Principles of

Diagram Design for

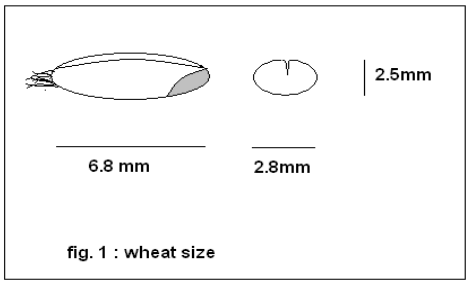
Wheat Flour Mill

Chapter 1 : Wheat specification

- ✓ **Target of milling :** producing flour from wheat
- ✓ **Row material :** cleaned and conditioned wheat
- ✓ **Physical specifications of wheat :**

Density: 0.75 – 0.8 ton/cubic m
Hectoliter: 74 – 78 optimums
1000 kernels weight: 33 – 40 gr

Wheat kernel's size as an average is shown in fig.1



(Fig. 1: wheat size)

- ✓ **Wheat kernel contains of :**

Endosperm: 83% of kernels weight
Bran: 15% of kernels weight
Germ: 2.5% of kernels weight

- ✓ **Chemical composition of wheat :**

Proteins:
- Soluble in water (albumin - ……..)
- Insoluble in water (glutenin – gliadine)

Mineral: ➔ (ash content)

Starch : ➔ (endosperm)

Glutenin + Gliadine + water => Gluten matrix

80% 20%

✓ **Quality of kernel from center to skin :**

Ash(mineral): ↑

endosperm: 0.3% - 0.4% bran : 2% - 4% germ 4.5% - 5 % aleurone 6% - 8%

Color: ↑

Protein: ↑

Gluten quality: ↓

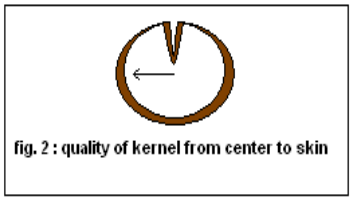


fig. 2 : quality of kernel from center to skin

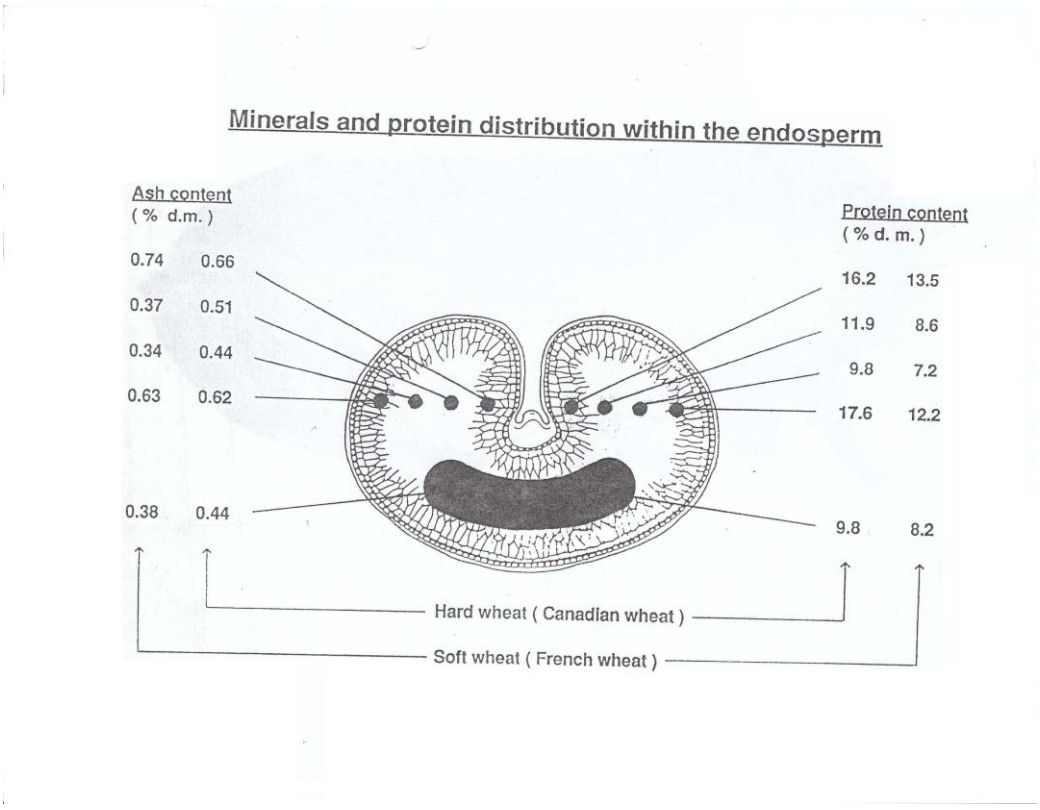


Fig. 3: mineral and protein content of wheat

Point: Aleurone is a part of endosperm

Producing the endosperm during cultivation

High ash content

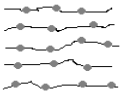
High stickiness with endosperm

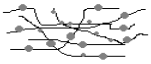
Should be separated from flour

100 days long after harvest to be naturally separated

- ✓ **Wheat variety :**

Endosperm contains of lipoprotein layer with starch granules





Kind of wheat	**Usage**	**Protein**	**Stickiness of bran and endosperm**	**Glassy**	**Thickness of bran**	**Amount of semolina produced**
Durum	Pasta	↑	↓	↑	↓	↑
Very hard	Pasta bakery					
Hard	bakery					
Semi hard (Iran)	Bakery confectionary					
Soft	confectionary					
Very soft	biscuits					

Chapter 2 : diagram specification

- ✓ **Mill flow chart (diagram) :** a chart which shows the way of stock during the milling process and the relations between stock & machines which is passed through

- ✓ **Function of the mill :**

  - shearing and open up the wheat
  - scraping the endosperm, from the skin
  - reducing the size of endosperm (semolina) to the size of flour

- ✓ **parts of a diagram :**

  - 1 – Break
    - Break rolls
    - Bran finishing
    - Grading
  - 3 – Purification (not necessary)
  - 2 – Reduction
    - Middling
    - Scratch
    - Collecting

- ✓ **passage :** A diagram contains different passages – a passage is a special path for a special quality of stock which is passed through special machines for a special process – each passage starts from the beginning of a roller mill to the end of a plansifter with all of the intermediate machines and process

- ✓ **function of the different parts of diagram :**

  - **Break:** open up the wheat kernel and scraping the endosperm from the skin
  - **Reduction:** reducing the size of endosperm produced in break system (in shape of semolina) to reach to the flour size
  - **Purification:** purify the semolina produced in break and send the clean semolina to reduction system

- ✓ **quality of stock in each part of diagram**

		Inlet	Function	result
Break	**Break rolls**	Wheat and its partial size	Scraping the endosperm	Semolina and bran (a little flour)
	Grading	Semolina	Grading	Different size of semolina
	Bran finishing	Bran and the endosperm adhering to bran	Separating the endosperm & reducing the bran size	Clean bran with less endosperm & small size of bran
Purification		Composite and dark semolina	Purification	Clean and pure semolina
Reduction	**Middling**	Clean semolina	Size reduction	Flour & small size of semolina
	Scratch	Composite semolina	Scratching the semolina	Pure semolina and flour
	Collecting	High ash content & germ	Size reduction & de germination	Pure germ & dark flour

- ✓ **best kind of milling :** gradual reduction

Results
- Fine flour
- More extraction
- Clean and white flour
- Low ash
- Control of starch damage

- ✓ **machines used in milling process :**

Main
- Roller mill
- Plansifter

Auxiliary
- Purifier
- Bran finisher
- Detacher

✓ information should be shown in diagram :

1. capacity of mill in tons of wheat per 24 hours (wheat/day)
2. capacity of product silo (if shown)
3. No. & size & model of machines
4. No. & size & kind of cyclone and filter and fan in pneumatic conveyors and aspiration
5. source & destination of each stock
6. fully information about roller mill and roll flute as :
   - ✓ flute /cm
   - ✓ total flute / roll
   - ✓ profile and angel of flute
   - ✓ spiral % of flute
   - ✓ disposition of rollers
   - ✓ speed of fast roller (Rpm)
   - ✓ speed ratio of rollers
7. No. of plansifters and purifiers with No. of sieve and size of sieve cover

✓ two professional point :

1. bran must be kept as large as possible during the mill to avoid producing of bran powder
2. semolina extracted from break system must be as large as possible – large particles are simple to clean

