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NEW APPROACH ON FLOTATION TAILINGS DEWATERING

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Abstract

Tailings pond is a main sources of mine hazards, so it is of utmost important to choose a reasonable discharge and damming methods for tailing pond management. Paste discharge is a brand new technology which has received its fast development recently, and it is especially popular among the mines for merits, such as environment-friendly, water recovery, stable damming and so on. Since 2012 research and development program has started to establish the opportunities for obtaining lead-zinc dewatered tailings from Lucky Invest Dressing Plant, located in the Eastern Rhodopes Mountain of Bulgaria. In a previous work in the frame of the research program have been proved that the new cyclone modifications have a potential in dewatering technology of flotation tailings.

The objective of the new test program was to determine the dewatering capability of Derrick HI-G Dryer Fines Recovery System at optimum operating conditions. Based on the pilot experimental results it was established the possibilities to obtain flotation dewatered tailings with 80.0% solids content. It appears that the Derrick HI-G Dryer Fines Recovery System can be a basic device in new tailings pond elimination technology.

Key words: *Tailings dam, Dewatering, Flotation tailings*

1. Introduction

Tailings management remains one of the most difficult environmental challenges for the mining sector. One of the main sources of land contamination in the mining industry pollution is mine tailings, which generally take the form of fine-grained slurry with a coarser fraction (Jewell 1998).

Tailings are finely ground residues or wastes resulting from ore extraction and processing. The traditional method of disposing of the waste is to use a settling pond and a dam (i.e. a tailings pond). Since the dam retains loose unconsolidated tailings and considerable process liquid, failure of a tailings facility may result in an uncontrolled spill, a dangerous flow-slide and/or the release of poisonous chemicals, leading to a major environmental disaster (Kwak et al. 2005).

The lead-zinc ores are dressed in Lucky Invest Concentrator in Bulgaria. Variable and complex mineral and physical composition these ores are characterized. Due to this fact, a selective flotation circuit was established. Finally, during the flotation cycle lead and zinc concentrates are produced and the final technological waste is precipitated in tailing pond.

Research and development program of Department of Mineral Processing and Recycling, University of Mining and Geology "St. Ivan Rilski", Sofia and Lucky Invest Concentrator has started to establish opportunities to transform the final technological tails into paste tailings and to replace traditionally tailing pond with surface disposal.

In previous studies the final technological tails of Lucky Invest Concentrator are characterized. The technological tailings parameters are determined. The flotation tails is relatively fine product – 85 % below 0.200 mm. The tailings slurry capacity is 270 m^3/h at 18 Wt % solids.

Dewatering tests of the technological waste were performed with laboratory prototype separator Linatex HK40, production of Weir Minerals Company. The pilot tests have been conducted with separator Linatex HK80 and dewatering hydrocyclone Krebs gMAX - model gMAX20-SSC production of FLSmidth Company. Based on the laboratory and pilot tests results mathematical modeling of the process on dewatering flow rate of technological waste was conducted.

The laboratory and pilot tests experimental results show that new cyclone modifications have a potential in dewatering technology of flotation tailings. The solids content of cyclone underflow is increased more than 4 times – from 18 Wt % in technological waste to 75 Wt % into the underflow at 63 μm particle size cutpoint of dewatering process. It appears that dewatering cyclones can be an approach on new tailings pond elimination

technology. This gives information that suitable technology for obtaining flotation dewatered tailings could be expected.

This paper describes the results on an experimental work to determine the dewatering capability of Derrick HI-G Dryer Fines Recovery System for flotation tailings at optimum operating conditions.

2. Experimental

A number of samplings in one month duration in Lucky Invest Concentrator were performed. Sampling was applied to final technological tails. The samples were collected every 30 minutes and combined in a shift every time. The representative sample of 1 000 kg lead-zinc flotation tailings was shipped to Derrick Customer Service Laboratory, Buffalo, USA. The tests are conducted with full-scale Derrick HI-G Dryer Fines Recovery System.

The objective of the test program was to determine the dewatering capability of Derrick HI-G Dryer Fines Recovery System for flotation tailings at optimum operating conditions. The Derrick HI-G Dryer is used in aggregate industry and coke fines recovery.



Fig 1. HI-G Dryer Fines Recovery System

The Derrick Fines Recovery System (Figure 1) consists of a cluster of Φ100 mm unibody 20 hydrocyclones mounted over a HI-G Dryer, high G-force linear motion vibratory screening unit. This combination provides unmatched performance and dependability.

The Derrick Φ100 mm hydrocyclones are mounted on a radial design manifold, which is fed the discharge under a constant pressure of 2.5 - 2.8 bar. This provides each hydrocyclone with the same amount of water, solids and pressure to assure the most efficient separation possible. Each hydrocyclone is outfitted with a ceramic lined thread in the cone tip, as well as an individual shut-off valve. The centrifugal separation extracts the fine particles discharging them out the underflow. The fines are leaving the hydrocyclone at approximately 55 to 60% solids where they are fed to high G-force dewatering screen.

The Derrick HI-G Dryer dewatering unit is outfitted with two 2.5 hp electromechanical vibrators that operate at 1,750 rpm with a stroke length of 5 mm. The combination of stroke length and rotation speed create 7.3 G's of acceleration on the screen surface, resulting in efficient separation of water from the fine solids. The dewatered fine solids are then discharged from the screening machine at 75 to 80% solids. All recovered solids are provided in a consistently stackable and conveyable form.

Tests were conducted on the Hi-G dewatering screen with Φ100 mm hydrocyclone. To simulate the proper solids loading (discharge of a 20-way hydrocyclone cluster) on the Hi-G screen, the usable width of the Hi-G test screen was restricted to 20 percent of the full width. In a full-scale commercial system, all the underflow from a 20 hydrocyclones manifold will feed a Hi-G dewatering screen.

Process flowsheet for pilot tests is given on the Figure 2. The process flowsheet includes HI-G Dryer Fines Recovery System, self-balancing sump and five sampling points – feed, cyclone overflow and underflow and screen oversize and undersize. The cyclone overflow and screen oversize and undersize are returned to the sump to assure constant cyclone feed during the test.

