



## Recovery of Clean Coal from 300 – 0 mm High Ash Dirty Coal Using both Gamma Rays and ZM Dry Separator at Dafeng Coal Mine

Tangshan Shenzhou Manufacturing Group

Date: November 14, 2019



# CONTENTS

01

Introduction of Dry Coal Separation Technology

02

Full Size Range Dry Coal Separation at Dafeng Coal Mine

03

Feasibility of Using Dry Separation Technology In India

04

Conclusions

# 01

## PART



## Introduction of Dry Coal Separation Technology

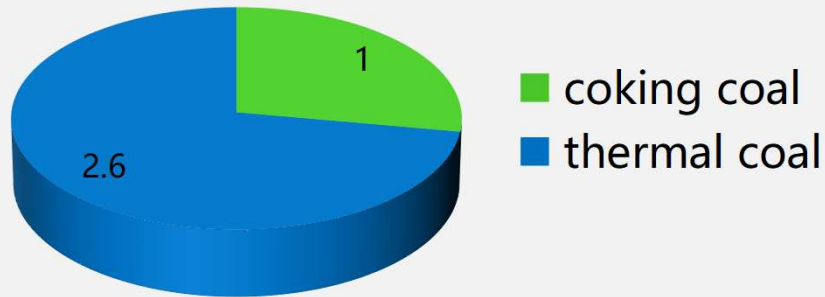
- ◆ Equipment Classification
- ◆ FGX and ZM Dry Separator
- ◆ Gamma-ray or X-ray Sorter
- ◆ Comparison of Different Type Equipment



# Overview of Coal Preparation in China



## Coal Preparation Ratio



Unit: Billion tons

Coal Production of China in 2018

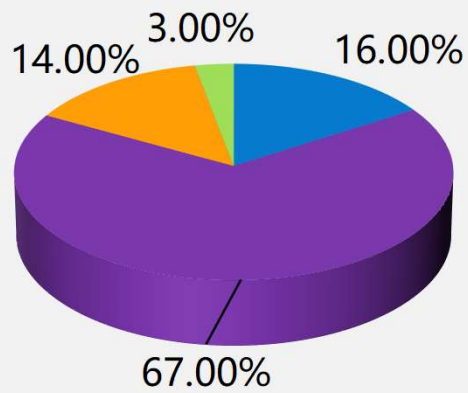
- 100% of coking coal processed;
- 61% of thermal coal washed;
- >2200 coal washeries;
- 81 washeries with capacity > 10 Mtpa;



# Overview of Coal Preparation in China

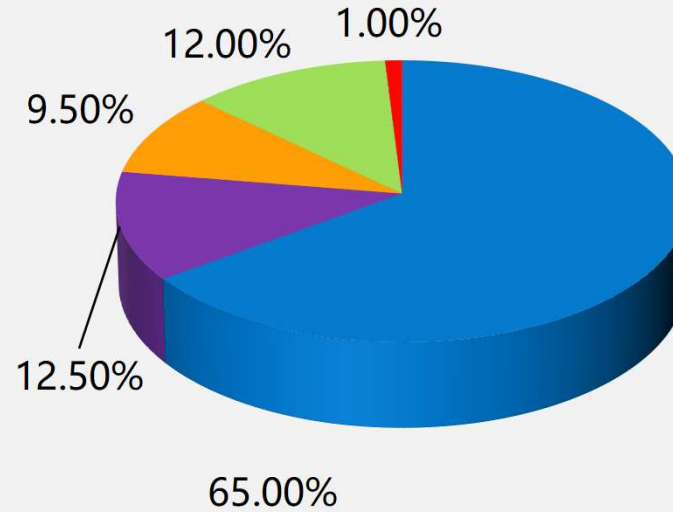


## Coal Preparation Process Used



1978

- Heavy Medium Separation
- Jigging
- Flotation
- Hand picking



2018

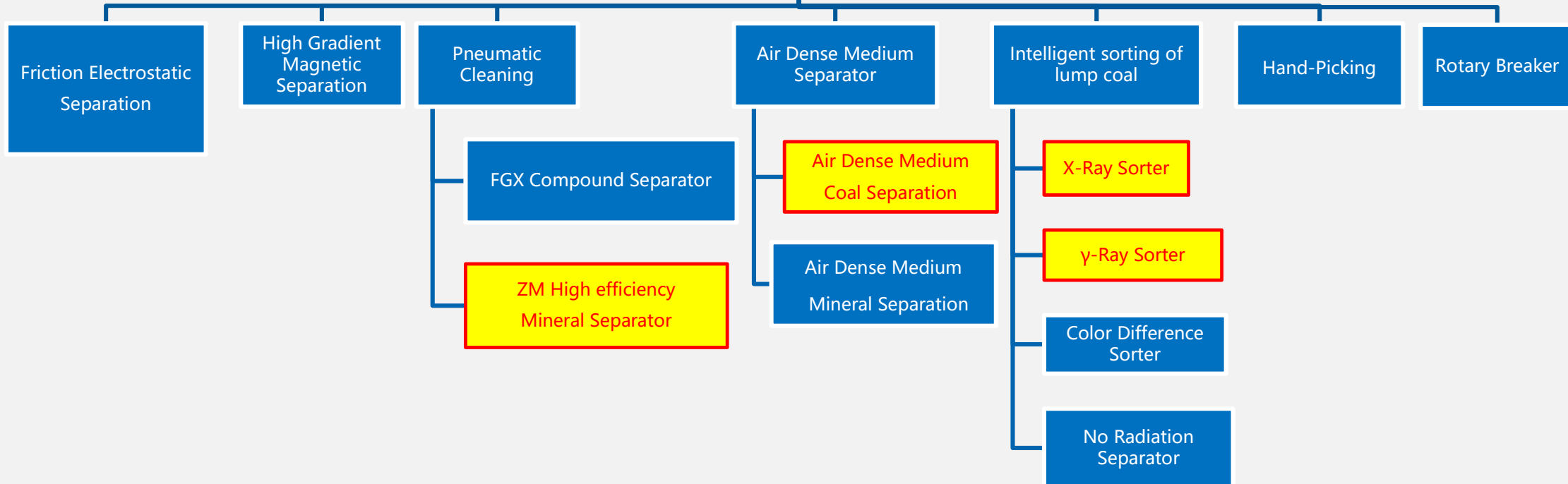
- Heavy Medium Separation
- Jigging
- Flotation
- Dry cleaning
- Hand picking



