.00	1.18	0.07	0.06	0.73	0.51	

According to Table 5.7 and 5.8, it shows the chemical composition that will receive after melting for the first example pattern and the second example pattern respectively. The specification of the product MS code 00001 are require %C = 0.04, %P = 0.02 and %S = 0.02. If comparing the composition of the carbon, phosphorus, and sulfur both the first example and the second example, it find that in the first example pattern %C,%P, and %S are more than the specification and more than the second example pattern. This shows that if the company selected the first example pattern to be using in the melting process, the company has to used the addition flux to eliminate the phosphorus and sulfur as well as the company use the quantity of oxygen increasing from the second example pattern because the oxygen will react with C that has over the specification.

In addition, if the company considers the cost of the scrap, the company will find that the cost of the first scrap mixing pattern and the second mixing pattern can be shown in Table 5.9

Table 5.9 The scrap cost of the first and second example pattern

Type	**Unit Cost**	**The first example**		**The second example**	
	Baht/t_s	**Quantity**	**Cost**	**Quantity**	**Cost**
S183	6,090.0	32	194880	34	207060
S187	6,525.0	6	39150	7	45675
S517	6,960.0	5	34800	8	55680
S400	7,100.0	0	0	1	7100
S406	7,400.0	68	503200	65	481000
S922	6000	3	18000	3	18000
S923	6,000.0	1	6000	1	6000
S900	6,000.0	2	12000	2	12000
I116	7,000.0	34	238000	30	210000
Total		151	1046030	151	1042515
		Cost Difference		3515	

As seen in table 5.9, the cost of the first example pattern is more than the second example pattern about 3,515 baht per heat. According to the reason of the chemical composition and the cost of the scrap, the pattern that should be selected is the second example pattern.

5.3.2 Technical scrap pattern mixing

The technical scrap pattern mixing are light scrap should be placed on the top of the charge because it reduce the damage the roof of furnace that happened due to arcing between the scrap and roof of the furnace to the ground. During arcing of electrode to the ground, if the scrap are heavy or high density and has melting point higher than the roof of the furnace, the roof of the furnace may be damaged before scrap melting. In addition, placing the light scrap on the top of furnace can assists reducing the melting time because the light scrap will melt in the short period for the first step of melting (low voltage) and then the molten steel from the light scrap help increasing the temperature of the other scrap higher. So, in this thesis, the new pattern uses the scrap (S187) to placed on the top of the charge because this scrap has lowest density comparing with other scrap

For the bottom of the furnace, the scrap should be the light or medium heavy or density because it will protect the bottom of the furnace from the attacking from the scraps arced. In this thesis, the new pattern uses the scrap (S183) to place on the bottom of the furnace.

For the medium of the furnace, mixing or placing the scrap depend on the density required, the quantity of each scrap that the company has, the cost of mixing the scrap and the cost of operation cost especially Addition material such as flux, carbon.

5.3.3 The new pattern of mixing the scrap

In the new pattern from 4-basket to 2 basket pattern, we try to mix the raw material (scrap, pig iron, flux) to receiving the principle requirement such as the total density of 2 baskets about 0.8-0.9 tons/m^3. According to the practical of the Japanese steel factory, at this density, it leads to using low energy to melting the scrap as shown in the figure.

