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by

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SYNOPSIS

The Department of Energy, Mines and Resources (EMR) has recently completed construction of a 10-tph CANMET-Process coal washing plant at the Western Research Laboratory (WRL) at Clover Bar near Edmonton.

The facility serves in part to support the department's own R & D programs in fine-coal beneficiation and washery water treatment; it is also available to the Canadian coal industry to assist in problem-solving programs for existing washeries and for providing data in relation to resource evaluation and design of new plants.

This paper describes the design and operational features of the facility and briefly touches upon related programs of research being carried out at WRL.

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INTRODUCTION

In the main, proper design of coal washeries follows from three basic preliminary steps: laboratory analysis and testing of representative samples of the raw coal, prediction of washing results by calculation, and finally, confirmation of predictions by pilot plant testing.

Laboratory work provides size distribution and washability data for ash and sulphur plus other pertinent information such as free swelling index, grindability, fixed carbon, etc. Bench work may furthermore be performed for feasibility and behavioural determinations; parameters such as reagent dosages, pulp conditioning and choice of reagents can be studied on this scale.

Calculations for prediction of expected results (performance evaluations) are conducted to obtain first estimates of the quantity and quality of coal and reject that can be produced at various specific gravity (sp gr) cutpoints and efficiencies for a cleaning unit or system. Theoretical yield and ash and/or sulphur contents at different specific gravities and information on near-gravity material derived from the washability curves are necessary for estimation of the theoretical cutpoint. Calculation of performance evaluation is based on the well-known procedure of applying partition numbers from error curves, which represent the performance of a separator (or combination of separators), to the elementary washability data of the coal. The choice of probable errors and cutpoints for the calculation is made by reference to previous experience with washing similar coals or similar size fractions. In some cases, major discrepancies exist between predicted and actual results. This may be attributed to significant changes in washability characteristics resulting from degradation of the feed coal during handling and treatment, the presence of flat particles in the feed or other factors such as porosity, etc. Pilot plant testing is therefore essential for reliable prediction of industrial-scale performance.

The pilot plant described in this report brings together tangible results of various R & D efforts of the Western Research Laboratory (WRL)

carried out within the CANMET energy program relating to the processing of fuels. The program objectives in this framework include developing improved methods of separating mineral matter from coal and methods of water treatment for water recycling and/or for pollution control.

A prime objective of the WRL pilot plant is to provide for thorough investigation of fine-coal preparation problems on a scale and in a manner consistent with the needs of commercial operations and, as such, to support a variety of investigative, R & D and advisory programs pertaining to fine-coal preparation and pollution control.

Programs originate within the department or may be undertaken at the specific request of coal producers. In the latter instance, the services may be provided on a full or shared cost-recovery basis. Recent cost-recovery projects have included washing tests on a wide range of metallurgical and thermal coals and laboratory studies supplemented by pilot plant work on flocculation, flotation, etc., to establish control parameters and optimize operation of existing water recovery and slimes beneficiation systems.

Characterization of the CANMET Process, formerly the EMR Process (1), is achieved through the washing tests which also provide information on the behaviour of the coals themselves during processing. Information on size degradation, breakdown of shales, etc., provides the project sponsor with first order design data and adds to the department's inventory on the processing and utilization potential of the Canadian coal resource.

The description that follows will serve to familiarize the coal producer with the CANMET Process and its pilot plant, and with other R & D facilities of the Dept. of Energy, Mines and Resources that are available in Edmonton, Alberta. These facilities are being utilized to help ensure maximum benefits to the Canadian people via the producer through WRL's continuing programs aimed at contributing to an improved technology of fine-coal preparation.