# Dry Separation Technology Classification



## Dry Coal Cleaning Methods





## Leading Dry Separation Equipment



**ZM High Efficiency  
Mineral Separator**

Deshaling of high ash 100-0mm coal ;  
Pre-deshaling of coking coal ;  
Low rank coal separation



**Y-Ray /X-Ray Sorter**

For separation of >80 (50) mm coal



**Air Dense Medium  
Separation**

Low density separation of +6mm coal;  
Production of low ash coking coal and coal used in pulverized coal injection



**Drying-Dry Separation  
System**

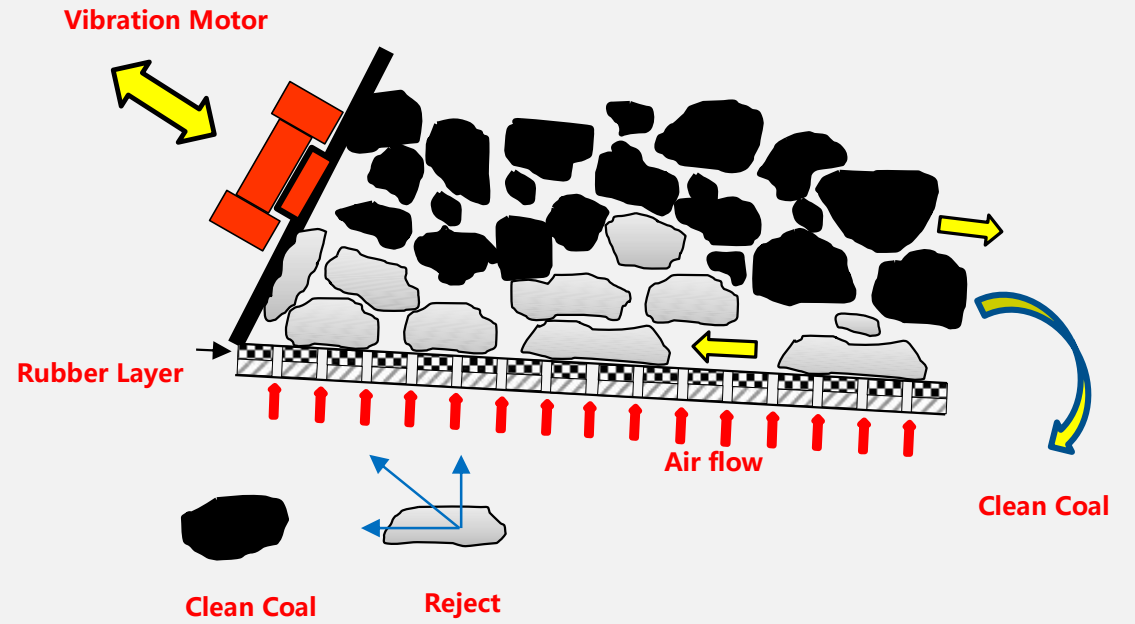
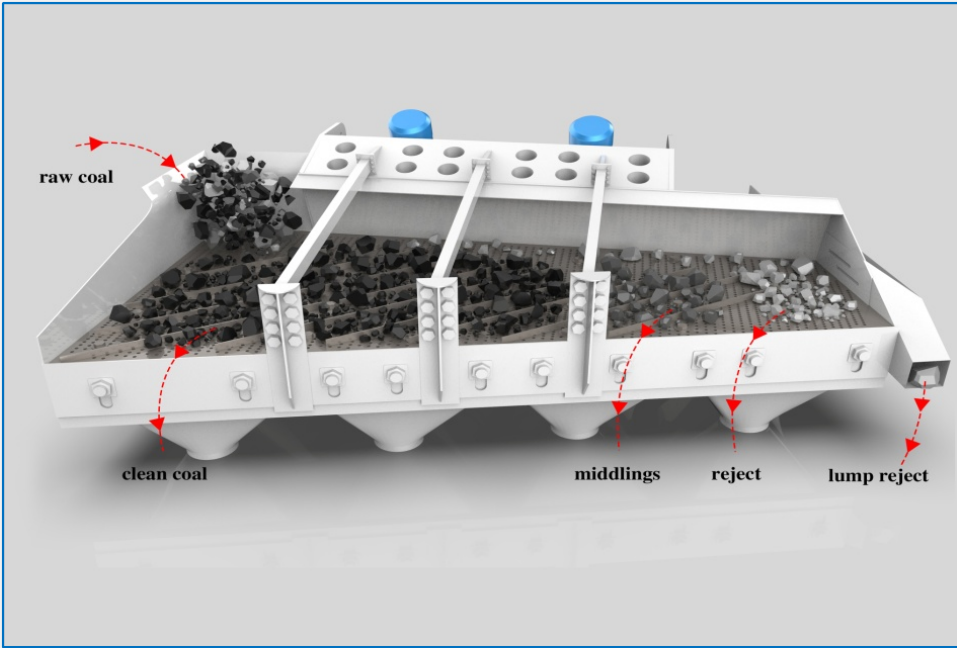
For sticky wet coal separation