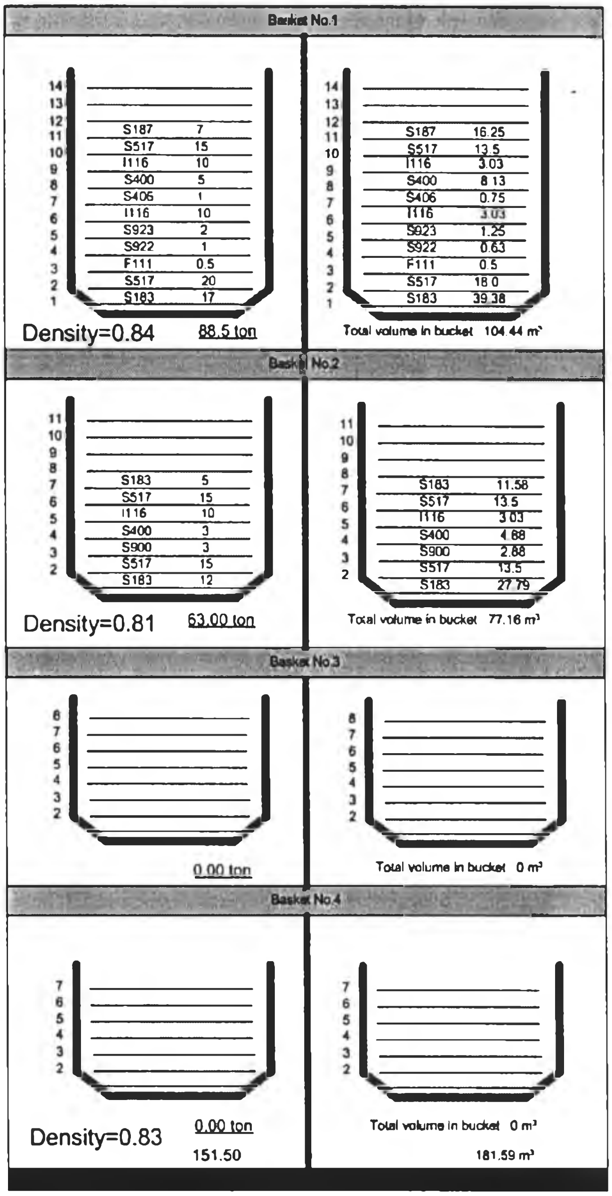

Figure 5.4 The two-basket pattern

According to Figure 5.4, it can be shown in Table 5.10 and 5.11 for the pattern of mixing the scrap and the density that received from each basket.

Table 5.10 The basket 1 of the scrap mixing pattern

Stage	Scrap types	Basket 1	
		Weight(tons)	Volume(m^3)
Top Stage11	S187	7	16.250
Stage10	S157	15	13.5
Stage9	I116	10	3.03030303
Stage8	S400	5	8.125
Stage7	S406	1	0.75
Stage6	I116	10	3.03030303
Stage5	S923	2	1.25
Stage4	S922	1	0.625
Stage3	F111	0.5	0.5
Stage2	S517	20	18
Bottom Stage1	S183	17	39.375
	Total	88.5	104.436
	Density	0.847412136	

Table 5.11 The basket 2 of the scrap mixing pattern

Stage	Scrap types	Basket 2	
		Weight(tons)	Volume(m^3)
Top Stage7	S183	5	11.5808824
Stage6	S517	15	13.5
Stage5	I116	10	3.03030303
Stage4	S400	3	4.875
Stage3	S900	3	2.87576687
Stage2	S517	15	13.5
Bottom Stage1	S183	12	27.7941176
	Total	63	77.1560699
	Density	0.816526815	

All of these are the new pattern of mixing the scrap that consider the scraps that the company has, the density requirement and the total cost.

5.4 Lay out of scrap yard after re-arranges the type of scrap

In the part of scrap yard section, the company has contracting with the company that has the experience in managing the scrap and has the completely equipment for material handling to be the subcontractor. The contracting company manages the scrap in the scrap yard of the company. However, the company has to sent the categorizing the type of the scrap that having the specification of the scrap to the contracting company to the contracting company provide the scrap following the specification that the company want. For the product MS code 00001, the types that the company want to produce and having in the scrap yard are S138, S187, S400, S406, S517,S900, S922, S923, I116. The layout of scrap yard can be shown in the figure 5.5