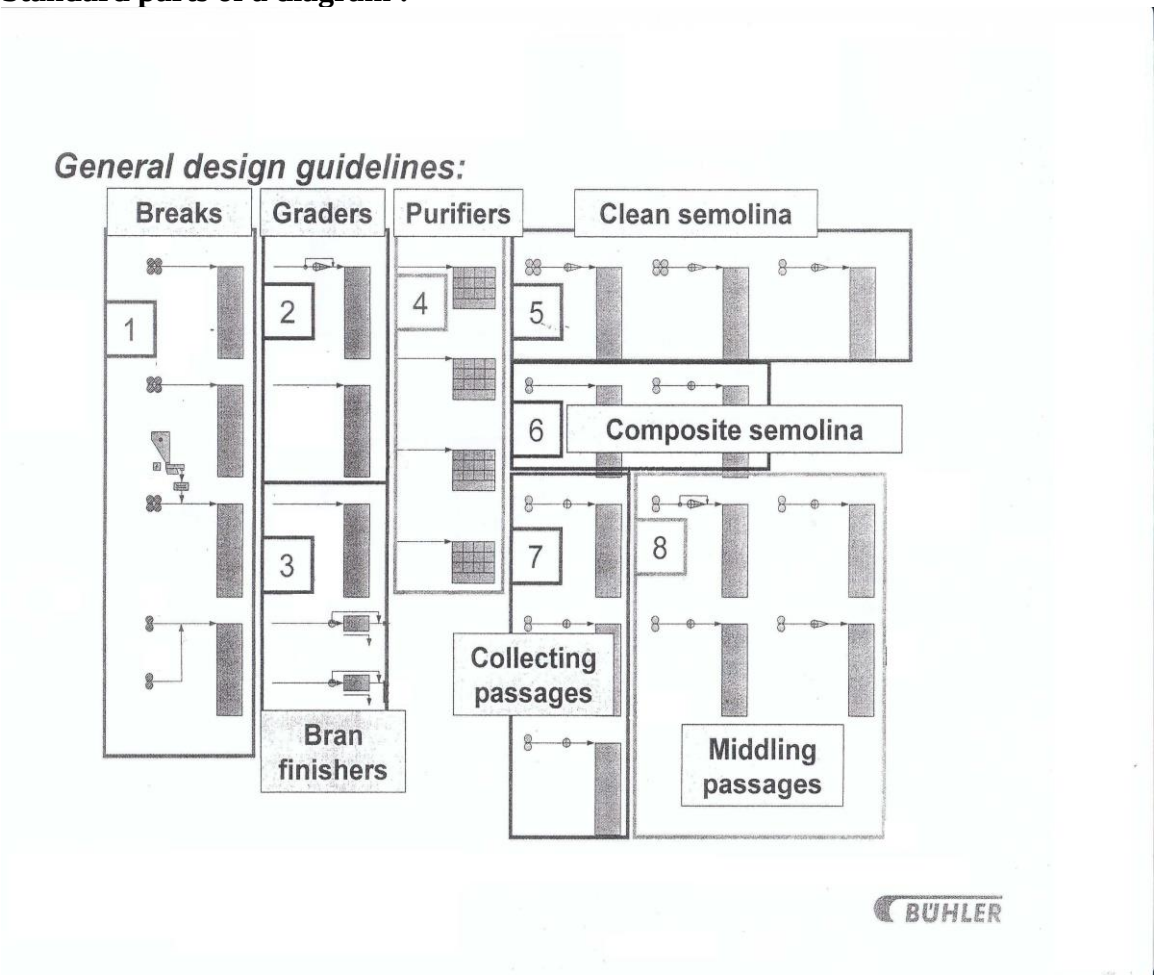
Chapter 3 : design of a diagram

✓ Rules of diagram

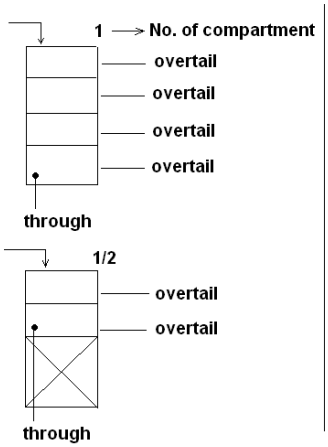
Keep **I**t **S**imple and **S**tupid

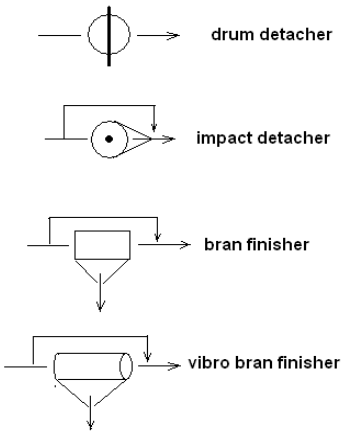
1. go straight
2. step by step
3. do not move from lower quality grade to higher quality grade
4. do not move from Red. To Break
5. do not turn back
6. mixing the stock (semolina) with same size and same ash (in reduction)

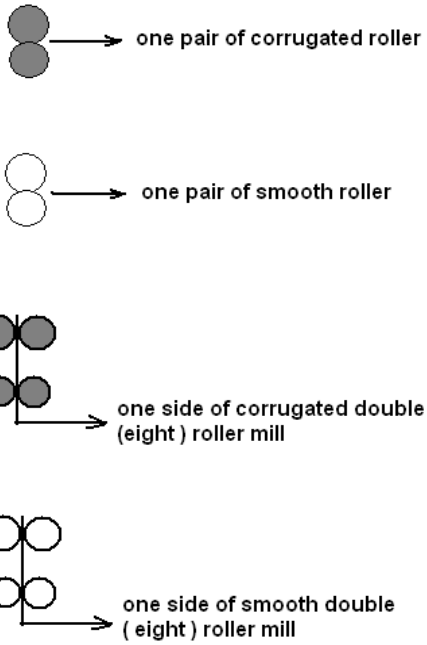
✓ Standard parts of a diagram :

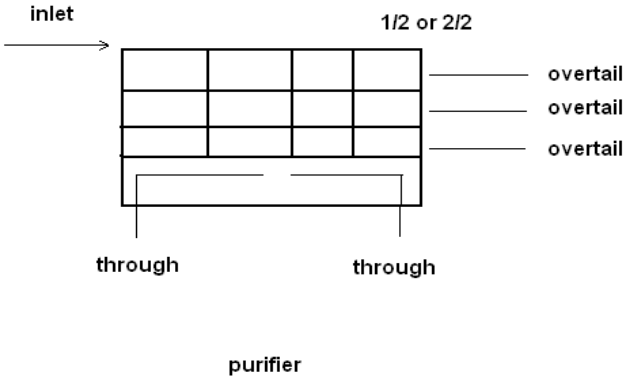


✓ Symbols of diagram and flow chart:









purifier

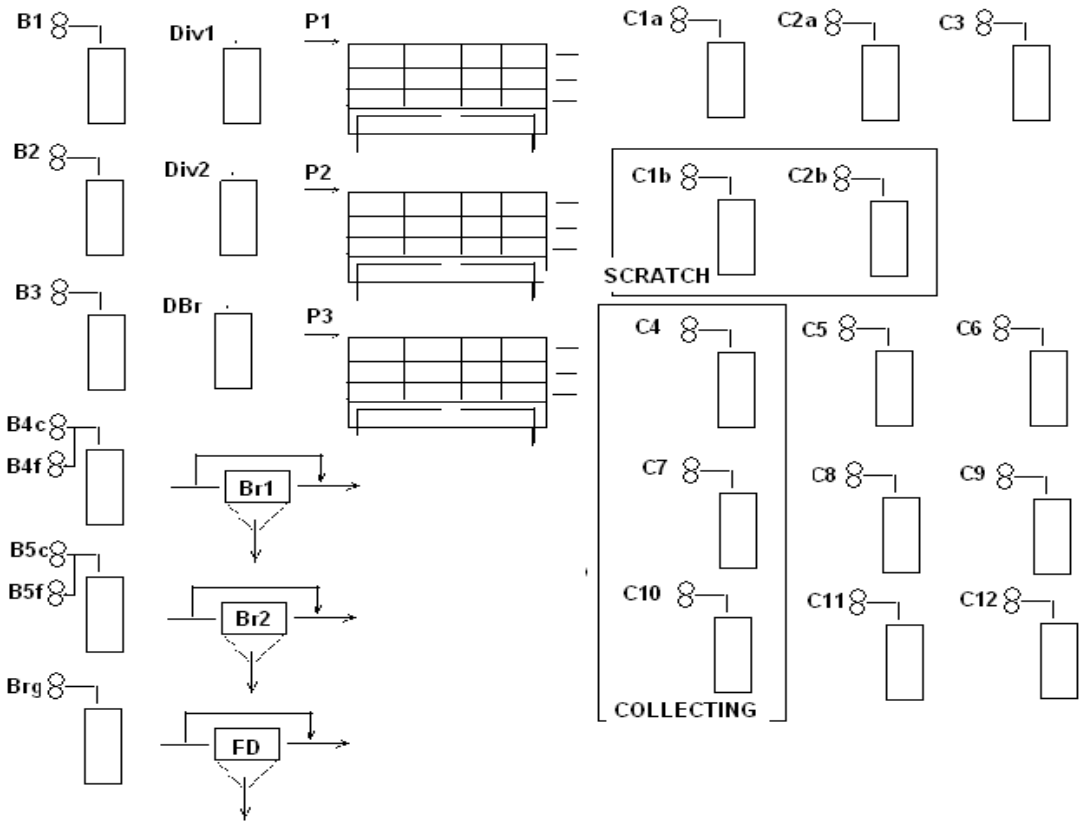
✓ **Nomenclatures of passages :**

B (1-5) → break
f → fine
c → course

C(1-12) → reduction
a → clean semolina
b → composite semolina

Br → bran finisher
FD → flour duster
DBr → bran finishing sifter
Brg → bran grinding – bran finishing roller
P → purifier
Div → grading