# Dry Coal Separation Technology of TSM



## ZM High-efficiency Mineral Separator









# ZM Mineral Separator



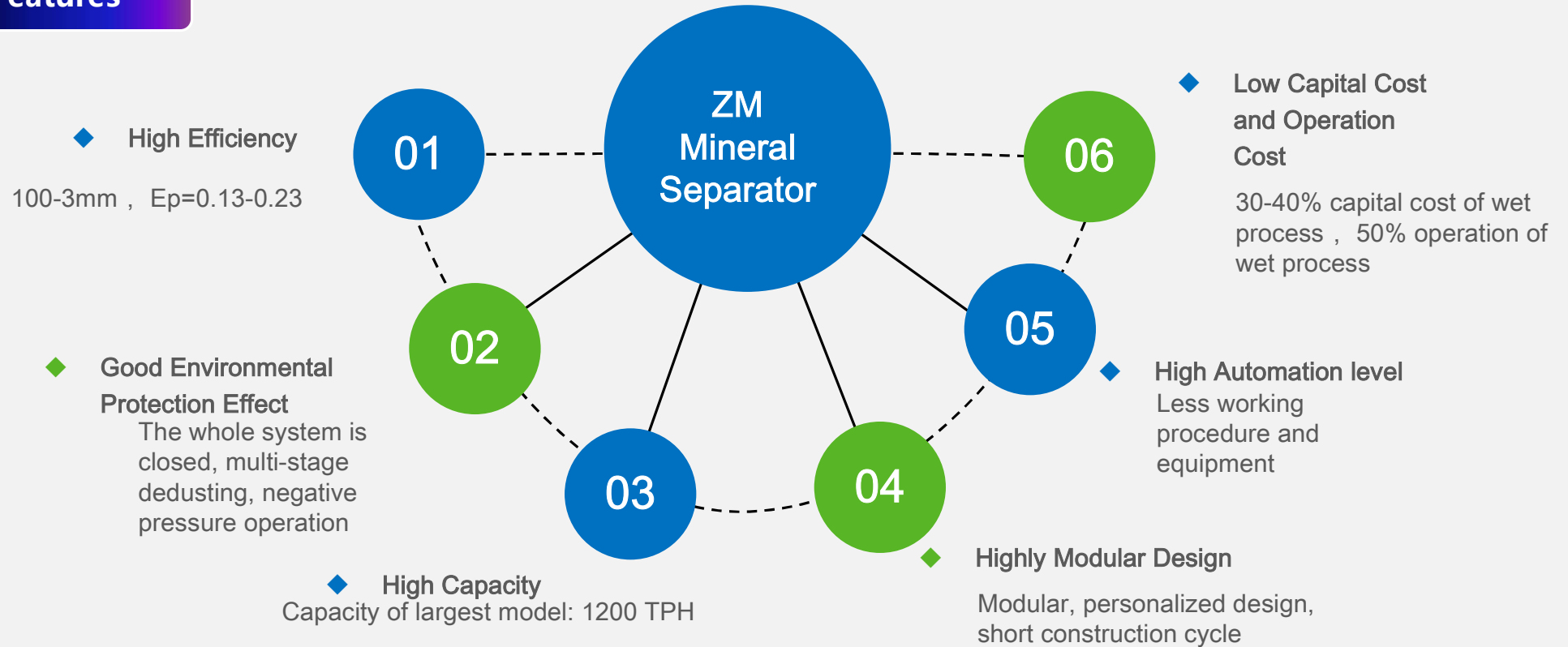
Model	Capacity (TPH)	Feed Size (mm)	Installed Power (kw)	Footprint of main system (m <sup>2</sup> )
ZM35	30-35	50-0	130	50
ZM70	60-70	60-0	245	90
ZM100	90-100	60-0	356	130
ZM150	125-150	80-0	425	150
ZM200	175-200	100-0	690	300
ZM300	250-300	100-0	825	300
ZM400	350-400	100-0	1200	500
ZM600	550-600	100-0	1400	1000
ZM1200	1100-1200	100-0	2800	1500



# ZM Mineral Separator



## Features

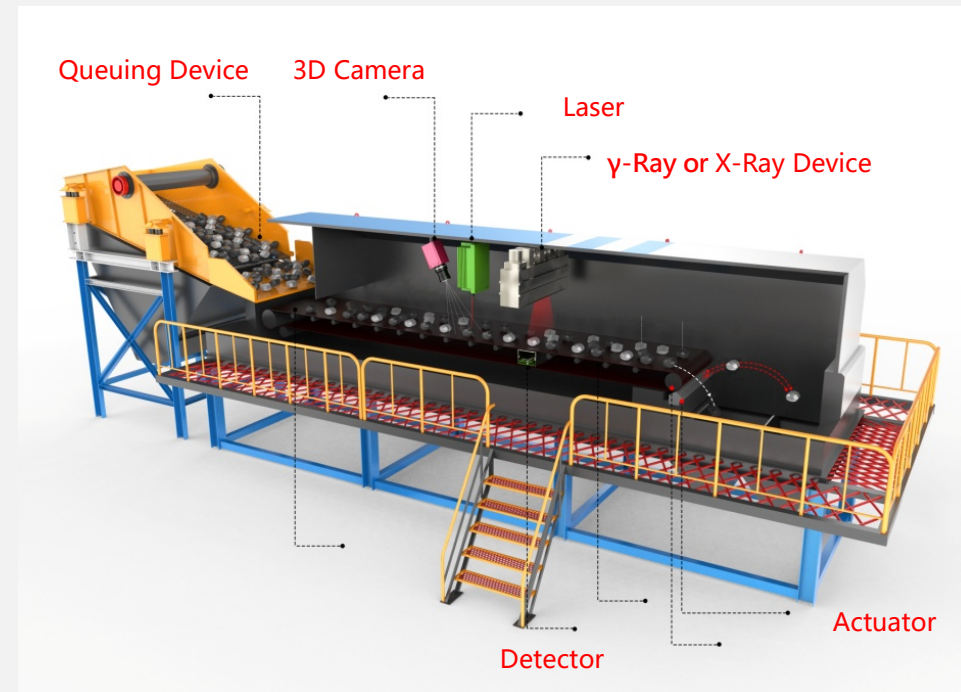
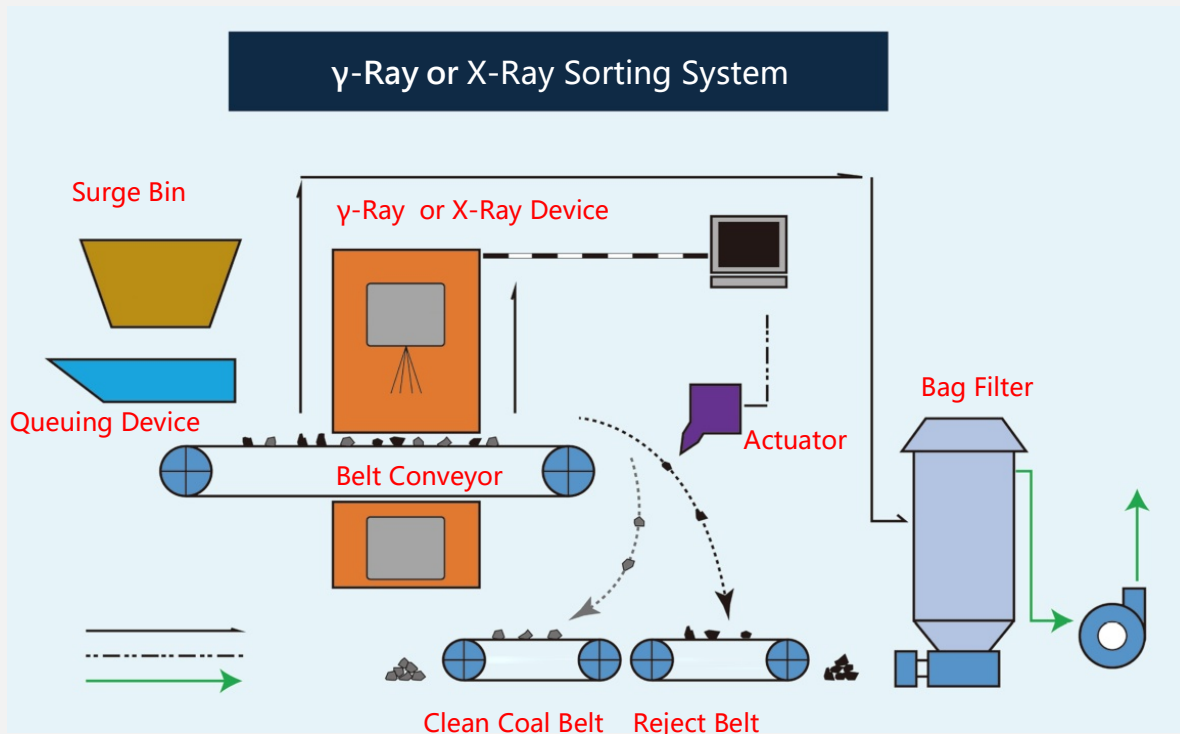