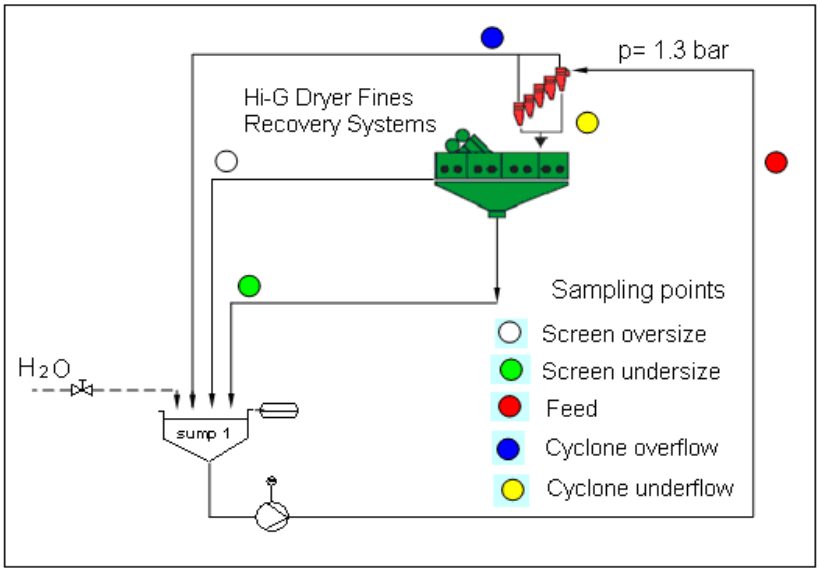


Fig 2. Pilot tests process flowsheet

The pilot installation is a closed loop system that requires the dewatering screen and hydrocyclone overflow to be returned to the hydrocyclone feed sump. In normal operation, only the dewatering screen underflow would report to the hydrocyclone feed sump. The pilot installation causes a hydrocyclone feed that is significantly finer than normal operation conditions.

Tests were conducted with 0.50 mm opening urethane panels on the Hi-G screen. The feed was diluted additional in order to achieve better separation and lower content solids in the cyclone overflow. 7.72 Wt % feed solids was observed to be optimum for Φ100 mm cyclone at 2.7 - 2.8 bar pressure.

The frequency of screening machine, motor weight and screen bed angle were tested:

- Frequency of screening machine: 40 and 50 Hz;
- Motor weight: 13.6 and 18.1 kg;
- Screen bed angle: 3 and 5^0.

The following characteristics of the five sampling products were determined: particle size distribution, slurry mass flow, solids Wt % and Vol. %, specific gravity, slurry and water volume flow and % solids.

3. Results and discussions

The test conditions are presented in Table 1.

Table 1. Derrick HI-G Dryer Fines Recovery System test conditions

Test №	Equipment Type	Bar/ Opening, (mm)	Frequency, (Hz)	Motor Weight, (kg)	Screen Bed Angle, (degree)
1	Φ 100 mm Cyclone	2.76			
1a	Dewatering Screen	0.5	40	18.1	3
2	Φ 100 mm cyclone	2.76			
2a	Dewatering Screen	0.5	50	18.1	3
3	Φ 100 mm Cyclone	2.76			
3a	Dewatering Screen	0.5	50	13.6	3
4	Φ 100 mm Cyclone	2.76			
4a	Dewatering Screen	0.5	40	13.6	3
5	Φ 100 mm Cyclone	2.76			
5a	Dewatering Screen	0.5	40	13.6	5
6	Φ 100 mm Cyclone	2.76			
6a	Dewatering Screen	0.5	50	13.6	5

The test results are presented in Figures 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14.