✓ **Standard places for each passage in a diagram**



✓ Difference of rollers between Red. & Break

	Reduction	**Break**
Speed	380 – 400 Rpm	400 – 450 Rpm
Speed ratio	1 – 1.25	1 – 2.5
Rollers	Smooth & corrugated	corrugated

✓ Important rule of sizing in a diagram :

Large particle size must be equal or less than twice of small particles

Pb = 2*Ps **or** **Pb < 2*Ps**

Pb/2 = Ps **or** **Pb/2 < Ps**

Chapter 4: set up of a diagram

- ✓ **Break system :**

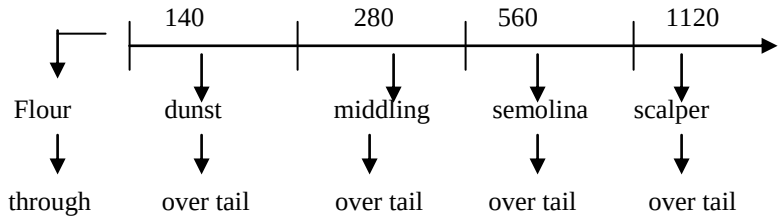
- ✓ **B1 : breaking up the wheat :**

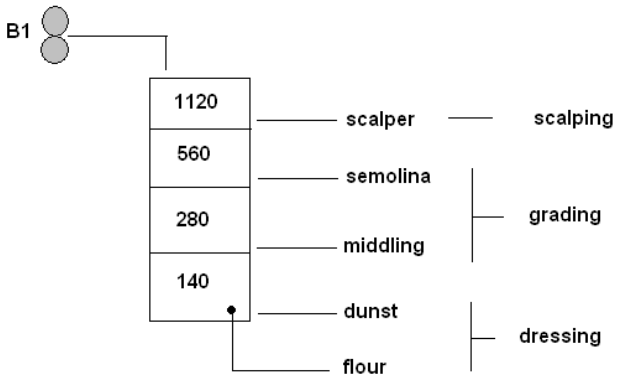
  Result of B1 grinding from large size to small size:

  1. **Scalper :** large particles of wheat and branny particles which should be continue the process
  2. **semolina :** should be purified and send to reduction system for reducing the size
  3. **middling :** it is almost clean and should send to reduction system
  4. **dunst :** small particles which can be use as flour or may be need to reducing the size
  5. **flour :** white powder which is produced from endosperm and used as final product

- ✓ **particle size will be as shown :** scalper > semolina > middling > dunst > flour

- ✓ **soft wheat :** 1120 => scalper
  1120/2 = 560
  560/2=280
  280/2=140
  } Pb = 2*Ps





- ✓ **Point :** dressing means taking out the flour from the stock

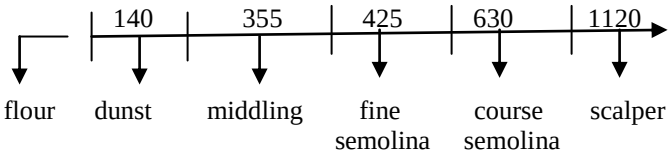
- ✓ **Semi hard wheat :**

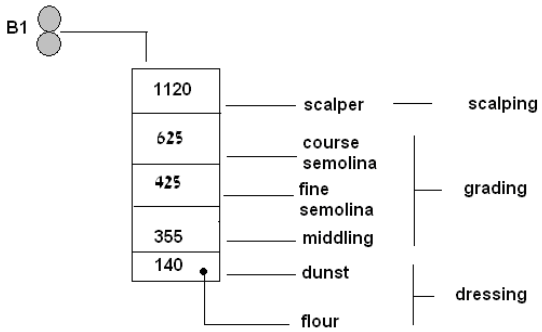
  As semi hard wheat produces more semolina and semolina which is sent to a Reduction passage must be in a narrow range of size and ash content then a miller must change the sieve size as follow to reach to a same size by grading the semolina

scalper = > 1120
1120/2 = 560 => 630
630 / 2 = 315 => 425
425 / 2 = 212 = > 355
Flour sieve => 140

$P_b < 2*P_s$

As it is shown above we miller must add any microns to the sieve size to have better and narrow range as ash and sizing for semolina



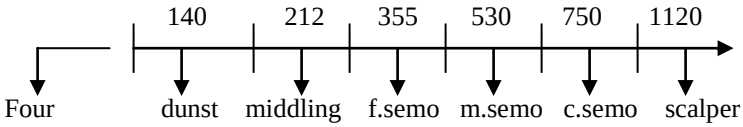


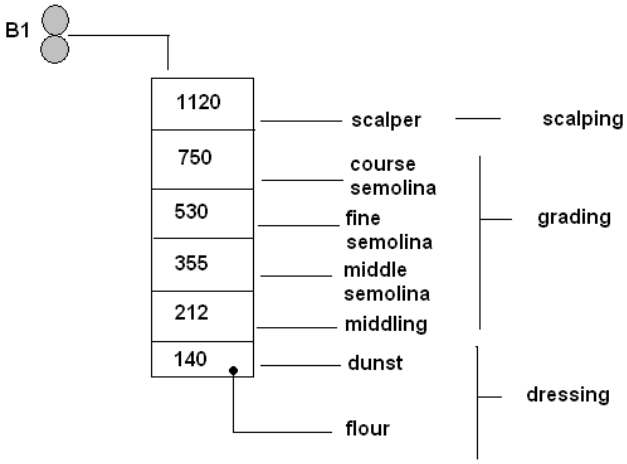
- ✓ **Point :** semolina which is sent to purifiers must be in a narrow and same range of ash content and size to have a better purification

- ✓ **Hard wheat :**

  More hardness in wheat means more semolina production then miller should reach to a nearer range of size and ash content than semi hard wheat and should add more microns to sieve size

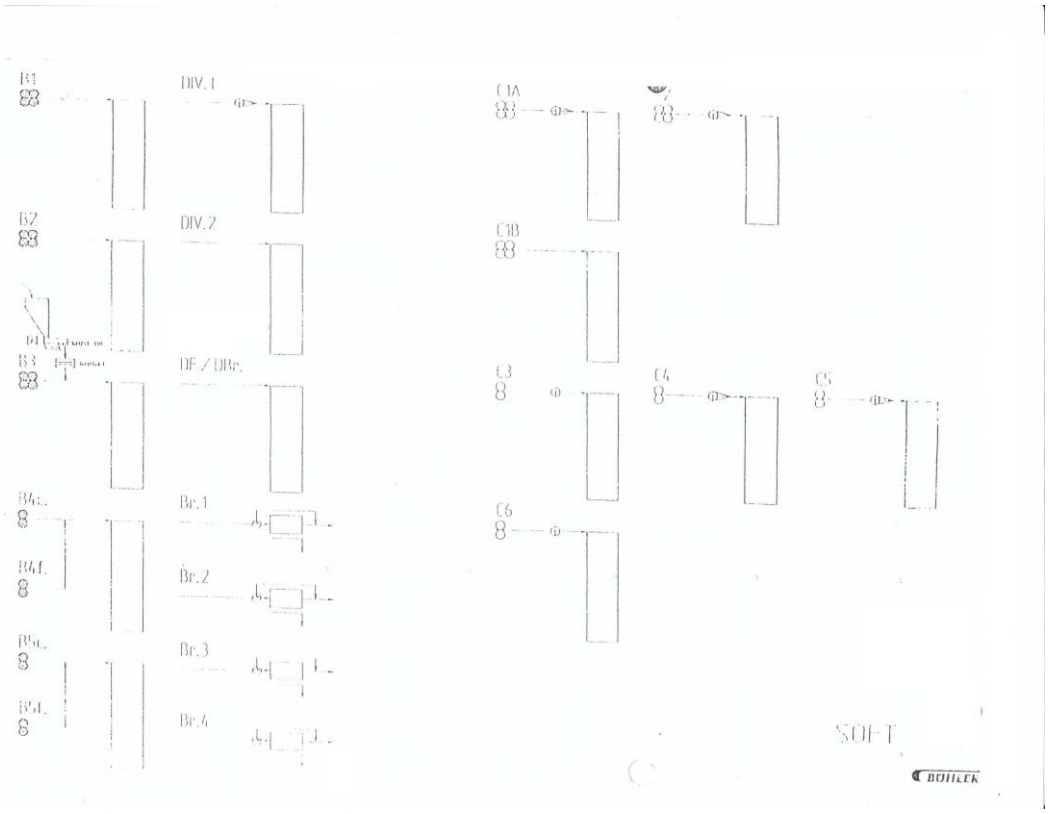
scalper => 1120
c. semolina => 750
m. semolina => 530
f. semolina => 355
middling => 212
dunst => 140
flour : less than 140