# Dry Coal Separation Technology of TSM



## 2、 $\gamma$ -Ray or X-Ray Sorter

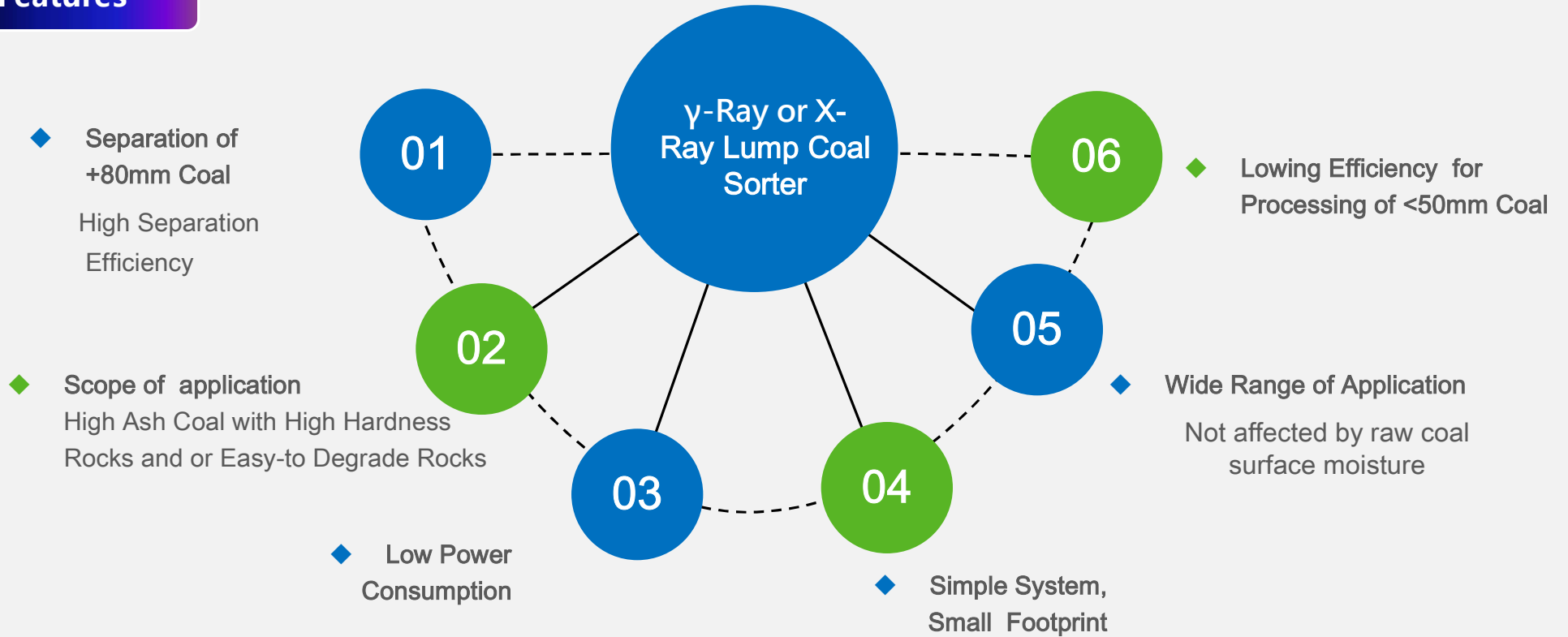




# Dry Coal Separation Technology of TSM



## Features





# Comparison of Different Process Equipment



Equipment	Efficient Separation Size Range, mm							
	300-200	200-100	100-50	50-13	13-6	6-3	3-0.5	0.5-.15
Heavy Medium Vessel	Efficient							
Heavy Medium Cyclone			Efficient					
Movable Sieve Jig	Efficient							
Mixed Coal Dry Separator			Efficient					
Lump Coal Dry Separator			Efficient					
Fine Coal Dry Separator				Efficient				
Y-Ray or X-Ray Lump Coal Sorter	Efficient							



# Comparison of Different Process Equipment



Equipment Name	Cutting Density Range, g/cm <sup>3</sup>									
	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	
Heavy Medium Vessel	Yellow bar									
Heavy Medium Cyclone	Yellow bar									
Sieve-Moving Jig					Pink bar					
ZM Separator (Mixed coal)				Green bar						
ZM Lump Coal Separator				Green bar						
ZM Fine Coal Separator				Green bar						
Y-Ray or X-Ray Sorter				Green bar						