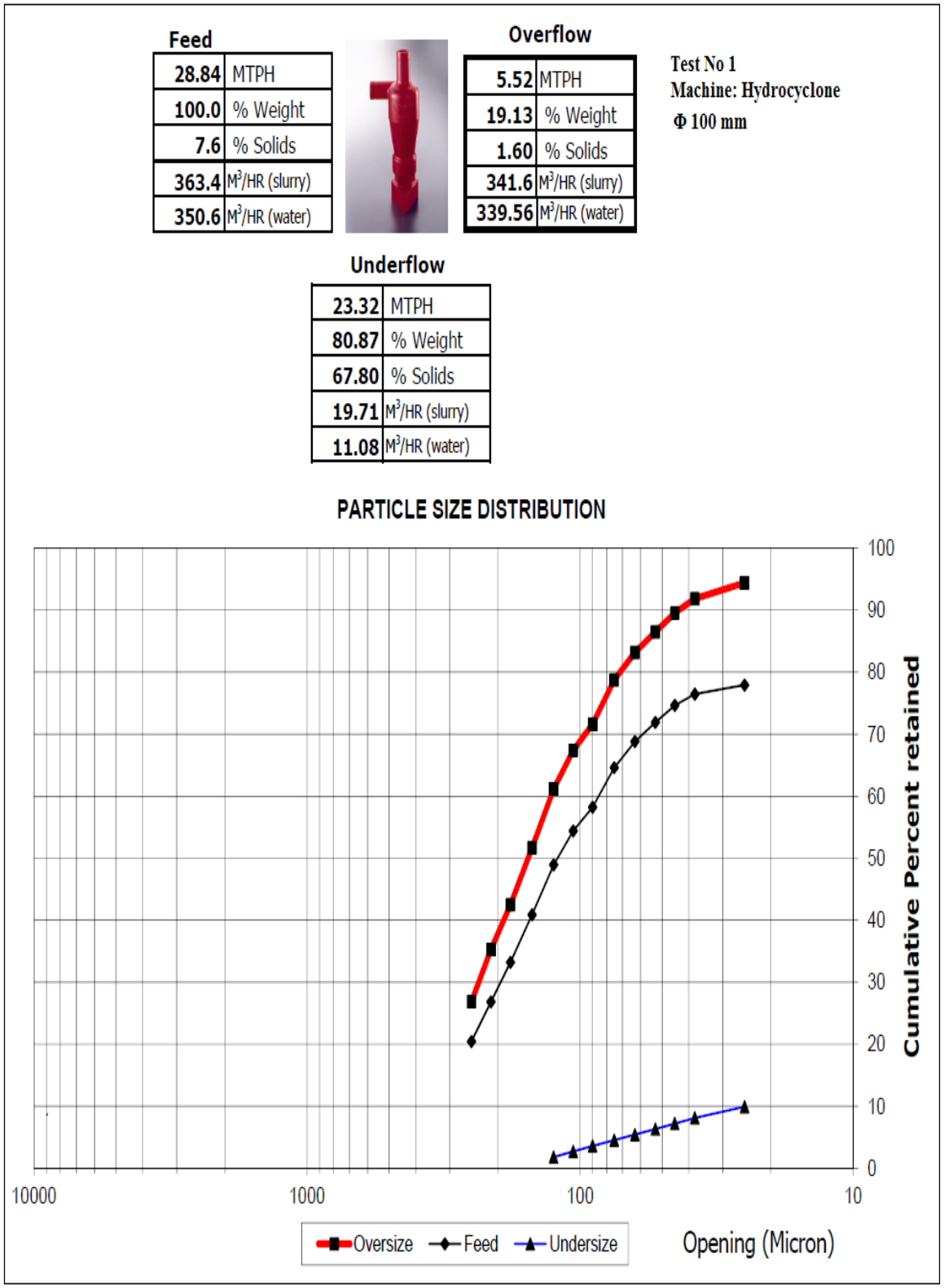


Fig 3. Test № 1 – Mass Balance and Particle Size Distribution

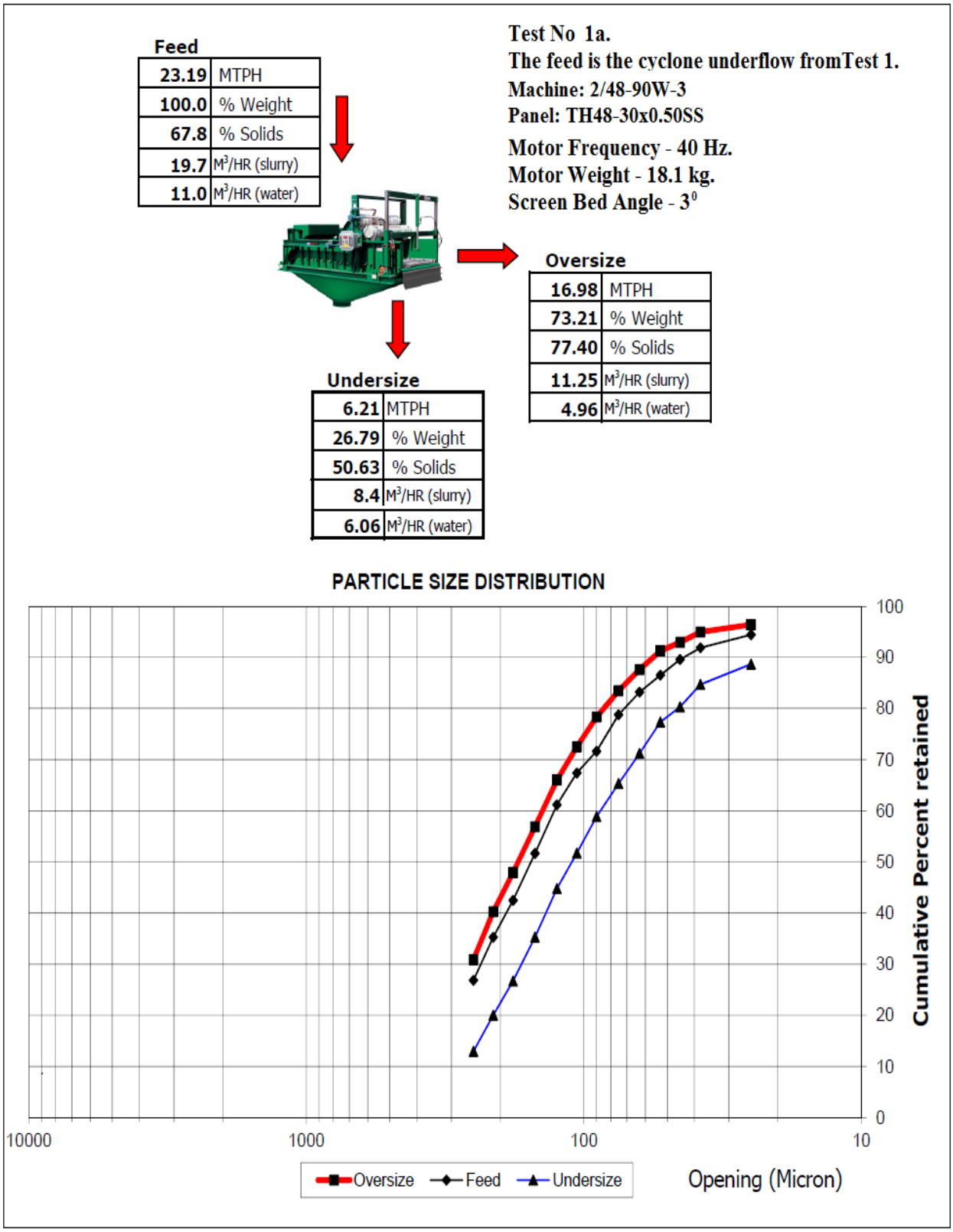


Fig 4. Test № 1a – Mass Balance and Particle Size Distribution