CANMET PROCESS PILOT PLANT

Operations in the CANMET coal cleaning process comprise crushing the raw coal, cleaning the crushed coal in bulk with cyclones using water as the medium, drying the predewatered clean coal and the fine reject by centrifugal force, agglomerating and drying the coal slimes by using a small amount of oil as a dewatering aid, and finally, treating the process water by means of flocculation followed by clarification to recover clean water for recycling while maintaining acceptable levels of discharge of pollutants to the environment. A total of six WRL patents are incorporated into the process. As indicated on the schematic flowheet in Figure 1, the 10-tph pilot plant can be divided into the following four sections which will be described in detail:

1. Feed Preparation
2. Cleaning
3. Drying
4. Water Recovery

A more detailed flowsheet is given in Figure 2 and an equipment list in Table 1.

1. Feed Preparation Section

The raw coal (2-in. x 0) is fed by means of a scraper conveyor followed by a belt conveyor to a hammermill which is equipped with a 1-in. round-screen to produce 3/8 to 1/4-in. x 0 plant feed. The crushed coal is stored in a 10-ton bin ahead of the cleaning section.

It has been found essential to dry the raw coal when its surface moisture exceeds 7-9% to avoid plugging of the hammermill and resulting reduction in capacity with considerable production of fines.

2. Cleaning Section

Two basic circuits are used for cleaning of the coarse coal (1/4-in. x 0) and slimes (28-mesh x 0) respectively. The automedium (AM) water-only cyclone (synonymous with compound water cyclone) is the main process used because of its simplicity of operation and its capability for

washing coal in bulk without prior screening. Maximum flexibility is obtained, on the other hand, by providing for back-up or optional treatment using a heavy medium (HM) cyclone system and/or froth flotation.

Coarse Coal Cleaning

The 1/4-in. x 0 raw coal is fed to two primary 8-in.-diam AM cyclones operating in parallel. The overflow products are deslimed in two 8-in.-diam classifier cyclones (Cl.C) to produce an underflow (clean coal) product containing 30-40% solids. This product is dewatered on a 28-mesh sieve bend (SB). The sieve bend oversize goes to the drying section; the undersize is fed to the slimes cleaning circuit. A portion of the Cl.C overflow is bled to slimes cleaning with the remaining portion being recirculated to the main sump (dual-mix tank I). The underproduct of the primary cyclones is recleaned in a single second-stage 8-in.-diam AM cyclone to obtain finished reject and a middlings. The reject is deslimed on a 28-mesh vibrating screen and the middlings are either recirculated to the main sump (dual-mix tank I) or deslimed on a 28-mesh sieve bend and a vibrating screen. The coarse (plus 28-mesh) middlings may be loaded directly in drums or undergo other treatment if necessary; the middlings screen undersize proceeds to the slimes cleaning circuit.

Slimes Cleaning

The feed to this section originated from the slimes sump, i.e., dual-mix tank II (DMT II), where a number of streams including the clean coal sieve bend undersize, the middlings sieve bend undersize, a portion of the 8-in. classifier cyclones overflow and others are collected. Recovery of low-ash coal from these slimes is achieved in a two-stage 8-in. diameter AM cyclone circuit where the primary cyclone is fitted with a 4-in. cylindrical spacer to lengthen the feed chamber. This simple modification gives lower cutpoints and higher efficiencies for washing minus 28-mesh coal than can be obtained in AM cyclones with standard chamber length (2). The overflow product of the elongated cyclone is dewatered in a classifier cyclone; the classifier underflow is conditioned with emulsified light furnace oil to effect agglomeration of the coal and thereby assist its dewatering in a pusher centrifuge. A portion of the classifier overflow

is treated in the water recovery section and the remainder is recirculated to the slimes sump (DMT II). The primary reject from the elongated cyclone is cleaned in the second-stage AM cyclone, producing finished fine reject which is dewatered in a centrifuge and a middlings that recirculates to the primary cyclone via DMT II.

3. Drying Section

The dewatered coarse coal and the oil-conditioned minus 28-mesh fine coal are dried together in a pusher centrifuge and loaded directly into drums. Total moisture content of the clean product is usually 5-7% including 1% by weight of oil added to the fine product. Undersize of the coarse reject dewatering screen is sent directly to the water recovery section.