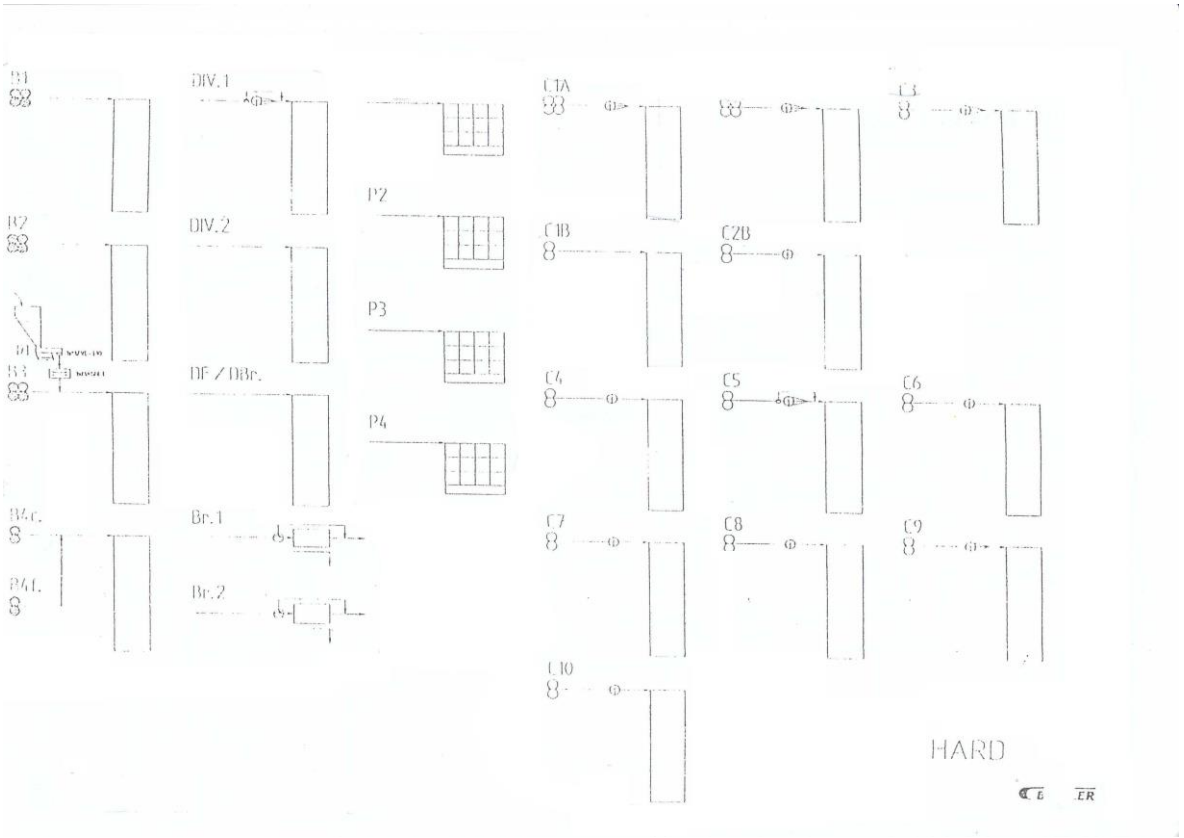


- ✓ **Typical flow chart :** as it is mentioned in wheat specification in chapter 1 and the kind of grinding the different kind of wheat in chapter 4 now we know that flow chart as different kind of wheat s are different to each other . some of the typical flow charts are as follow :

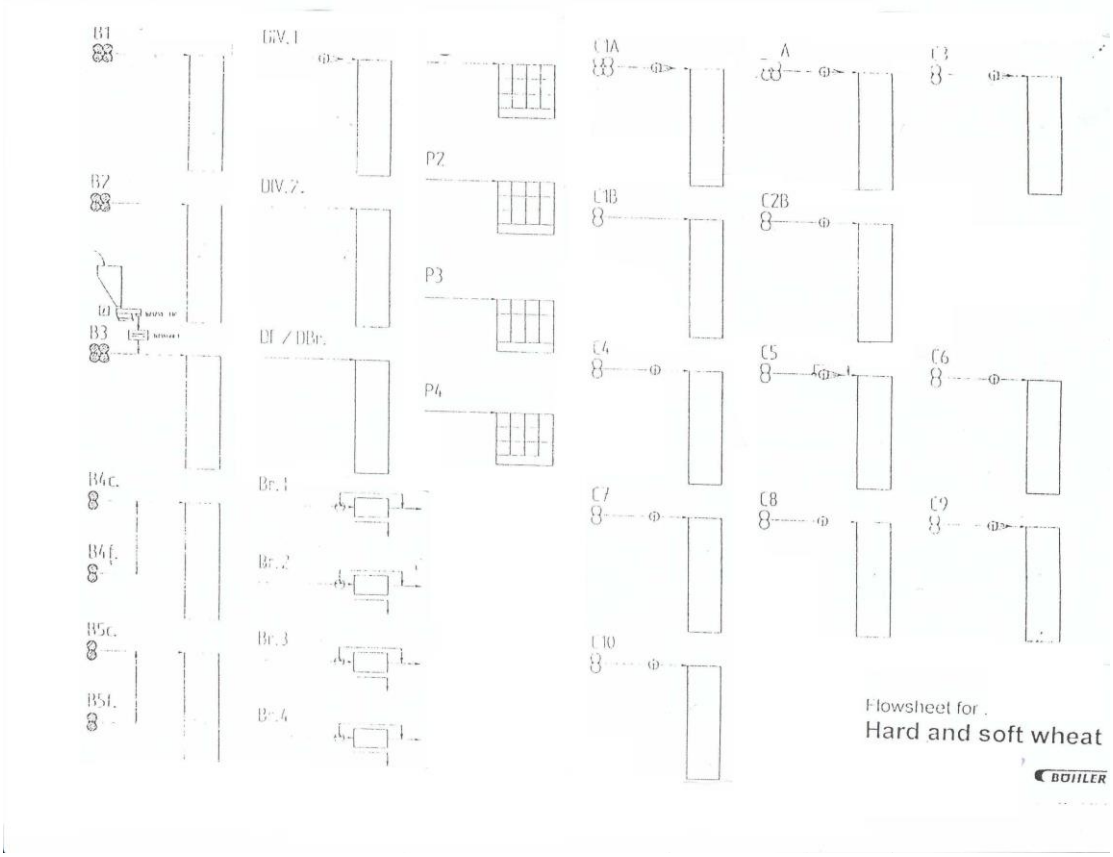
A – soft wheat : - Producing less semolina and more bran
- More stickiness of bran and semolina
- Need more bran finisher
- Need less purifier
- Need more break rolls


B1
DIV.1
B2
DIV.2
B3
DF / DRc.
B4c.
Br.1
B4f.
Br.2
B5c.
Br.3
B5f.
Br.4
C1A
C1B
C3
C4
C5
C6
SOFT
BOHLER

B – hard wheat : - Producing more semolina
- Need more purifier
- Less stickiness of bran and endosperm
- Need less bran finisher
- Need more reduction rolls



C – semi hard wheat : - The characteristic is between hard and soft
- No. of purifiers are equal to hard wheat
- No of bran finishers are equal to soft
- Equal rollers of break and reduction



- ✓ **Point :** semi hard wheat is used un Iran then all the diagram set up will be adjusted as used in Iran

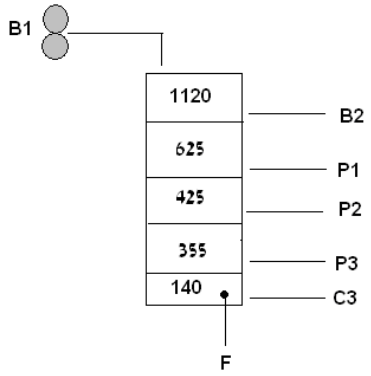
✓ Quality grades :

There are 4 different quality grades in a flow chart which is shown by different colors as following diagram

Quality grades are very important and a miller should know them as well to avoiding some mixing or turning back in quality grades and following the instruction of quality when sending any stock from break to reduction or from reduction to other parts of diagram

✓ Set up of B1 :

Function of B1 is shearing and opening up the wheat then a large range of quality and sizes will be produced . each stock must be sent to its own passage as quality and size fore more process as follow :

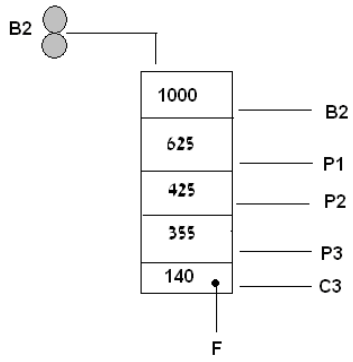


B2: scalpers which are big particles of wheat must go to the next stage of break system
P1: course semolina is always dark and composite then must be sent to the first purifier to be Cleaned
P2: fine semolina must be sent to the next purifier as their difference of size for cleaning
P3: middling is almost clean but for more insurance and quality production for white flour it will send to the 3rd purifier for cleaning
C3: dunst and fine middling are always clean and will be sent to their first stage of reduction in the same quality grade of B1 base on their size
F: flour will be produced in each stage and miller must get rid of flour in every stage as soon as possible

✓ Set up of B2 :

As the quality flow chart shows ‘ B1 & B2 are in the same quality grade . B2 is nearly the same of B1 and the quality of stocks are the same then miller can set up the same sieve in the sifter and send the stock to the same target .

the difference between B1 and B2 is in the first row of sieve . because the stock (scalpers) which are coming from B1 are in smaller size then miller can choose a little smaller sieve size to have more
efficiency in sifting and grading



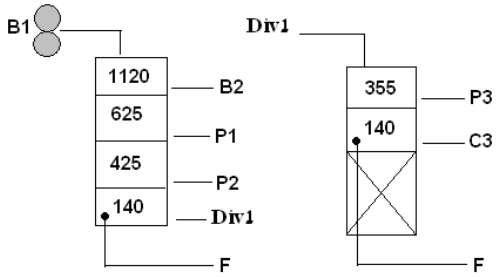
✓ Introducing the grading system (Div) :

Plansifters have any limited in sifting area or No. of sieves for grading the stock as shown in B1 and B2 .