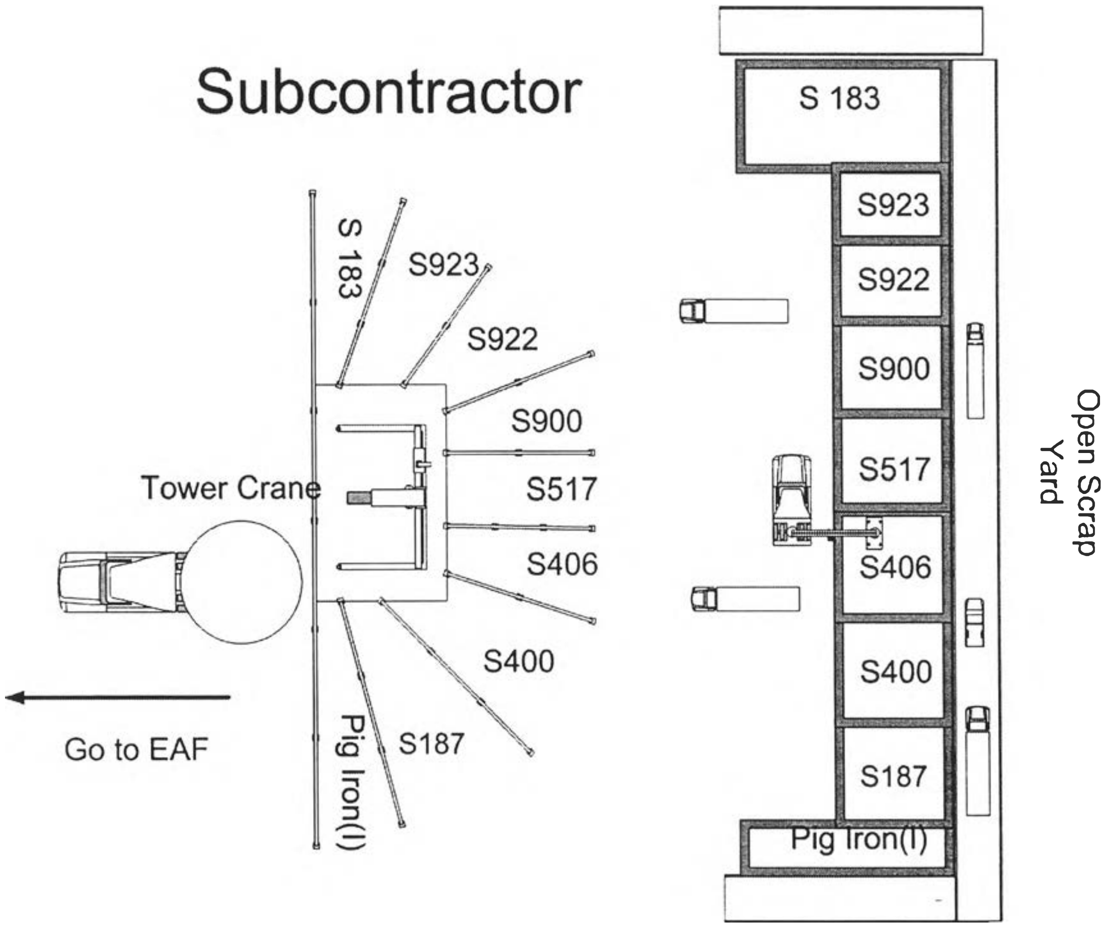

Figure 5.5 The layout of the scrap yard after re-arrange the scrap types

5.5 Making the melting program

There are making the new melting program for 2 baskets to define the value related melting process as shown in Figure 5.6 (EAF procedure of 2 baskets)