4. Water Recovery Section

Effluent from slimes cleaning and reject dewatering screen undersize are fed into a flocculator apparatus at 10 psi where mixing with flocculant solution injected at 50-80 psi inlet pressure is effected in one or two blenders (4). The flocculated effluent passes through two 8-in.-diam pulp dividers to two 4-in.-diam classifier cyclones. The pulp divider overflow combined with the classifier cyclone overflow proceeds to a bottom-feed thickener. Thickener sludge and classifier cyclone underproduct are dewatered with the fine reject from slimes cleaning in a solid-bowl centrifuge before disposal. Clarified water is sent to a reservoir prior to recycling to the plant.

ALTERNATIVE WASHING PROCESSES

As indicated earlier and as shown in Figure 1, a number of alternatives are available within the pilot plant to provide flexibility for dealing with coals which may differ widely in washing characteristics. The use of conventional heavy-medium or froth flotation systems may be dictated by these characteristics in order to obtain optimum results.

1. Coarse Coal or Bulk Cleaning

Four alternative circuits are available. Separation into two products (clean coal and reject) may be achieved in the pilot plant by simple recirculation of middlings (overflow, secondary cyclone) to the primary feed tank.

For a 3-product separation, the middlings may be deslimed and dewatered without further treatment provided it is of marketable thermal quality. The deslimed plus 28-mesh middlings may also be recleaned in a back-up 3-tph heavy medium cyclone (8-in. diam) circuit to produce clean coal and reject which can then be combined with their respective products from the AM cyclones. Alternatively, high-ash deslimed middlings can be crushed in a 5-tph Gundlach Cage-Paktor for liberation of inter-grown coal which is then recovered either in the AM-8L slimes cleaning section or by flotation.

2. Slimes Cleaning

In bulk cleaning using standard length AM cyclones as used in the coarse cleaning section, the minus 28-mesh sizes are usually separated at high cutpoints (dp $\geq$ 1.8 sp gr). In the 2-stage elongated AM cyclone circuit, these fines can be rewashed at lower specific gravities (dp = 1.4-1.8) with froth flotation employed in a back-up role to recover minus 150-mesh coal from the effluent. The fine clean coal produced in both these processes is oil-conditioned to assist dewatering and drying in the centrifuge. An additional benefit of oil-conditioning is that stray high-ash particles which are not wetted by the oil will also be removed in the effluent of the centrifuge.

A combination elongated AM cyclone-froth flotation system is advantageous from the point of view that oversize (plus 28-mesh) and oxidized coals can be washed in the cyclones and flotation used on the cyclone effluent for recovery of the minus 150-mesh coal to improve overall yield and prevent overloading of the water recovery circuit.

WRL R & D PROGRAM

As stated earlier, the CANMET Process is the direct result of various WRL research efforts whose objective has been development of efficient, cheap, simple and rugged systems for fine-coal cleaning. In its supportive role for on-going R & D programs on fine-coal preparation and pollution control, the pilot plant gives the capability of testing concepts emanating from laboratory scientific and engineering studies.

Coal preparation projects now in progress at WRL include some of general applicability relating to novel and improved processes, and some of more specific application relating to particular characteristics of given coals. Examples in the former category are studies on development of an ash-monitoring system as a first step towards washery automation, continued testing of the elongated AM cyclone for washing of minus 28-mesh fines, studying the mechanism of bed formation in the AM cyclone, column flotation, etc. Projects of more specific application included in the latter category involve process development and design for treatment of high-sulphur coals, low-rank coals containing clay and/or alkali, pond and dump materials, and fundamental studies on surface and other characteristics of high- and low-rank coals as these relate to their processing.