# Comparison of Different Process Equipment



Equipment	Escart Probable, Ep, Kg/L										
	0.01	0.03	0.05	0.07	0.10	0.12	0.15	0.20	0.22	0.25	0.30
Heavy Medium Vessel		0.01	0.03	0.05							
Heavy Medium Cyclone		0.01	0.03	0.05	0.07	0.10					
Movable Sieve Jig			0.03	0.05	0.07	0.10	0.12	0.15			
Mixed Coal Dry Separator						0.10	0.12	0.15	0.20		
Lump Coal Dry Separator				0.05	0.07	0.10	0.12				
Fine Coal Dry Separator								0.15	0.20	0.25	0.30
Y-Ray or X-Ray Lump Coal Sorter			0.03	0.05	0.07	0.10	0.12	0.15			



# 02

## PART



### Full Size Range Dry Coal Separation at Dafeng Coal Mine

◆ Raw Coal Washability

◆ Separation Process Flowsheet

◆ Separation Results

Washability Analysis



## Washability Analysis

Table 1 Raw coal size analysis

Size, mm	Individual yield, %	Plant Yield, %
+60(coal)	20.44	5.13
+60(rock)	79.56	19.96
-60		74.91
Total		100

Table 2 Size distribution of -60mm raw coal after crushing

Size mm	Wt %	Individual			Cumulative				
		Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg	Size mm	Wt %	Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg
+25	29.80	3.69	66.88	8.85	+25	29.80	3.69	66.88	8.85
25-13	21.02	3.78	69.33	7.99	+13	50.82	3.73	67.89	8.49
13-6	18.83	3.94	61.58	10.75	+6	69.65	3.78	66.19	9.10
6-3	7.68	3.92	59.93	11.32	+3	77.33	3.80	65.57	9.32
-3	22.67	6.70	58.58	11.32	Total	100.00	4.46	63.98	9.77
Total	100.00	4.46	63.98	9.77					

## Washability Analysis

Table 3 Float-sink testing of +25mm raw coal

S.G g/cm <sup>3</sup>	Wt %	Individual			Cumulative				
		Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg	S.G g/cm <sup>3</sup>	Wt %	Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg
-1.4	11.49	5.1	4.66	32.15	-1.4	11.49	5.10	4.66	32.15
1.4-1.6	10.34	5.1	7.58	30.68	-1.6	21.83	5.10	6.04	31.45
1.6-1.8	4.42	4.8	15.54	26.84	-1.8	26.25	5.05	7.64	30.68
+1.8	73.75	3.2	87.96	1.08	Total	100	3.69	66.88	8.85
Total	100	3.69	66.88	8.85					

## Washability Analysis

Table 4 Float-sink testing of 25-13mm raw coal

S.G g/cm <sup>3</sup>	Wt %	Individual			Cumulative				
		Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg	Size mm	Wt %	Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg
-1.4	9.15	5.3	5.07	31.89	-1.4	9.15	5.30	5.07	31.89
1.4-1.6	11.62	4.9	7.94	30.62	-1.6	20.77	5.08	6.68	31.18
1.6-1.8	2.47	4.5	20.25	25.46	-1.8	23.24	5.01	8.12	30.57
+1.8	76.76	3.4	87.86	1.15	Total	100	3.78	69.33	7.99
Total	100	3.78	69.33	7.99					

## Washability Analysis

Table 5 Float-sink testing of 13-6mm raw coal

S.G g/cm <sup>3</sup>	Wt %	Individual			Cumulative				
		Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg	S.G g/cm <sup>3</sup>	Wt %	Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg
-1.4	9.66	5.4	3.93	32.04	-1.4	9.66	5.40	3.93	32.04
1.4-1.6	17.24	5	7.37	30.36	-1.6	26.90	5.14	6.13	30.96
1.6-1.8	5.52	4.7	18.83	25.93	-1.8	32.42	5.07	8.30	30.11
+1.8	67.58	3.4	87.14	1.46	Total	100	3.94	61.58	10.75
Total	100	3.94	61.58	10.75					