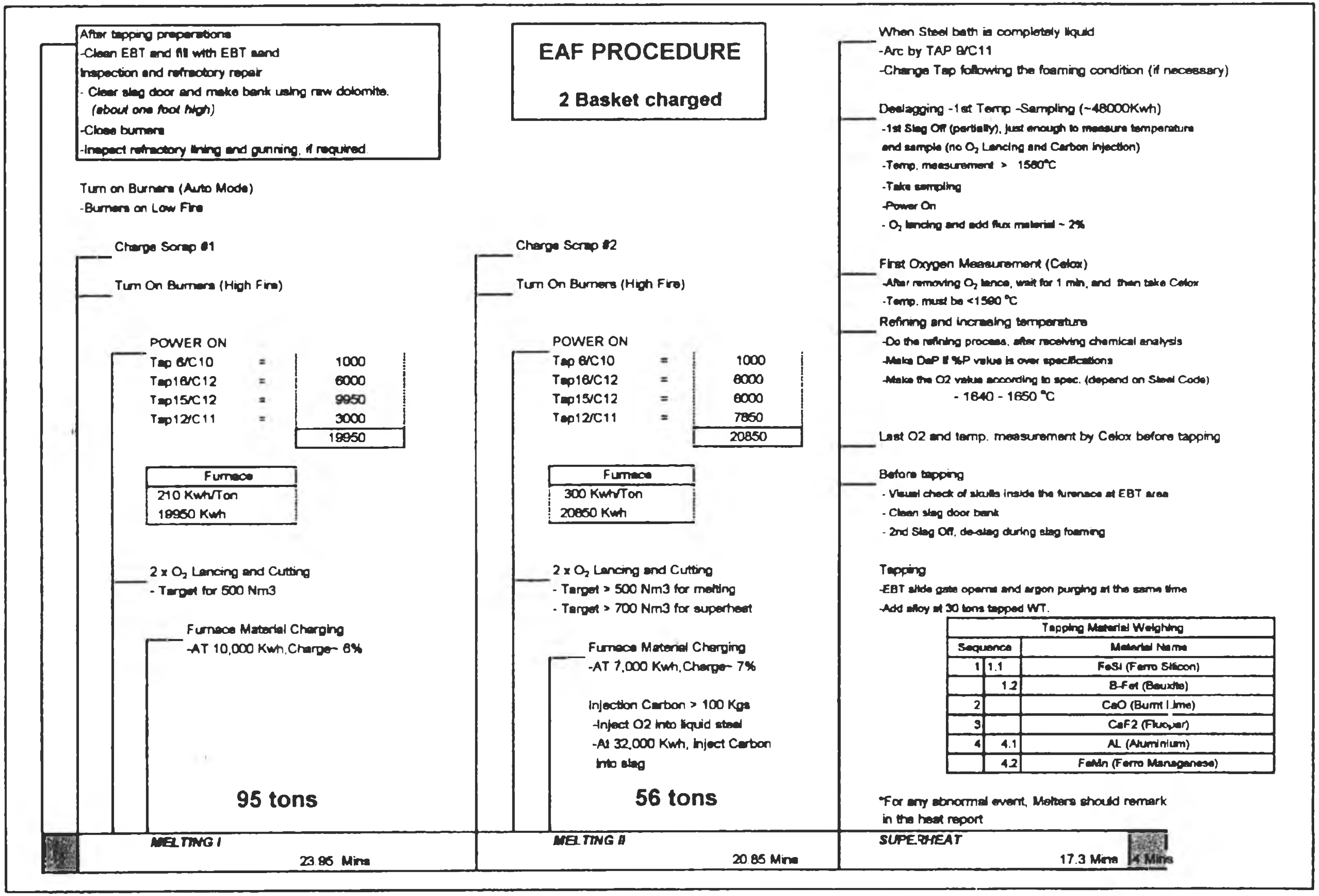

Figure 5.6 EAF procedure for 2-baskets pattern

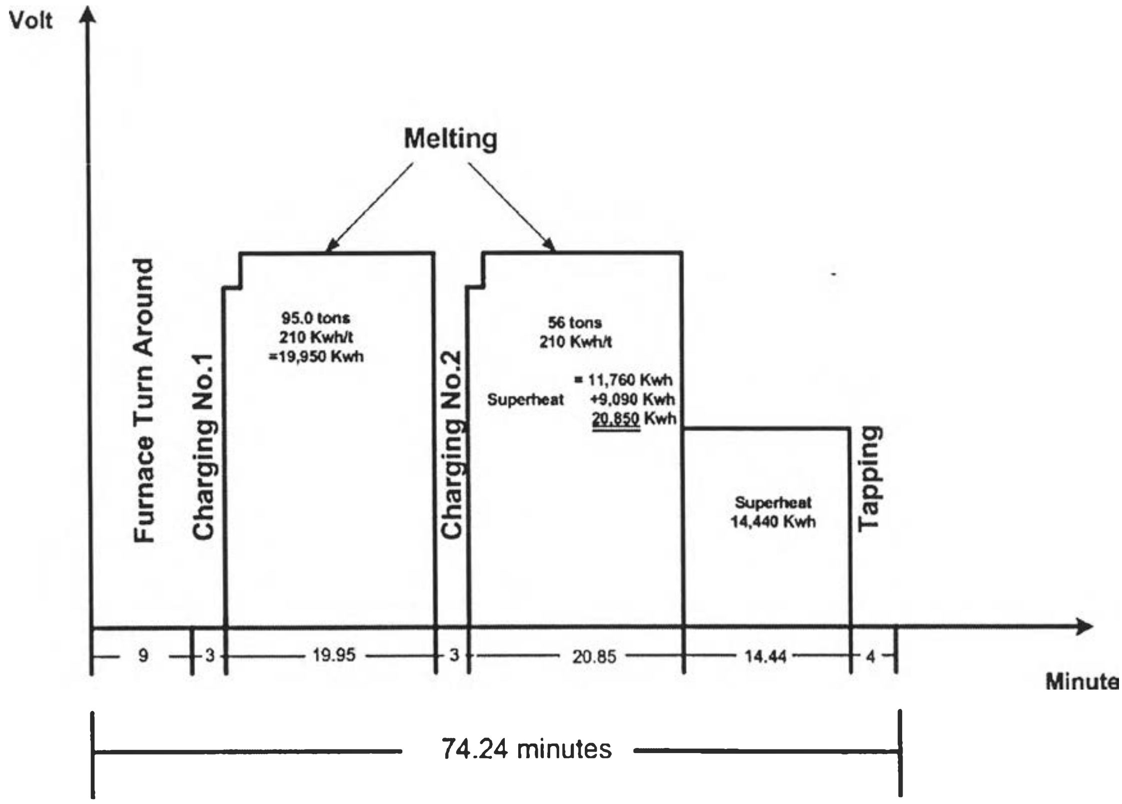

Figure 5.7 Procedure of used energy for melting process

According to the procedure above, we found that

On time	=	55.24 mins/heat
Off time	=	19 mins/heat
Total	=	74.24 mins/heat

On time 55.24 minutes can be separate into:

On Ttime

From Scrap: $\dfrac{151t \; x \; 331.4 \; Kwh/t}{1000 \; Kwh/\min}$ = 50.04 minute

From Addition Lime: $\dfrac{5.2t \; x \; 1000 Kwh/t}{1000 Kwh/\min}$ = 5.2 minutes

Off time 25 minutes can be separate into:

OFF Time

Charging bucket 4 times	=	6	minutes
Tapping time	=	4	minutes
Other	=	9	minutes

5.6 The utilizing of flux for 2 baskets

The detail of utilizing flux can be show below:

5.6.1 Add material additive charging to the baskets

Table 5.12 Charging Flux in Scrap basket

CaO *(Kg)*	*Dolomite* *(Kg)*
500	-

5.6.2 Add between melting by EAF Material Weighting/Charging

Table 5.13 EAF material Weighting/Charging

Charge No.	*Bin No.2* *CaO*	*Bin No.3* *B-Dolomite*
1st	1600	700
2nd	700	440

5.6.3 Add before refining by Tapping Material Weighting/Charging

Table 5.14 Tapping Material weighting/Charging

Charge No.	*Bin No.2* *CaO*	*Bin No.5* *B-Dolomite*
1st	1200	60

According to utilizing the flux above, the total flux utilizes are equal to 5,200 kg/heat. The detail of utilizing can be show below:

Flux Utilization of 2 basket pattern

CaO	=	500+7,600+700+1,200	Kgs
	=	4,000	Kgs
B-Dolomite	=	700+440+60	Kgs
	=	7,200	Kgs
Grand Total Flux	=	4,000+1,200	Kgs
	=	5,200	Kgs
Melting flux time	=	$\frac{5.2 \text{ tons} \times 1000 \text{ Kwh/tons}}{1000\text{Kwh/min}}$	
	=	5.2	Minutes

According to Flux utilization of 4 basket pattern in the chapter 3, the total flux utilization is equal to 7,200 Kgs. The difference of using flux between 4 basket pattern and 2 basket patterns are equal to:

Difference flux Utilization	=	7,200-5,200	Kgs
	=	2,000	Kgs

According to computer calculation, the quantity of raw material (scrap, pig iron, flux and so on) at 151 tons are more suitable from managing the raw material 149.5 tons at density 0.8 tons because it is easy to mix the raw material from the actual raw material that the company has in the scrap yard.

All of these benefit from the company expected that the company will receiving the production 132 tons per heat from using the two-basket pattern at raw material 151 tons. The detail can be shown below:

Scrap using	=	151 tons
Production receiving	=	132 tons
Yield	=	$\frac{132}{151}x100$ percent
	=	87.42 percent

In addition to the benefit above, from mixing this scrap pattern, The Company expected utilizing the addition flux are reduced from 7200 kg/ heat to 5,200 kg/heat or about 35kg/$Tons_{scrap}$. This is the advantageous result of mixing the suitable chemical composition and it leads to melting time reducing due to lower quantity of melting addition flux. The detail can be shown in the next section

5.7 Conclusion expecting result of Improvement

1. Melting time reducing	=	83 – 74.2	minutes/heat
	=	8.8	minutes/heat
2. Production increasing	=	132 - 112.12	tons/heat
	=	19.88	tons/heat
3. Yield increasing	=	87.42 – 75	percent
	=	12.42	percent
4. Flux reducing	=	7200-5200	Kg
	=	2000	Kg

According to the expected benefit receiving, the company has agreement to experiment melting 2-basket pattern for about 45 days (1-31January and 1-15 February, 2003) following the improvement plan. So the company try to melts the raw material following the above melting procedure and then collect the data as shown in the next chapter that the result are the company expectation.