Pollution control, which deals with fine particles on a more general basis, involves fundamental research into surface properties of fine particles, chemical and physical properties of solid-liquid systems including the solids themselves, the suspending liquid and the totality of the two, and chemical and physical characterization of commercial flocculants and their interactions with specific system properties. This information is aimed at establishing a scientific basis for sound engineering of washery pollution control and water recovery systems, taking into account the great number of flocculants from which the best choice must be made, possible variations in quantity and quality of slimes and other aspects of washery operation. In this respect, a survey of raw water at the mines has been initiated to determine seasonal variations in quality which may affect both flocculation and flotation processing. A mobile

water-recovery unit is now in the first stages of being fitted and is scheduled to be ready for field tests in the summer of 1978.

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TABLE 1: CANMET Processing Plant

OPERATION	UNIT NO.	EQUIPMENT	FUNCTION
1. Feed Preparation	(1)	10-tph scraper and belt conveyor	Handling of raw coal (2-in. top size) with reduction to minus 3/8-in. and storage
	(2)	20-tph hammermill	
	(3)	20-tph bucket elevator	
	(4)	10-ton bin	
2. Cleaning			
(a) coarse cleaning-two stage AM-8	(10)	regulated feeder (0 to 10 tph)	Slurrying of minus 3/8-in. bulk feed to 7-10% solids, cleaning in two-stage AM-8 system: two- or three-product separation
	(11,12)	dual-mix tank I (coal slurry sump): 5 x 4-in. pump	
	(13-16)	AM-8: two stage	
heavy-medium cyclone	(17,18)	sieve bend and desliming screen (2 x 4-ft)	Optional desliming and cleaning of middlings product of the two-stage AM-8 system to produce a two-product separation (coal and reject)
	(19)	holding tank	
	(20)	3 x 3-in. pump	
	(21)	8-in. HM Cyclone	
	(22,23)	rinsing screens: 2 x 4-ft and 1 1/2 x 3-ft	
	(24)	drum-type magnetic separator	
(b) slimes cleaning-two stage AM-8L	(25,26)	dual-mix tank II: 3 x 3-in. pump	Cleaning of minus 28-mesh fines from clean coal and middlings products of the coarse cleaning section or cleaning of crushed middlings
	(27-30)	AM-8L: two-stage	
	(31,32)	emulsifying tanks & pump	
	(33)	oil conditioning tank	
	(34)	5-tph Gundlach crusher	
froth flotation	(35)	Cyclo-cell (3)	Optional cleaning of minus 28-mesh fines from clean coal and middlings products of the coarse cleaning secion or back-up to AM-8L
	(36)	reagent feeder	

TABLE 1: CANMET Processing Plant (continued)

	OPERATION	UNIT NO.	EQUIPMENT	FUNCTION
3.	Dewatering	(40)	dewatering screen: 1 1/2 x 4-ft	
		(41)	sieve bend	
		(17,18)	sieve bend and desliming screen	
	Drying	(42)	two-stage pusher centrifuge	Dewatering and drying of finished products
		(43)	solid bowl centrifuge	
		(44)	DeLaval pusher centrifuge	
			2 centrifuge effluent pumps:	
		(45)	2 1/2 x 2 1/2-in.	
		(46)	1 1/4 x 1/4-in.	
4.	Water Recovery	(50,51)	dual-mix tank III: 5 x 4-in. pump	Flocculation, clarification and storage of water for re-use
		(52)	two-stage 8-in. blenders, 4-in. classifier	
		(53,54)	flocculant tank: metering and Moyno pumps	
		(55)	6-ft diam bottom feed thickener	
		(56)	Moyno pump	
		(57)	2 1/2 x 2 1/2-in. pump	
		(58)	water reservoir	