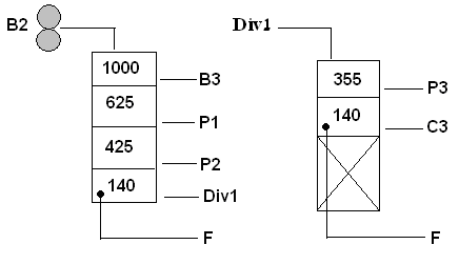
if miller set the sieves as shown in above diagram then limitation in capacity will be occurred and if miller needs the proper capacity then lost of fraction and quality will be happened

diverting a part of stock to a different sifter for grading is the solution for holding the proper capacity and different fraction with each other

Div . passage is extension of break sifter and a part of break system by name of grading Which is mentioned as follow :



As mentioned before B1 and B2 are the same passages in a same quality grade then they can send their stock to a same extension or to different Div system according to the diagram then :



According to the mill capacity Div. can be a complete or half compartment of a sifter

✓ Set up of a Purifier :

Purifier is a kind of machine for cleaning and purifying the composite semolina with the action of both sieve and aspiration and its function is based on quality

each sieve cover should have the proper size to separate semolina and bran as well as possible

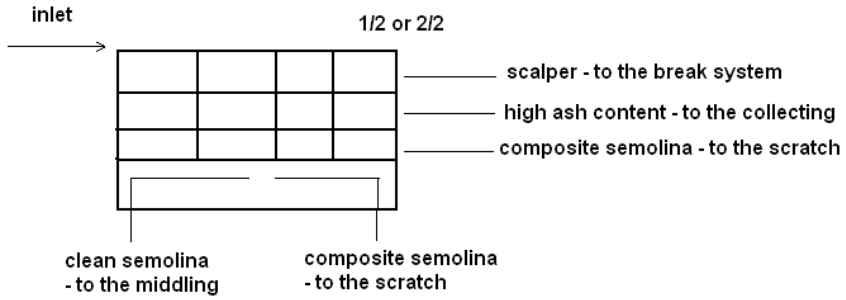
different stock which is entering to a purifier are as follow :
a – little parts of scalper
b – coarse and fine semolina with bran adhered to them
c – coarse and fine semolina which are clean
d – little bran particles
e – flour and bran powder

as a purifier separates the stock as quality (size & density together) then miller must be familiar to the density of different stock as it mentioned bellow

- clean and fine semolina — more density – fine size
- clean and course semolina
- composite semolina
- branny particles — less density – large size

fluidfication and stratification will occur at the beginning of each purifier by air current. Small and dense semolina which are clean and pure will touch the sieve cover and become separated by sifting but large and composite semolina and other light particles will stay over the sieve by air current.

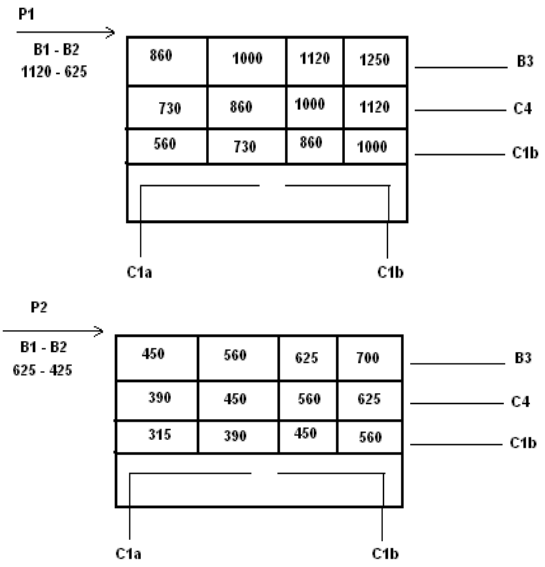
Large and light particles will lead out from the machine as over tail and small particles which are pure semolina will passed through sieves .



✓ set up and sieve design of a purifier

sieve cover and size will estimated according to sifter cover which stock comes from . change in sieve size in purifier is as shown below :

- coarse semolina : 100 – 150 micron
- medium semolina : 80 – 100 micron
- fine semolina : 50 – 80 micron



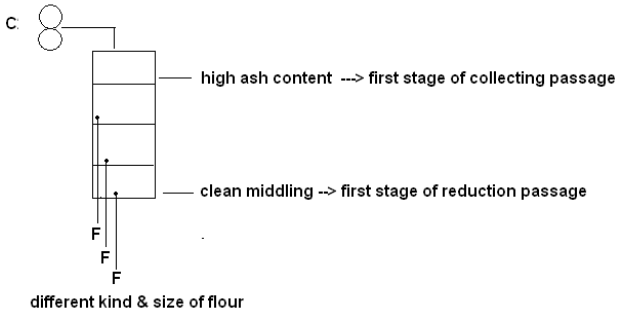
✓ set up of reduction passages :

early reduction sifters have a presifter to separate high ash content (sieve cover No. 500 to 300 micron) and high ash content stock will send to collecting passages

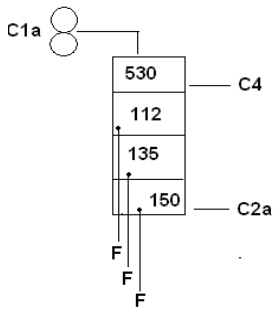
source and destination of each stock in reduction is mentioned as following chart :

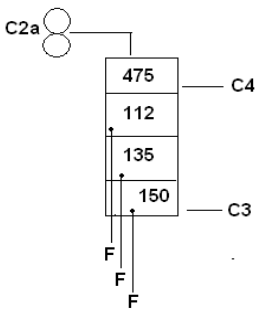
Setup of reduction system

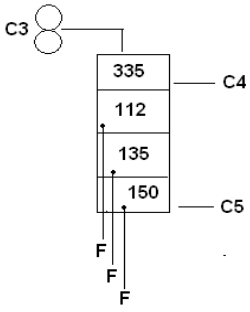
				Quality group
Approx. granulation from purifier Quality of stock	C 1 A Coarse > 340 µ Clean	C 2 A Medium 340 - 212 µ Clean	C 3 Fine < 212 µ Clean	I
Approx. granulation from purifier Quality of stock	C 1 B Coarse > 315 µ Composite (brany)	C 2 B Medium/ fine < 315 µ Composite (brany)		II a
Quality of stock	C4 Collecting passage	C5 Middlings passage	C6 Middlings passage	II b
Quality of stock	C 7 Collecting passage	C 8 Middlings passage	C 9 Middlings passage	III
Quality of stock	C 10 Collecting passage	C 11 Last brany passage		I V