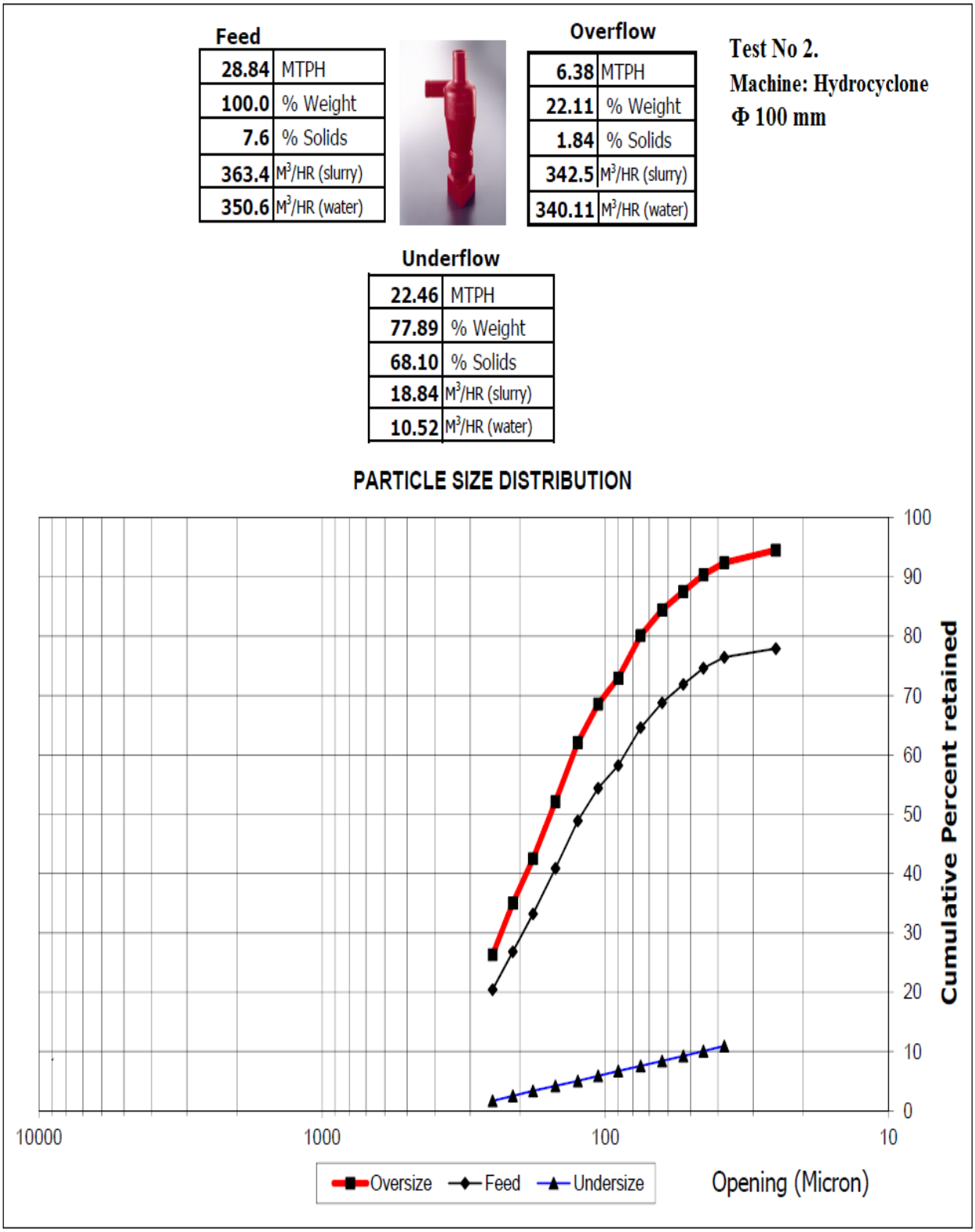


Fig 5. Test № 2 – Mass Balance and Particle Size Distribution

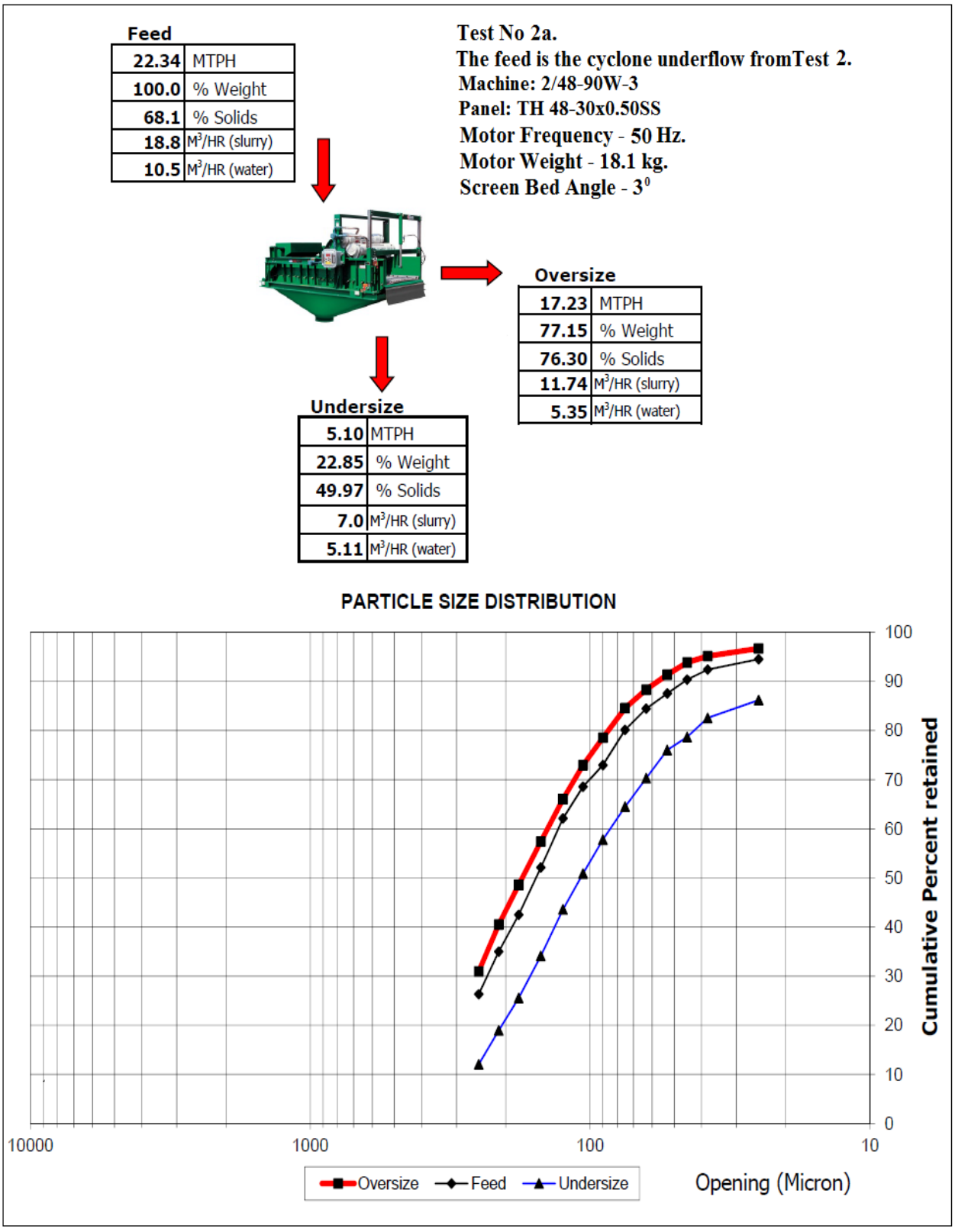


Fig 6. Test № 2a – Mass Balance and Particle Size Distribution

Feed

28.84	MTPH
100.0	% Weight