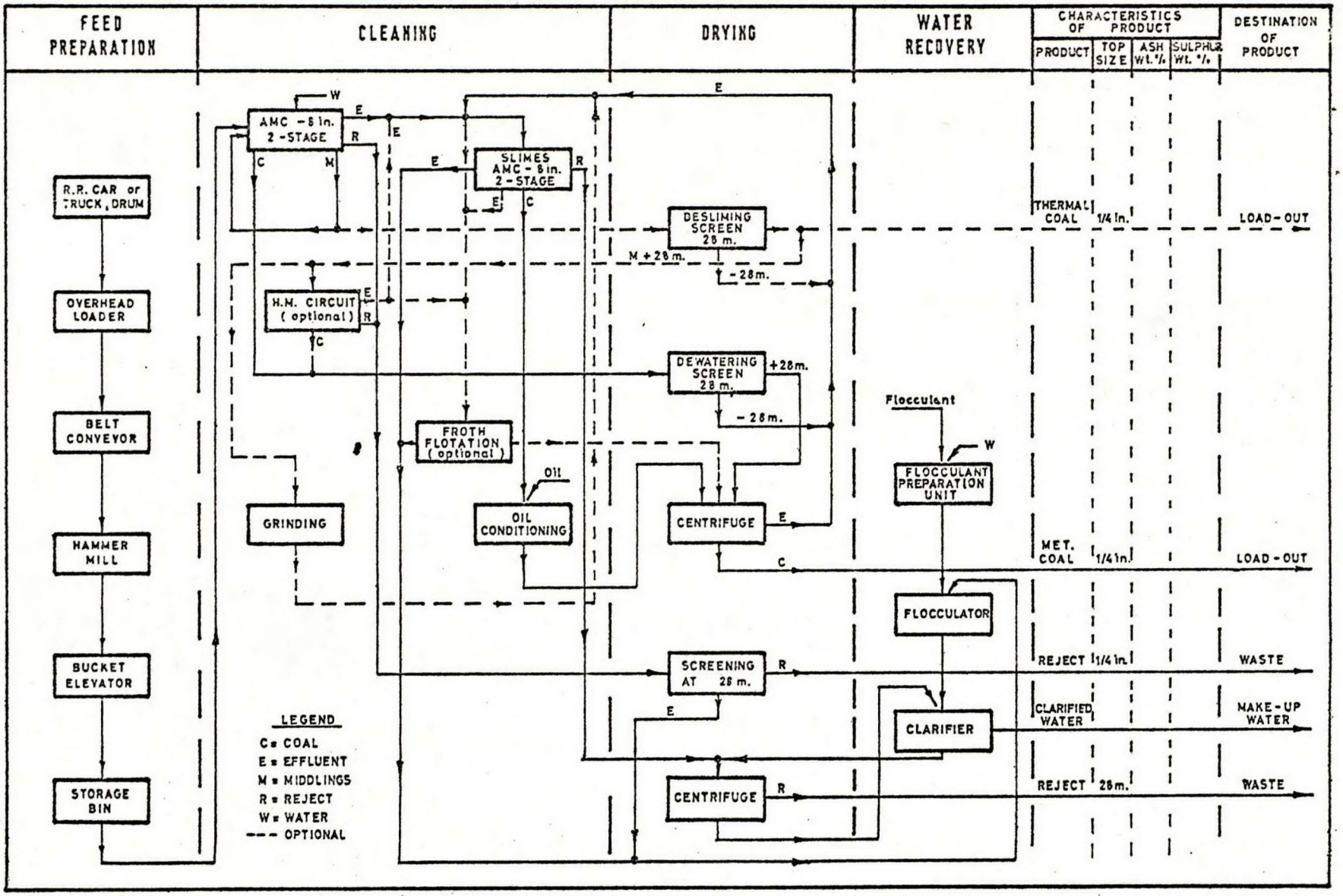

Figure 1: CANMET-Process Flowsheet - 10 STPH Pilot Plant