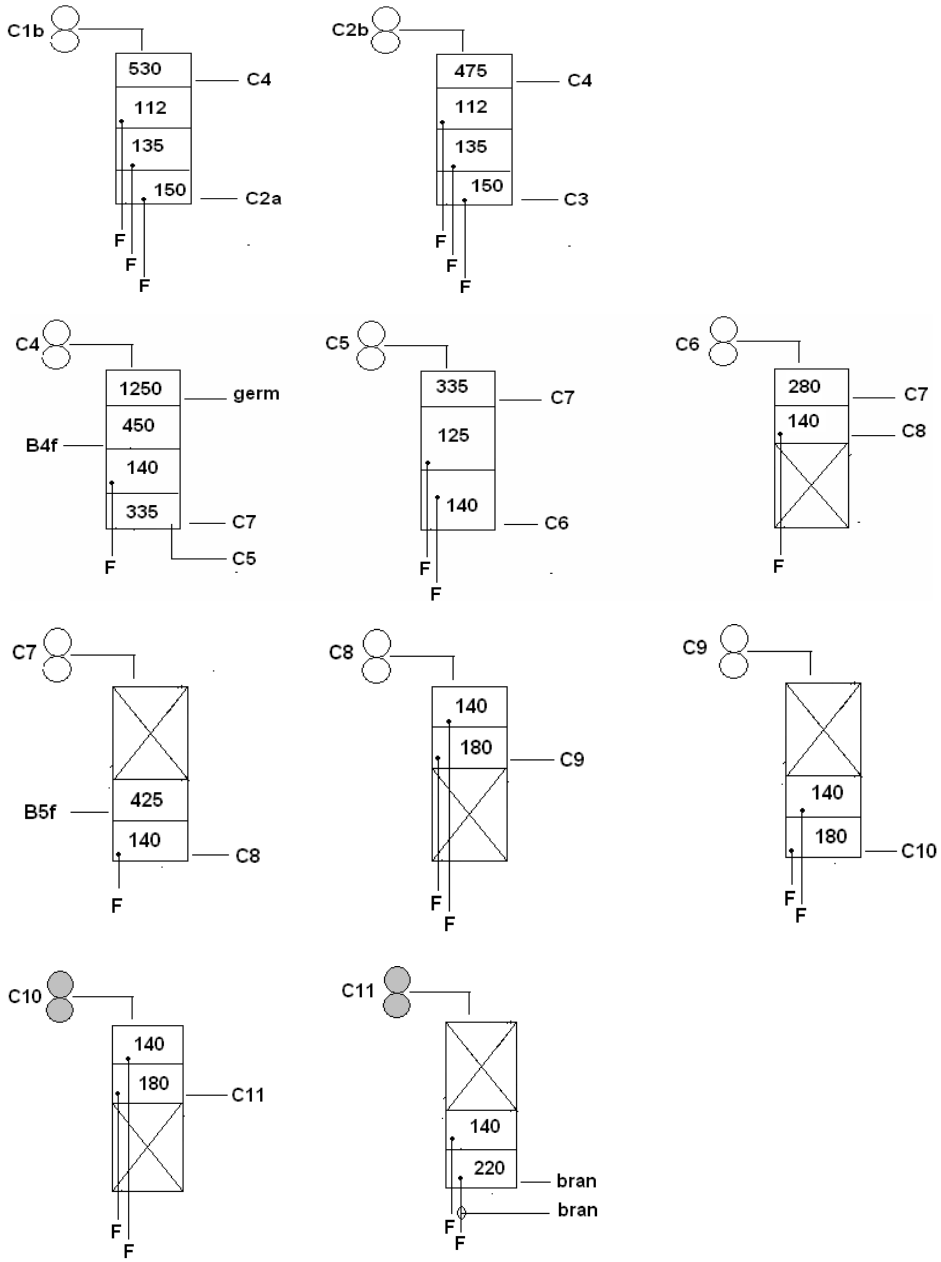


different kind & size of flour









- ✓ **Germ extraction :**

Germ :

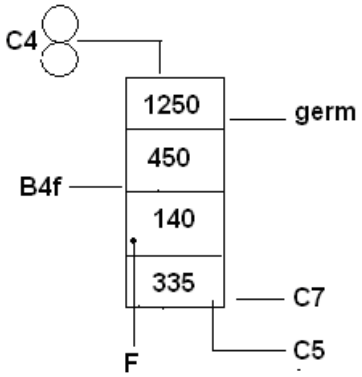
- Alive part of kernel
- Almost 10% fat content
- Producing fatty acid in silo condition and rancidity in flour
- Decreasing the shelf life of flour

➔ **Must be separated from flour**

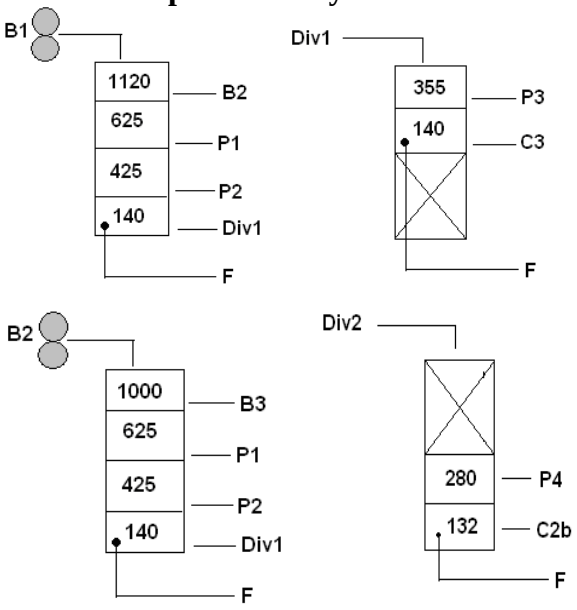
How to extract:

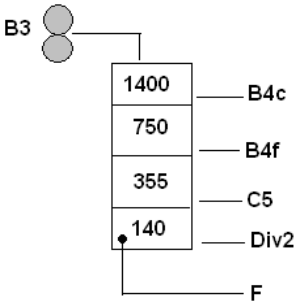
- 50% in cleaning system with brushing and scourer
- 25% in reduction system

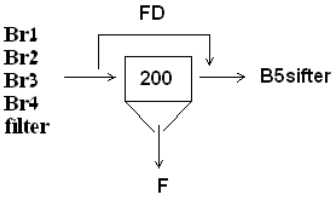
- C4 passage must have smooth rollers for flaking the germ and increasing the size
- 1250 micron sieve cover can separate the flaked germ

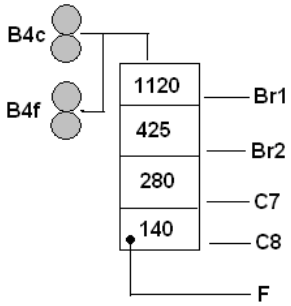


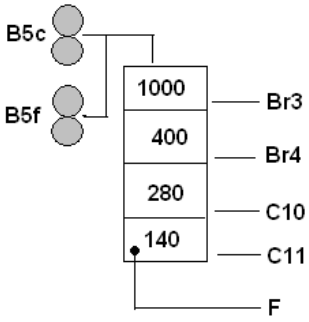
✓ **Set up of break system**

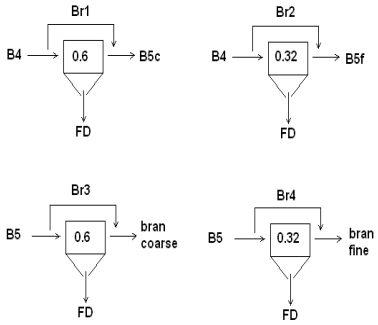




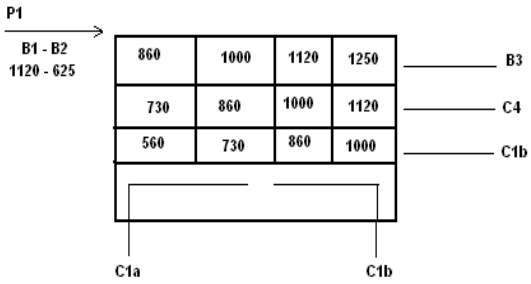


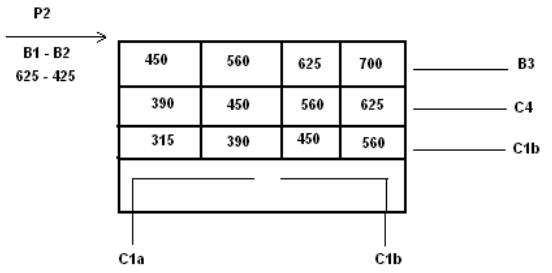


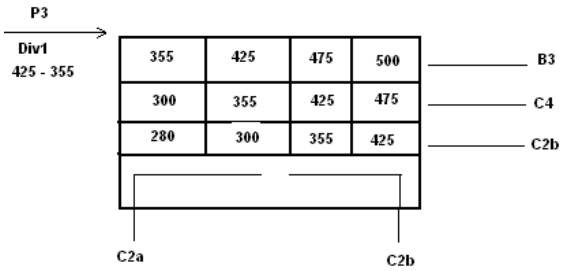


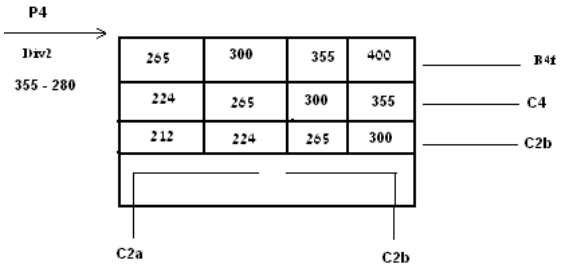


✓ **Set up of purifiers**




P2
B1 - B2
625 - 425
450
560
625
700
B3
390
450
560
625
C4
315
390
450
560
C1b
C1a
C1b


P3
Div1
425 - 355
355
425
475
500
B3
300
355
425
475
C4
280
300
355
425
C2b
C2a
C2b


P4
Div2
355 - 280
265
300
355
400
B4t
224
265
300
355
C4
212
224
265
300
C2b
C2a
C2b

Chapter 5 : calculation of a diagram and mill balance

✓ Roller length :

9 – 16 mm / 100 kg / 24 hr

Wheat type	Reduction	Break
Soft	40%	60%
Semi hard	45% - 50%	55%-50%
hard	50%-55%	50%-45%

Roller length & capacity has been calculated by miller

✓ Sifting area :

0.055 square m / 100 kg / 24 hr

50% break sieve	50% reduction sieve
50% flour sieve	

Sifting area should be find by the information of plansifters according to the capacity of mill

✓ Break release :