7.6	% Solids
363.4	M^3/HR (slurry)
350.6	M^3/HR (water)



Overflow

6.33	MTPH
21.95	% Weight
1.81	% Solids
346.7	M^3/HR (slurry)
344.36	M^3/HR (water)

Test No 3.
Machine: Hydrocyclone
Φ 100 mm

Underflow

22.51	MTPH
78.05	% Weight
78.20	% Solids
14.61	M^3/HR (slurry)
6.27	M^3/HR (water)

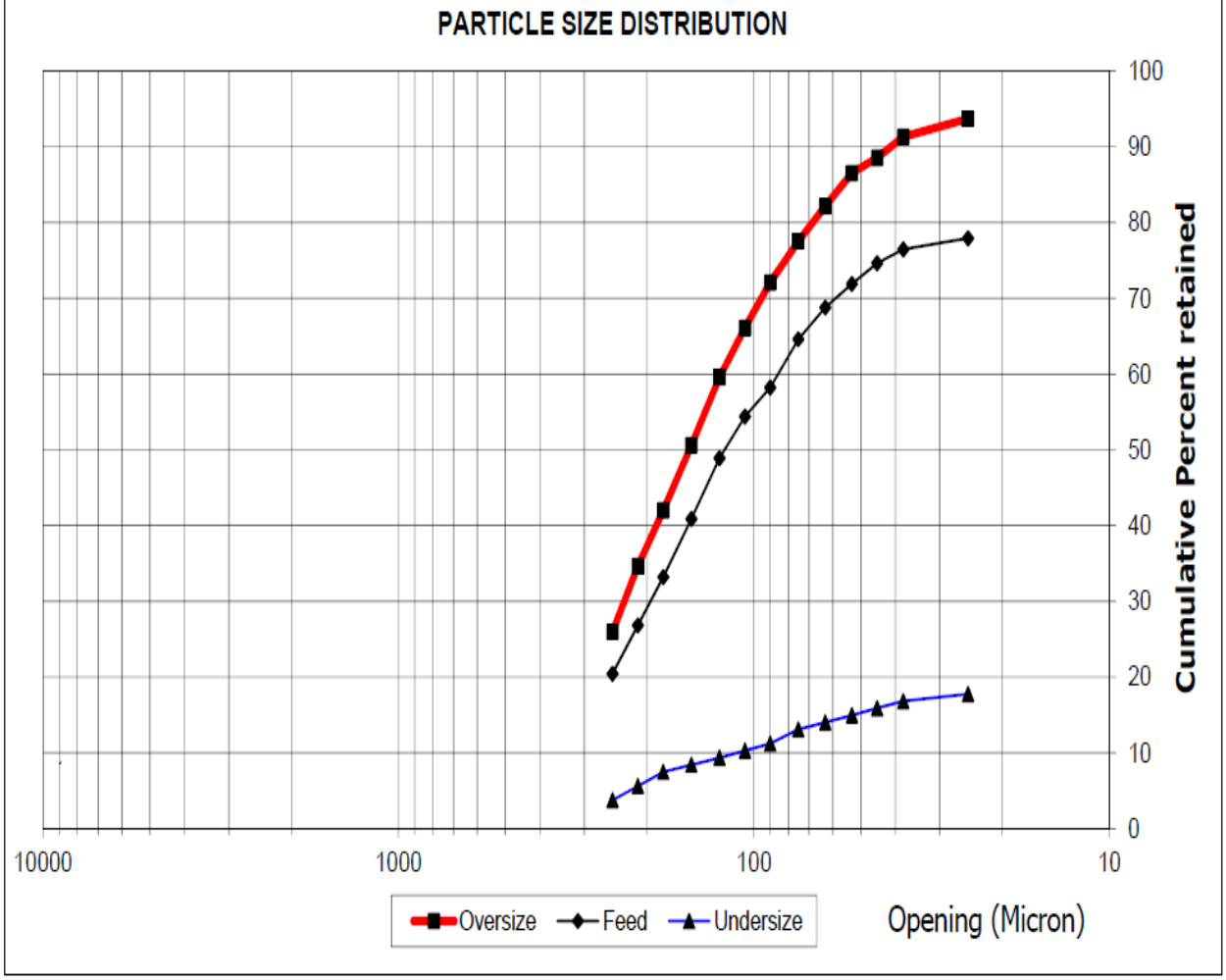


Fig 7. Test № 3 – Mass Balance and Particle Size Distribution

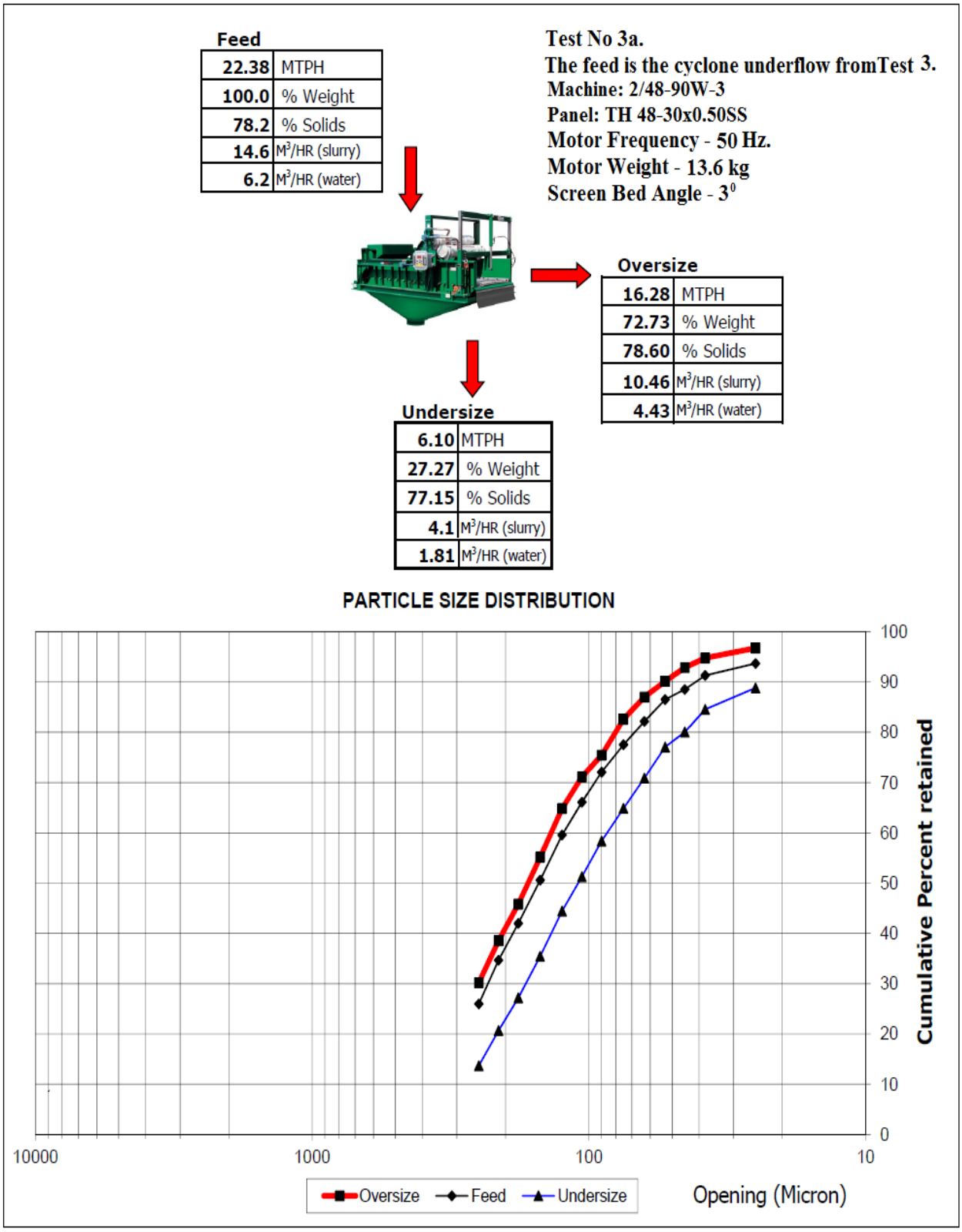