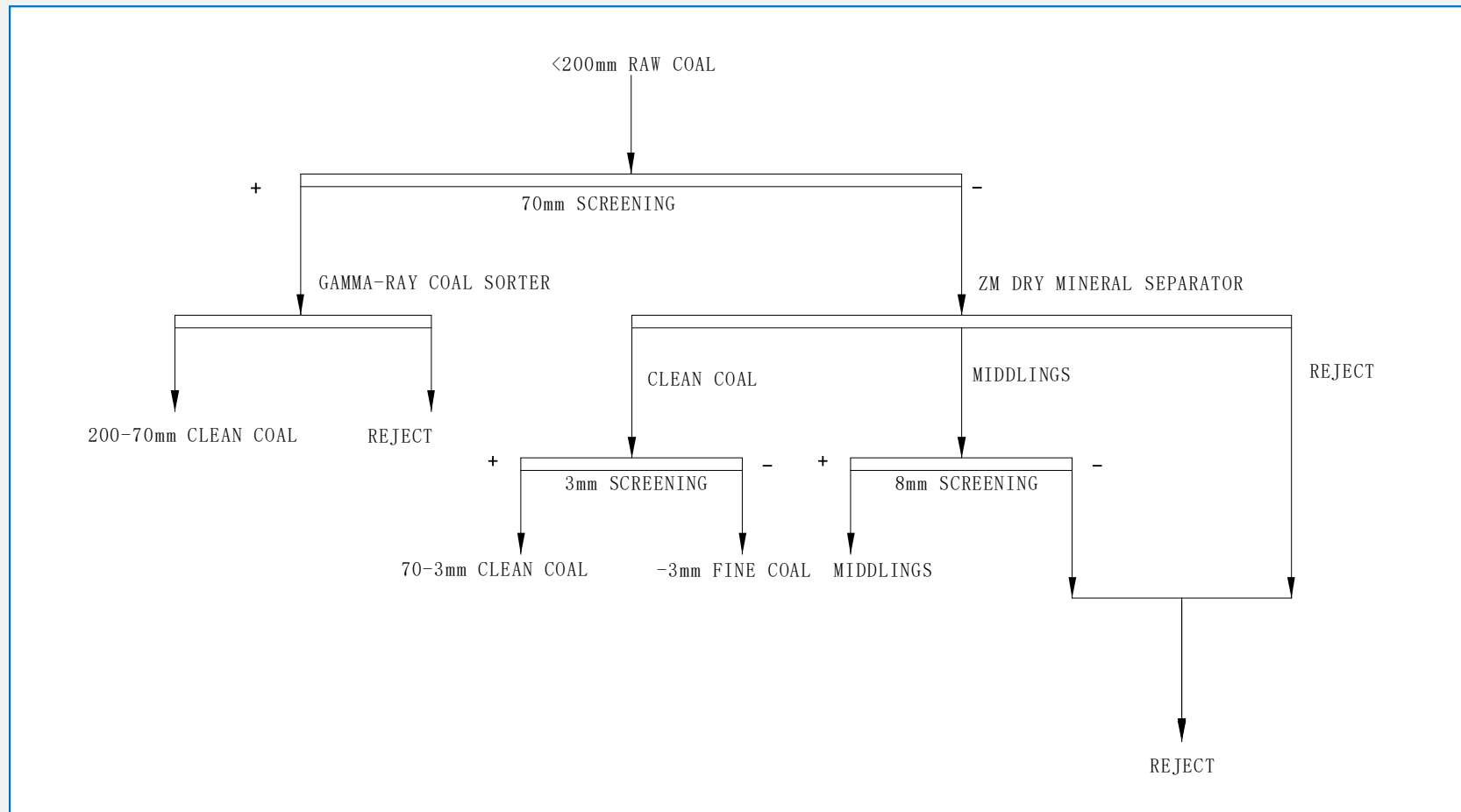
## Washability Analysis

Table 6 Float-sink testing of 6-3mm raw coal

S.G g/cm <sup>3</sup>	Wt %	Individual			Cumulative				
		Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg	S.G g/cm <sup>3</sup>	Wt %	Moisture Mt%	Ash Ad%	LHV Qnet.ar , MJ/kg
-1.4	8.99	5.2	3.37	32.18	-1.4	8.99	5.20	3.37	32.18
1.4-1.6	16.81	5.0	6.74	30.14	-1.6	25.80	5.07	5.57	30.85
1.6-1.8	7.15	4.6	15.16	27.10	-1.8	32.95	4.97	7.65	30.04
+1.8	67.05	3.4	85.63	2.12	Total	100	3.92	59.93	11.32
Total	100	3.92	59.93	11.32					



## One-Stage Separation

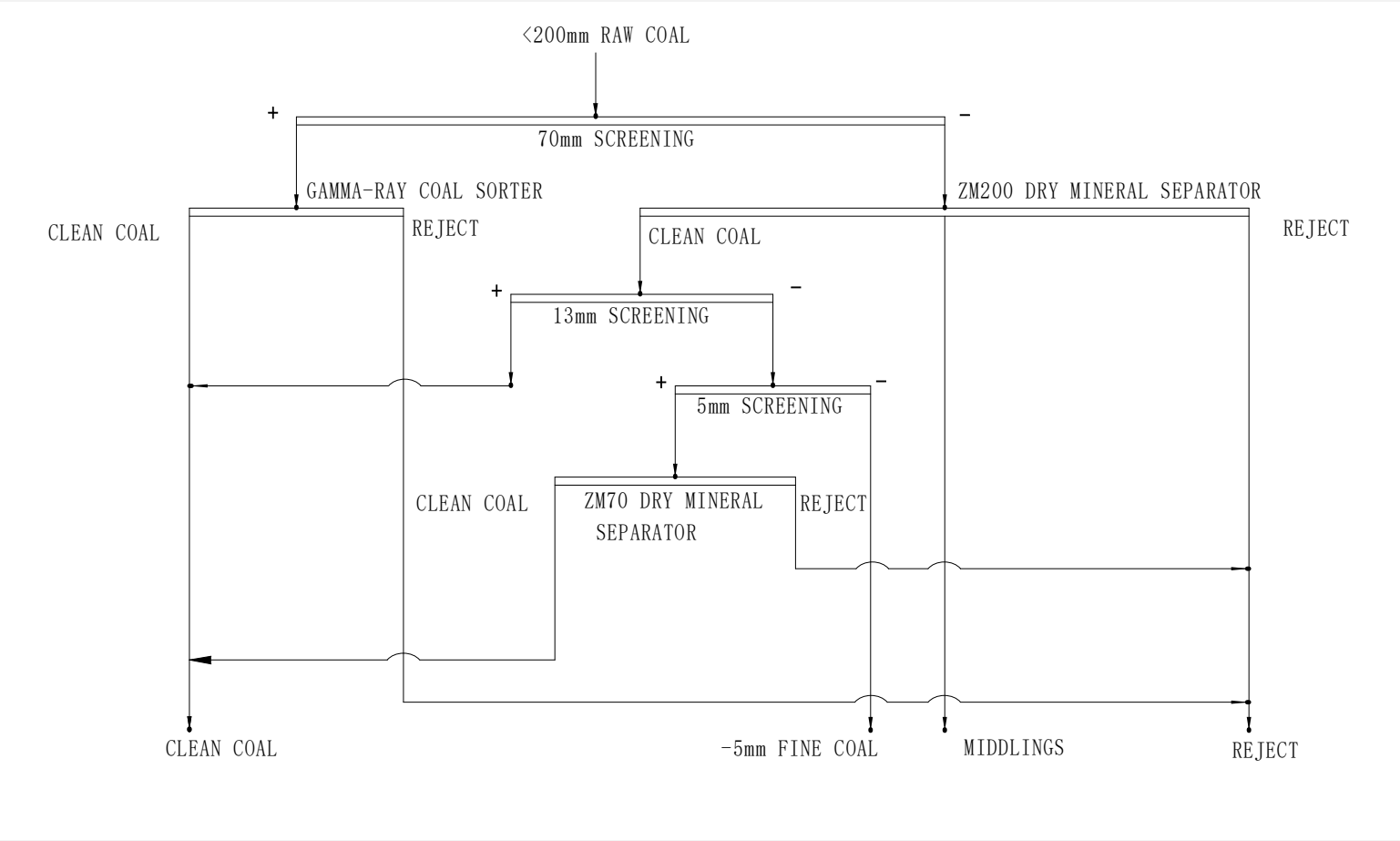




## Separation Results

Product	Size, mm	Wt , %	Ash , %
Clean coal	>70	8.89	17.36
	70-13	6.99	13.55
	13-3	10.95	41.77
	<3	2.21	48.29
	Total clean coal	29.04	28.00
Coal powder	<3	8.39	48.29
Middlings		10.54	50.04
Reject of ZM separator	70-0	32.92	65.08
Reject of Gamma-ray sorter	>70	19.11	78.99
Raw coal	Total	100.00	53.98