3 min sifting over 1120 sieve cover :

	Total stock inlet	Over tail	through	
B1	100%	65%	35%	
B2	65%	50%	50%	
B3	32.5%	40%	60%	Over 800 is more than 1120
B4	13%	---	---	Flute must have affected the stock and little grinded

✓ Calculation of No. of roller mill and plan sifters :

Point : each pair of rollers have following capacity :
1 – roller 1000 * 250 ➔ 5 ton/hr wheat in B1
2 – roller 1250 * 250 ➔ 7.5 ton/hr wheat in B1

Exmple 1 : 120ton/24hr
11.6mm/100kg/25hr

11.6 100
X 120000 ➔ (120000*11.6)/100 = 13920 mm = 14000 mm
➔ 7 roller mill 1000*250

Break roller	Break sifter	Reduction roller	Reduction sifter
B1➔one pair	1 section	C1a➔ one pair	1 section
B2➔one pair	1 section	C1b➔ one pair	1 section

B3➔one pair	1 section	C2➔ one pair	1 section
B4➔one pair coarse one pair coarse	1 section	C3➔ one pair	1 section
B5➔ one pair	1 section	C4➔ one pair	1 section
Div	½ section	C5➔ one pair	½ section
		C6➔ one pair	½ section
		C7➔ one pair	½ section

Calculation : 0.055 sq m / 100 kg /24 hr
Capacity = 120 000 kg / 24hr
Roller 1000 250 = 5ton / hr 5*24=120 ton/24hr = 120000 kg/24hr

0.055 100
X 120000 ➔ (0.5*120000)/100 = 66 sq m

Each sifter 628 = 35 sqm ➔ 66/35 = 1.8 = 2 plansifter 628 = 12 compartment

Exmple 2 : 250ton/24hr
9.6/100kg/25hr

9.6 100
X 250000 ➔ (250000*9.6)/100 = 24000 mm
➔ 12 roller mill 1000*250

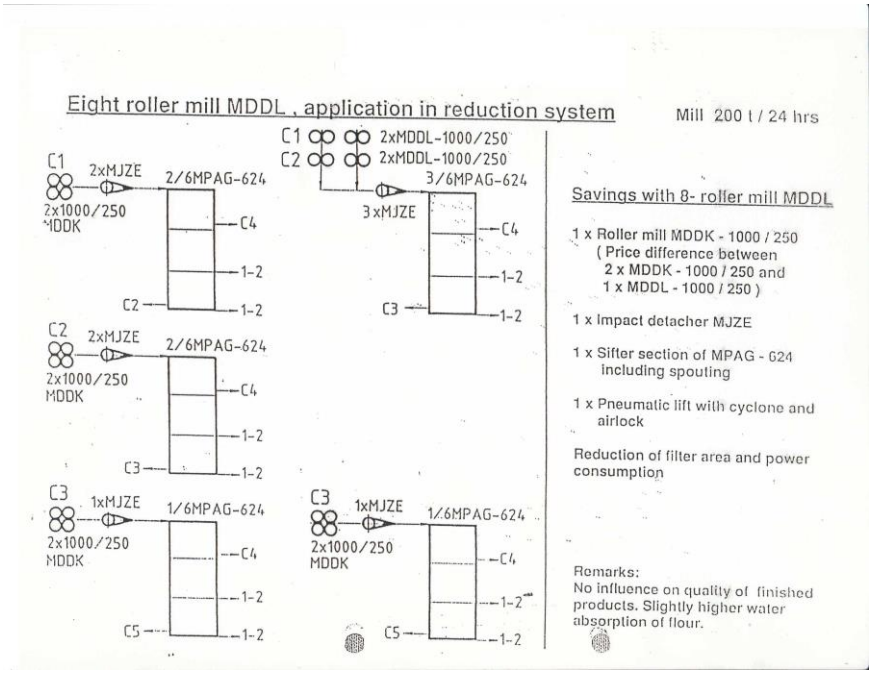
Break roller	Break sifter	Reduction roller	Reduction sifter
B1➔two pair	2 section	C1a➔ two pair	1 section
B2➔two pair	2 section	C1b➔ one pair	1 section
B3➔two pair	2 section	C2a➔ two pair	1 section
B4➔one pair coarse one pair coarse	2 section	C2b➔ one pair	1 section
B5➔ one pair	1 section	C3➔ one pair	1 section
Brg➔ one pair	1 section	C4➔ one pair	1 section
Div1	1 section	C5➔ one pair	1 section
Div2	1 section	C6➔ one pair	1 section
		C7➔ one pair	1 section
		C8➔ one pair	1 section
		C9➔ one pair	1 section
		C10➔ one pair	1 section

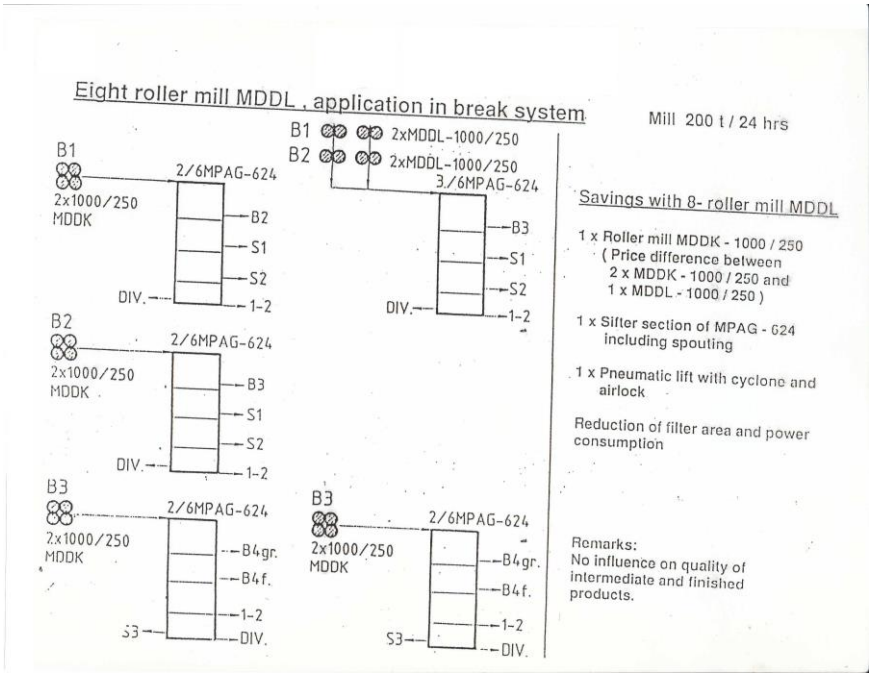
Calculation : 0.055 sq m / 100 kg /24 hr
Capacity = 250000 kg / 24hr
Roller 1000* 250 = 5ton / hr 2*5*24=250 ton/24hr = 250000 kg/24hr

0.055 100
X 250000 ➔ (0.5*250000)/100 = 137.5 sq m

Each sifter 628 = 35 sqm ➔ 137.5/35 = 1.8 = 4 plansifter 628 = 24 compartment

✓ **Usage of double roller mill :**





✓ Fluting in rollers

To have a correct milling process :

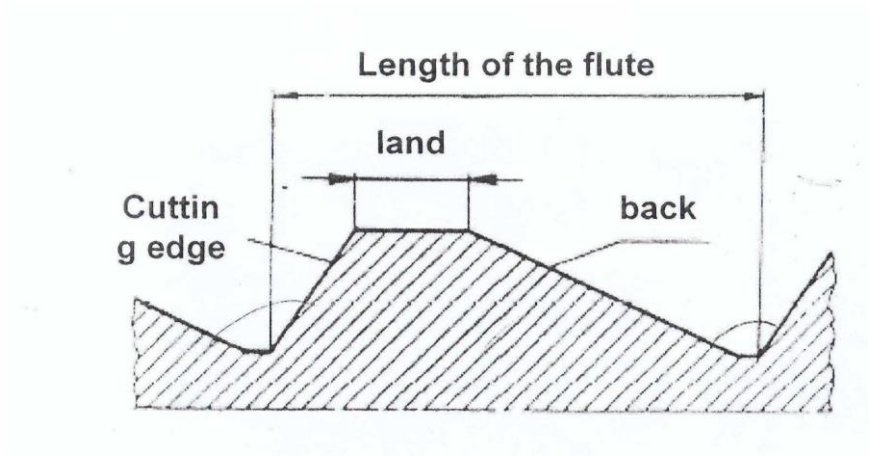
- **choosing right rolls with a proper quality**
- **design right fluting for each passage**
- **notice to the right gap between rollers**
- **notice to best gap and parallel adjustment**
- **design the best kind of taper for soft rolls**