Fig 8. Test № 3a – Mass Balance and Particle Size Distribution

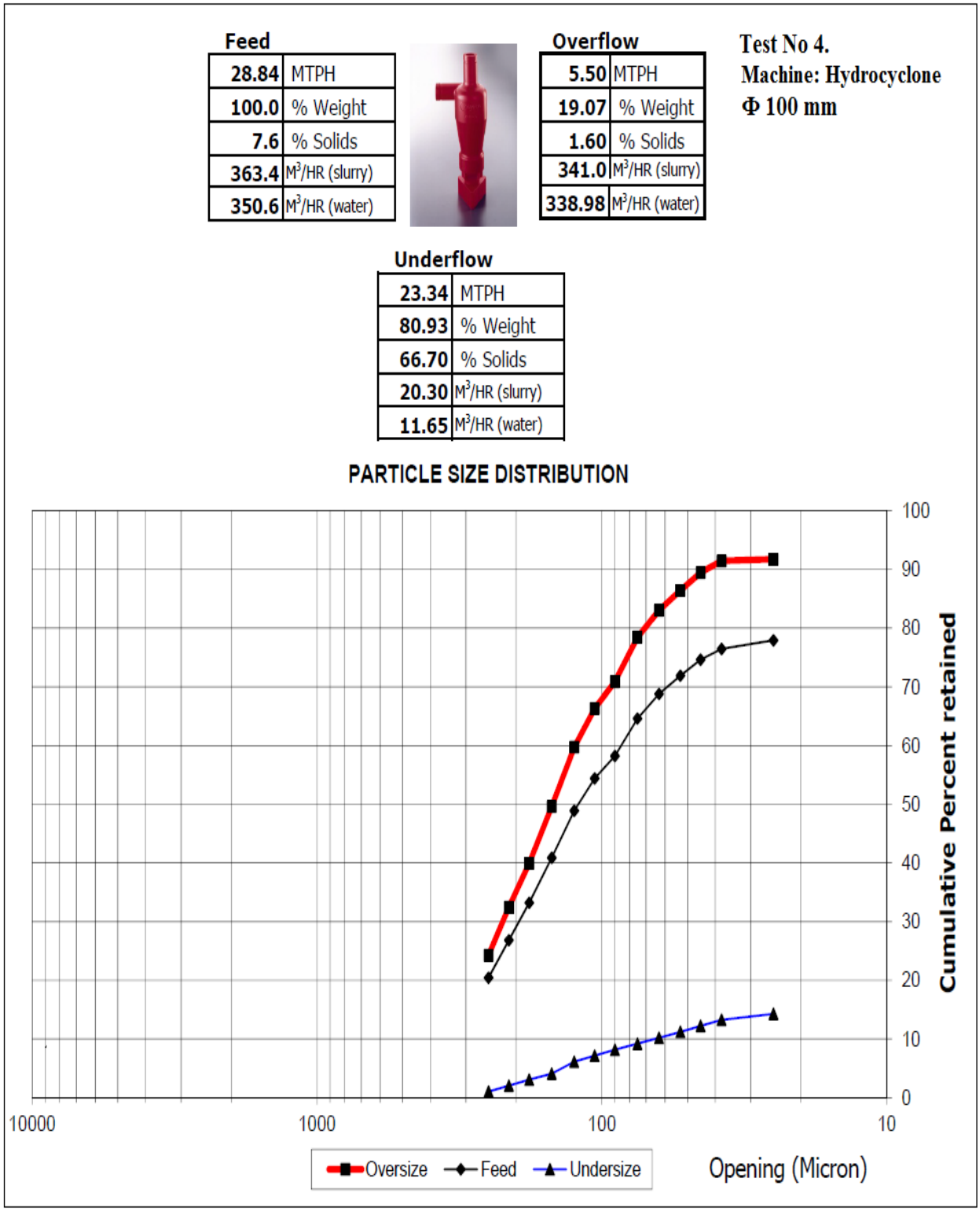


Fig 9. Test № 4 – Mass Balance and Particle Size Distribution

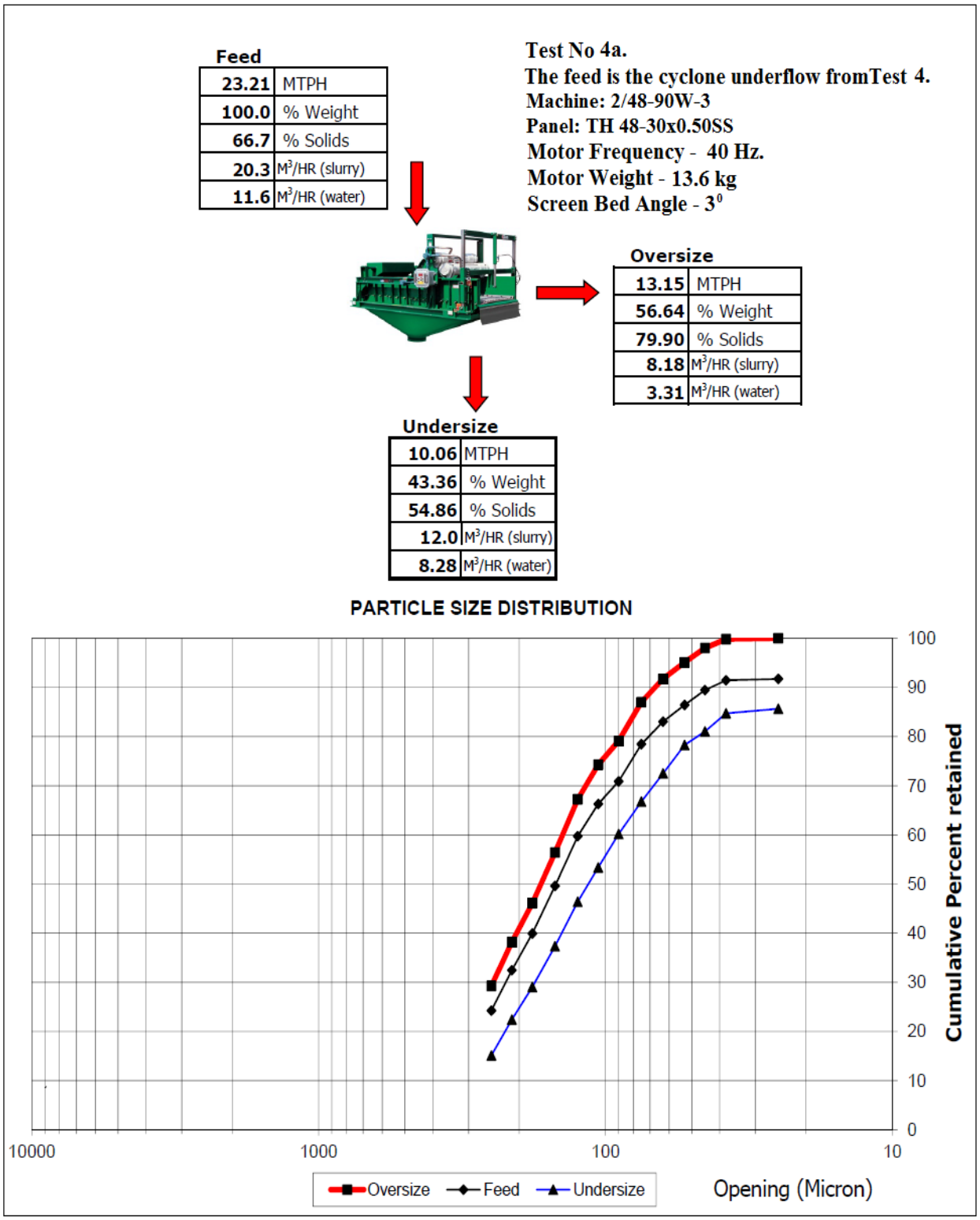


Fig 10. Test № 4a – Mass Balance and Particle Size Distribution