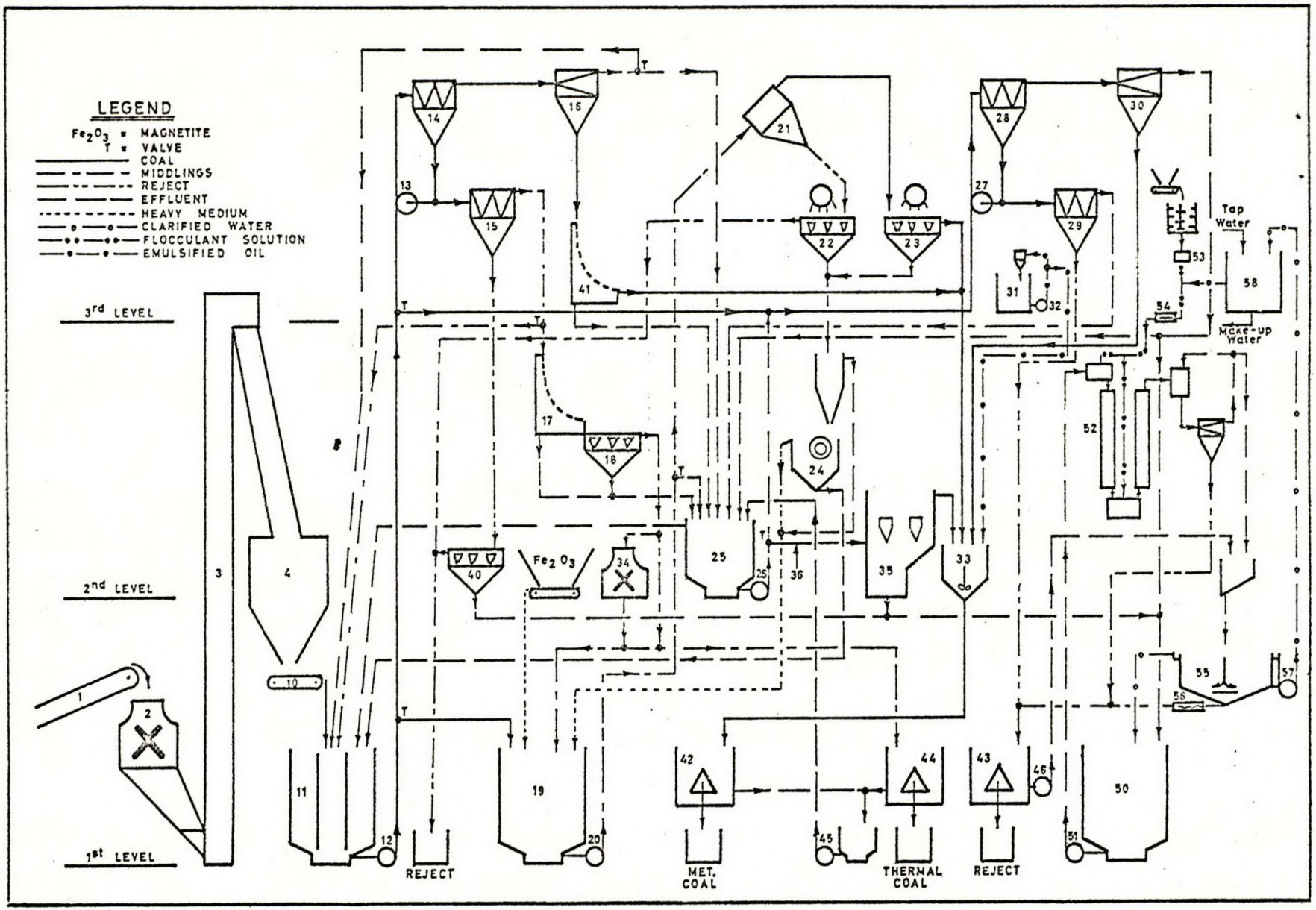

Figure 2 - CANMET-Process Coal Washing Pilot Plant (10 stph capacity)