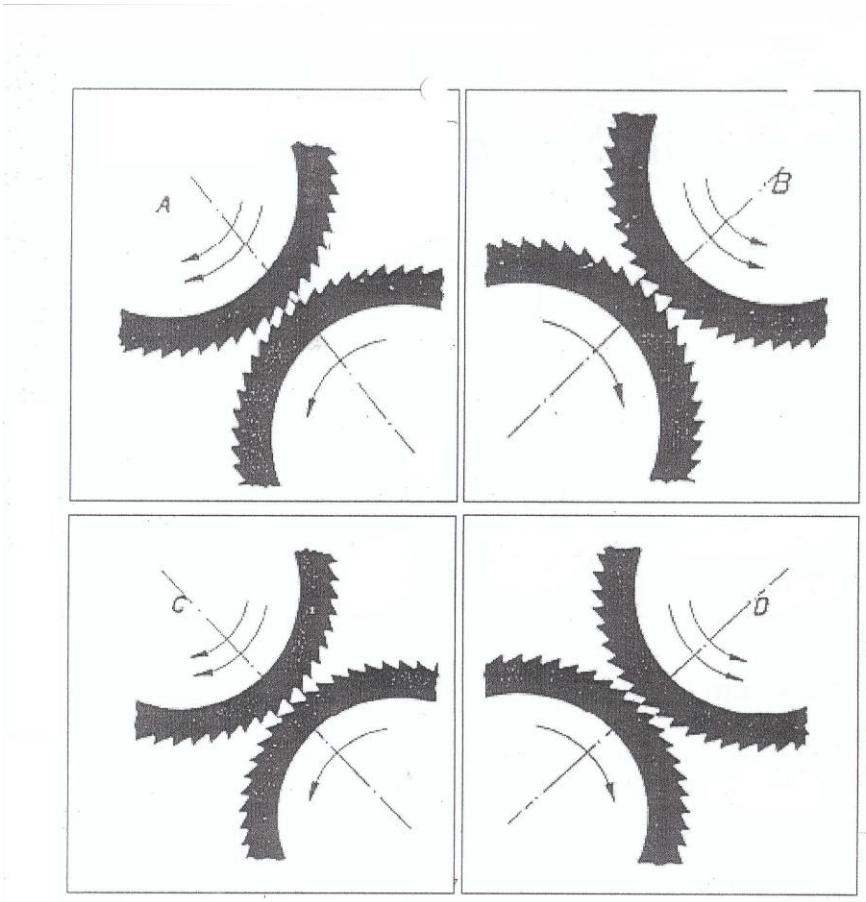
Right milling affect on break rolls :

- **fluting profile**
- **spiral %**
- **No. of flute per centimeter (f/cm)**

Choosing the right fluting profile :

- **Kind of wheat**
- **capacity of mill**
- **roller length of mill**
- **quality of flour required (white – dark – semolina)**





Roll fluting

Flute positions

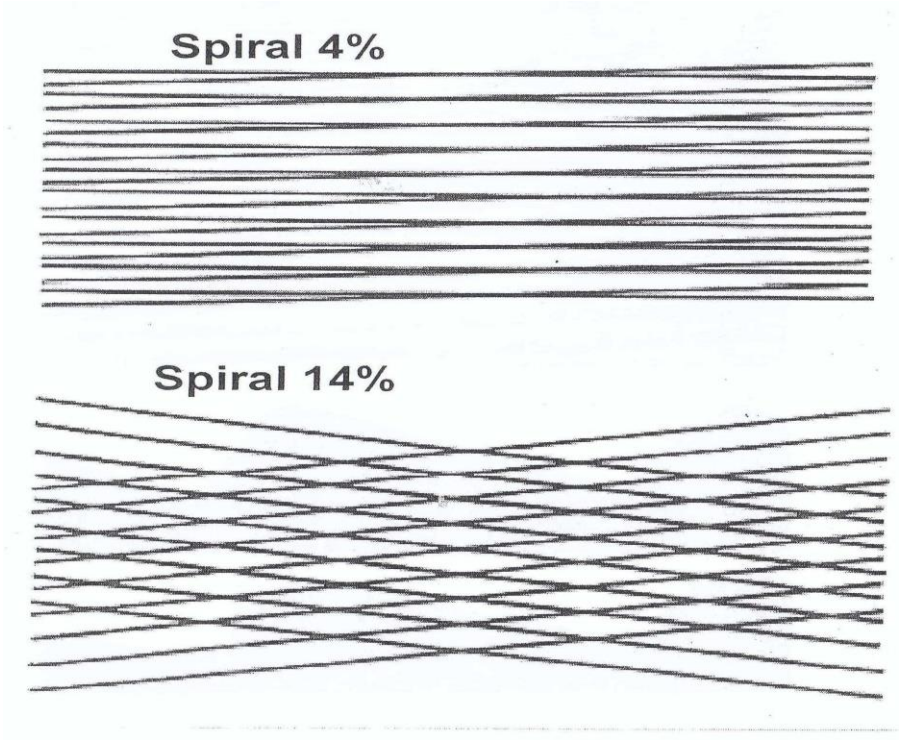
Fast roll

Slow roll

A = Sharp / Sharp
B = Dull / Sharp
C = Sharp / Dull
D = Dull / Dull

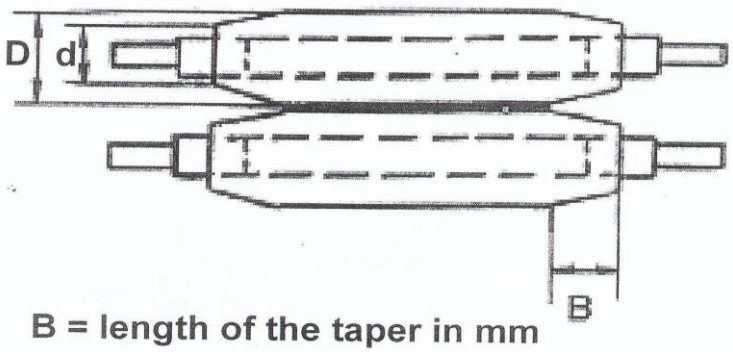
Fluting spiral

- **producing cutting effect (scissor effect)**
- **avoiding the pressing of particles**

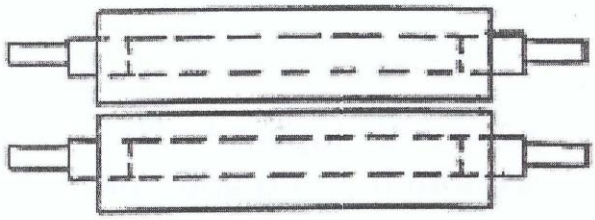


Roll tapering
smooth rolls

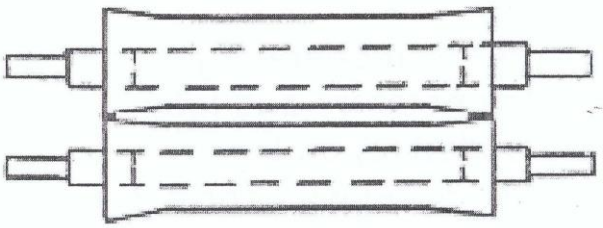
Taper = D-d in micron (µm)



B = length of the taper in mm



•Rolls at operating temperature and fully loaded (operating pressure) with correct taper



•Rolls at operating temperature and fully loaded (operating pressure) with too little or no taper

Roller mill & roller specification

Passage	Grinding Rolls			Roll Corrugation						Rough.	Drive			
	Qty.	Length	Diameter	No		Spiral	Angle	Style	Land		Gear Ratio	Motor		
		mm	mm	Total	/cm	%			mm	Um		rpm	kW	
B1	6	1000	250	250	3.2	4	30/65	R:R	0.2	-	1:2.5	1000	3X22	new
B2	6	1000	250	400	5.1	6	30/65	R:R	0.2	-	1:2.5	1450	3X18.5	existing
B3	6	1000	250	500	6.4	6	40/75	R:R	0.1	-	1:2.5	965	3X15	existing
B4 c.	4	1000	250	700	8.9	8	40/75	S:S	0.1	-	1:2.5	965	2X11	existing
B4 f.	2	1000	250	800	10	8	40/75	S:S	0.1	-	1:2.5	1000	1X15	new
B5 f.	2	1000	250	900	12	10	40/75	S:S	0.1	-	1:2.5	1000	1X15	new
Br.G	2	1000	250	600	7.6	10	40/75	S:S	0.1	-	1:2.5	1000	1X15	new
C1A	2	1000	250	-	-	-	-	-	-	40-45	1:1.25	1450	1X18.5	existing
C1B	2	1000	250	-	-	-	-	-	-	40-45	1:1.25	1450	1X18.5	existing
C2	6	1000	250	-	-	-	-	-	-	40-45	1:1.25	1000	3X15	new
C3	4	1000	250	-	-	-	-	-	-	30-35	1:1.25	1000	2X15	new
C4	4	1000	250	-	-	-	-	-	-	30-35	1:1.25	1000	2X15	new
C5	2	1000	250	-	-	-	-	-	-	30-35	1:1.25	1000	1X15	new
C6	2	1000	250	-	-	-	-	-	-	30-35	1:1.25	1000	1X15	new
C7	2	1000	250	-	-	-	-	-	-	30-35	1:1.25	965	1X11	existing
C8	2	1000	250	1000	12.7	10	30/65	S:S	0.1	-	1:2.5	965	1X11	existing
C9	2	1000	250	1000	12.7	10	30/65	S:S	0.1	-	1:2.5	965	1X11	existing

Finish