## Two-Stage Separation



## Separation Results

Product	Size , mm	Wt%	Ash%
Clean coal	>70	12.47	18.14
	70-5	14.12	24.24
	5-0	8.35	49.08
	Subtotal	34.94	28.00
Removed coal powder	5-0	7.53	49.08
Middlings		18.00	52.21
Reject of ZM separator		29.53	75.68
Reject of gamma ray sorter		10.00	79.71
Total		100.00	53.20

# Dafeng Coal Mine of Shenhua Group Company



## Plant Built





# Full Size Range Operation in Open Pit Mine



## Case 1: Huolinhe Open Pit Mine



300-0mm Lignite Dry Separation (2Mtpa Plant)





## Full Size Range Operation in Open Pit Mine



### Case 2: Coal Star Open Pit Coal Mine



80-0mm Dry Separation (3Mtpa Plant)

# 03

## PART



### Feasibility of Using Dry Separation Technology In India

- ◆ Adani Raw Coal Separation
- ◆ Pilot Scale Testing



### **How Indian coal industry can speed up setting up of required washery capacity ?**

- Heavy dependence on coal for long-term energy security in India.
- Indian coals contain high ash content with very difficult washability;
- Indian raw coal cause combustion related problems and environmental pollution;
- Pace of setting up of new wet process coal washeries in India has been very slow;
- Dry separation technology shall be explored for adoption.



## Raw Coal Washability

Screen analysis of -50mm raw coal

Size(mm)	Wt, %	Ash, %
50-25	54.2	49.9
25-13	19.5	47.0
13-6	10.7	43.7
6-3	5.8	34.1
3-0.5	6.8	25.7
-0.5	3.0	25.1
Total	100.0	45.4

The Combined Washability data developed from F&S test results of 0.5-50mm

Sp.Gr			Cumulative Float		Cumulative Sink	
	Wt, %	Ash, %	Wt, %	Ash,%	Wt, %	Ash,%
<1.40	7.80	14.70	7.80	14.70	100.0	40.8
1.40-1.50	16.60	25.10	24.40	21.78	83.6	46.3
1.50-1.60	14.90	36.30	39.30	27.28	62.8	52.5
1.60-1.70	13.70	45.30	53.00	31.94	43.7	59.4
1.70-1.80	6.50	51.70	59.50	34.10	29.9	65.3
1.80-1.90	12.60	56.50	72.10	38.01	21.5	70.7
>1.90	27.90	70.40	100.00	47.05	14.9	75.4
Total	100.00	47.05				

## Separation Simulation

Separation Result Simulation			
Product		Wt %	Ash%
Clean coal	Clean Coal (50-3mm)	16.55	26.79
	Middlings (50-3mm)	35.39	41.38
	Fine coal (3-0mm)	9.80	25.53
	Subtotal clean coal	61.74	34.96
Reject	Reject (50-3mm)	38.26	62.19
Total Raw Coal		100.00	45.38

## Pilot Scale Testing

### ADANI COAL DRY SEPARATION PILOT TESTING RESULTS

PRODUCT	FRACTIONAL				CUMULATIVE			
	Wt%	Ash%	HHV, kcal/kg	LHV, kcal/kg	Wt%	Ash%	HHV, kcal/kg	LHV, kcal/kg
CLEAN COAL 1	45.74	32.11	5072	4374	45.74	32.11	5072	4374
CLEAN COAL 2	14.69	43.37	4169	3648	60.43	34.85	4852	4197
MIDLINGS	5.99	54.44	3056	2708	66.42	36.61	4690	4063
REJECT	33.58	79.16	904	778	100.00	50.90	3419	2960
	100.00	50.90	3419	2960				

Clean coal yield: 60.43% at LHV of 4197 Kcal/kg, 1237 kcal/kg increase;  
or 66.42% at LHV of 4063 kcal/kg; 1103 kcal/kg increase;



## Dry Separation Simulation

### DRY SEPARATION PRODUCT BALANCE

Product	Wt, %	Ash, %
Clean coal	42.20	34.71
Reject	19.47	69.12
Bypass-10mm from classification	38.32	30.51
Total clean coal + bypassed -10mm raw coal	80.53	32.71
Raw coal	100.00	39.80



**Konar Dry Coal Washery**

**DRY SEPARATION PRODUCT BALANCE (Karo Seam VI&VII combined)**

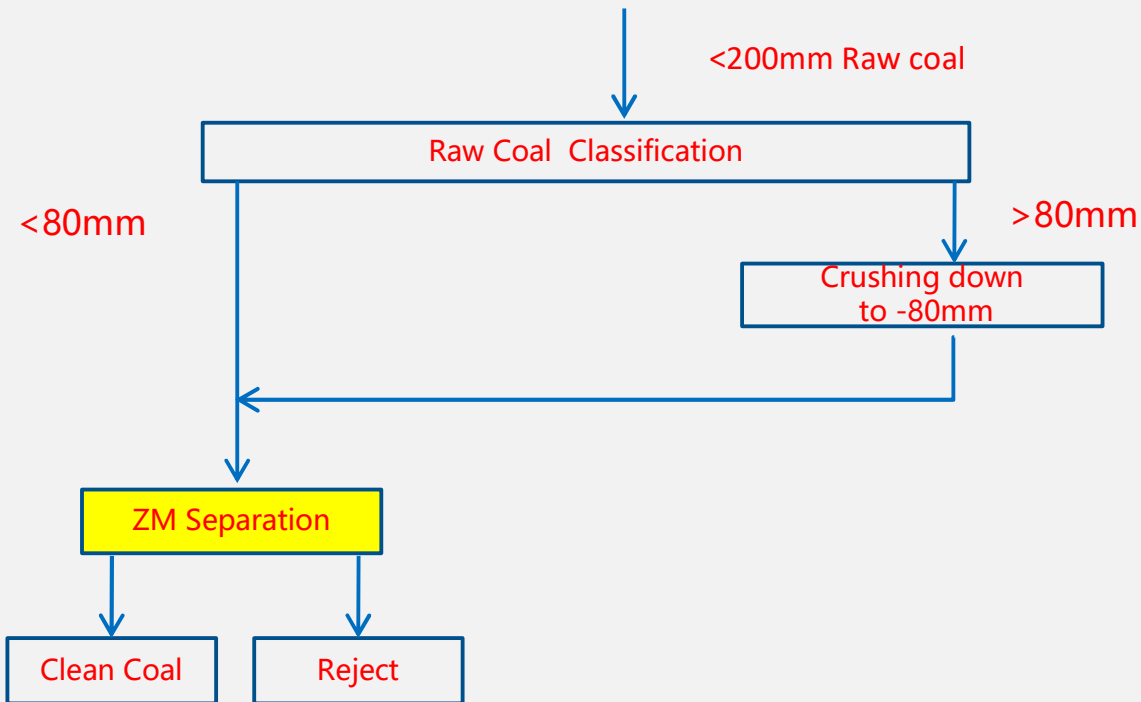
Product	Wt, %	Ash, %
Clean coal	49.86	34.14
Reject	50.14	61.60
Raw coal	100.00	47.91



# Recommended Dry Coal Separation Flowsheet in India



## 1、 Mixed Coal Deshaling

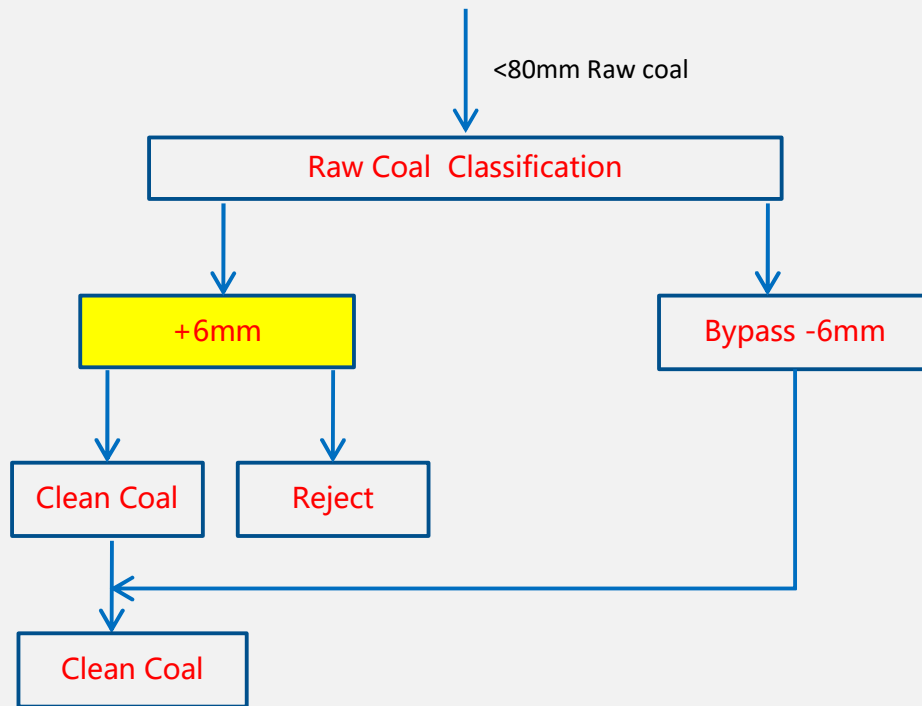




# Recommended Dry Coal Separation Flowsheet in India



## 2、 Lump coal deshaling



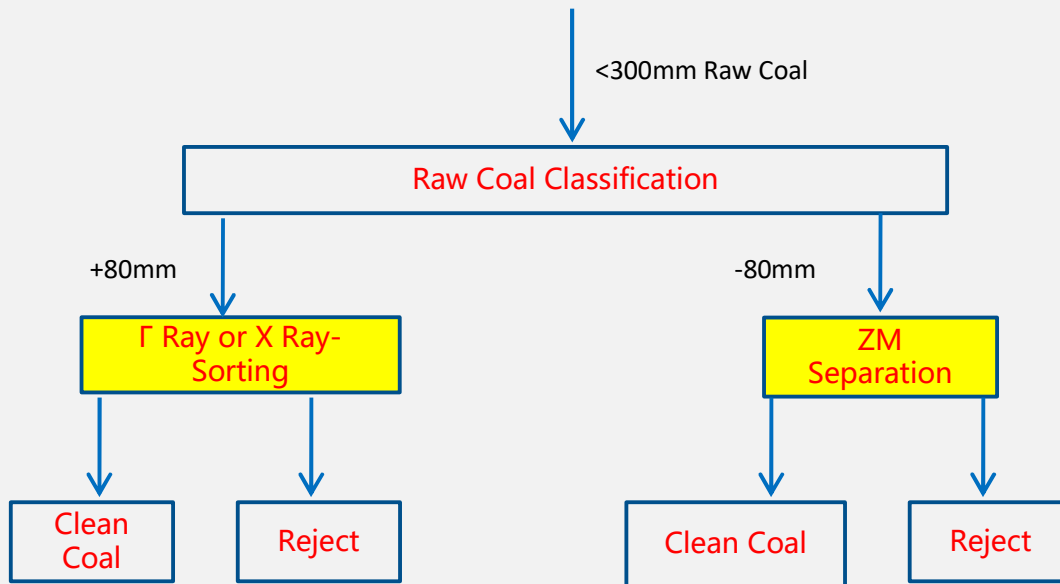
- ◆ When -6mm Coal Ash is low or Surface Moisture is too high
- ◆ Pre-deshaling of coking coal;



# Recommended Dry Coal Separation Flowsheet in India



## 3、 Full size range separation



- Save reject crushing cost;
- Strengths of each equipment get the full play;
- No high moisture coal slime cake produced;
- Good for use in new large size coal washery;



# 04

## PART

### CONCLUSIONS

- ◆ Dry Separation Technology Becomes Well Developed after Years of R&D by TSM;
- ◆ Big Progress in Serialization and Scaling-up of Dry Separation Equipment;
- ◆ Great Improvement in Separation Efficiency and Environmental Protection Performance of Dry Separation;
- ◆ Full Size Range Dry Separation is Realized by Combination Application of Different Dry Separators;
- ◆ Dry Separation Technology and Equipment Has a Broad Application Prospect in India



# THANKS

**Tangshan Shenzhou Manufacturing Co., Ltd**



Address: No. 6, Sanjiaodi Tangshan, China

Tel: 15232633118

[www.tsshenzhou.com](http://www.tsshenzhou.com)

Email: [xyk@tsshenzhou.com](mailto:xyk@tsshenzhou.com)