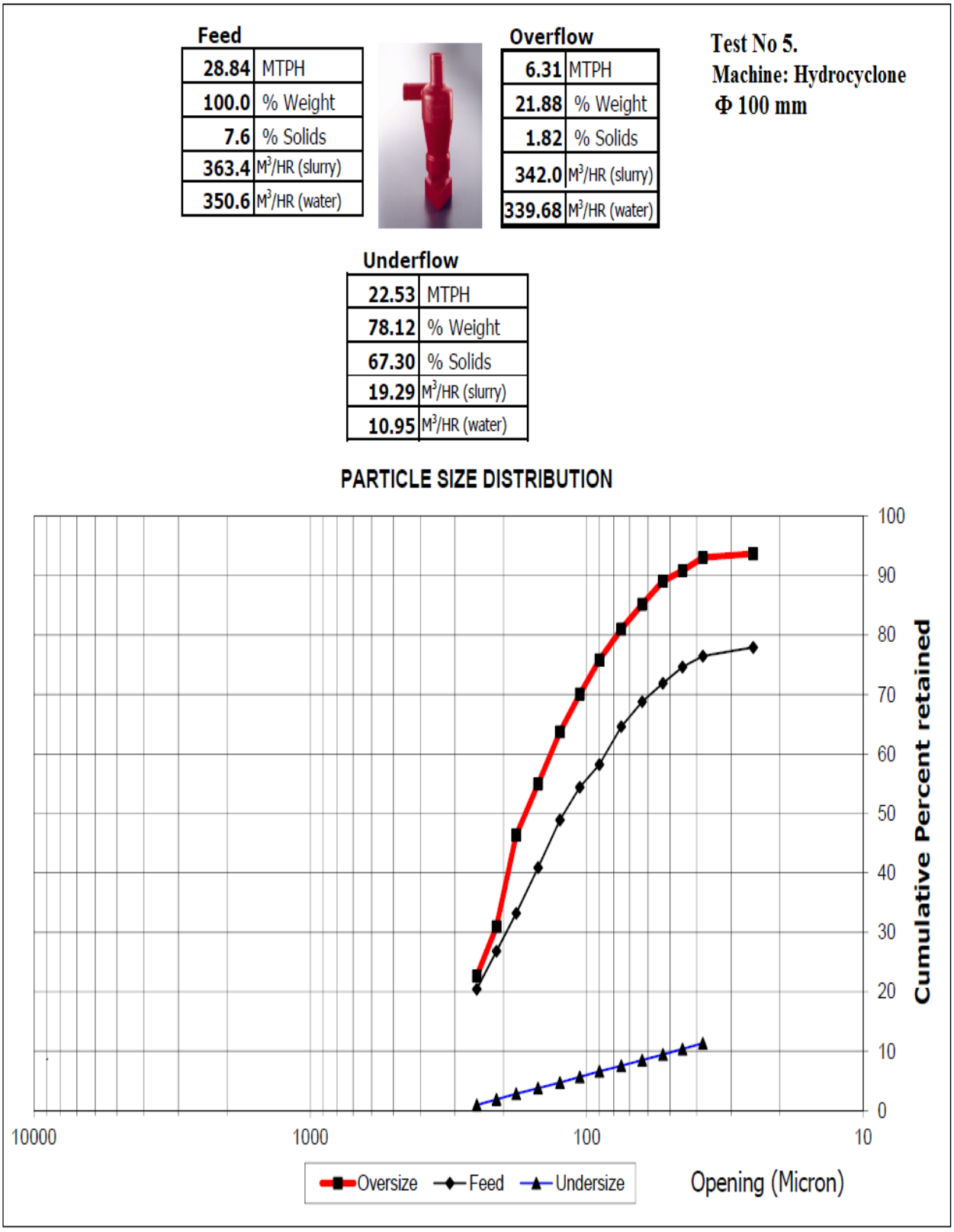


Fig 11. Test № 5 – Mass Balance and Particle Size Distribution

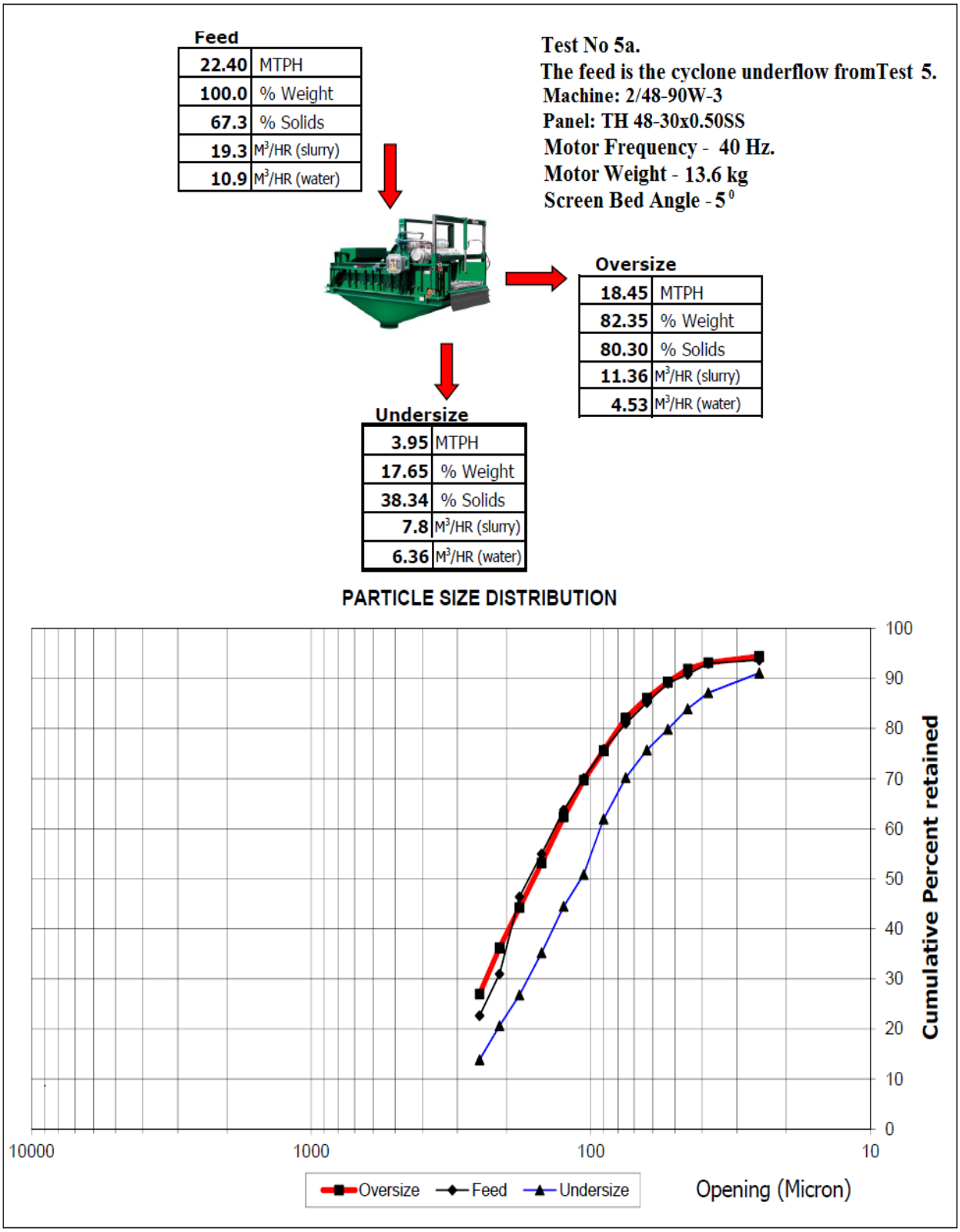


Fig 12. Test № 5a – Mass Balance and Particle Size Distribution

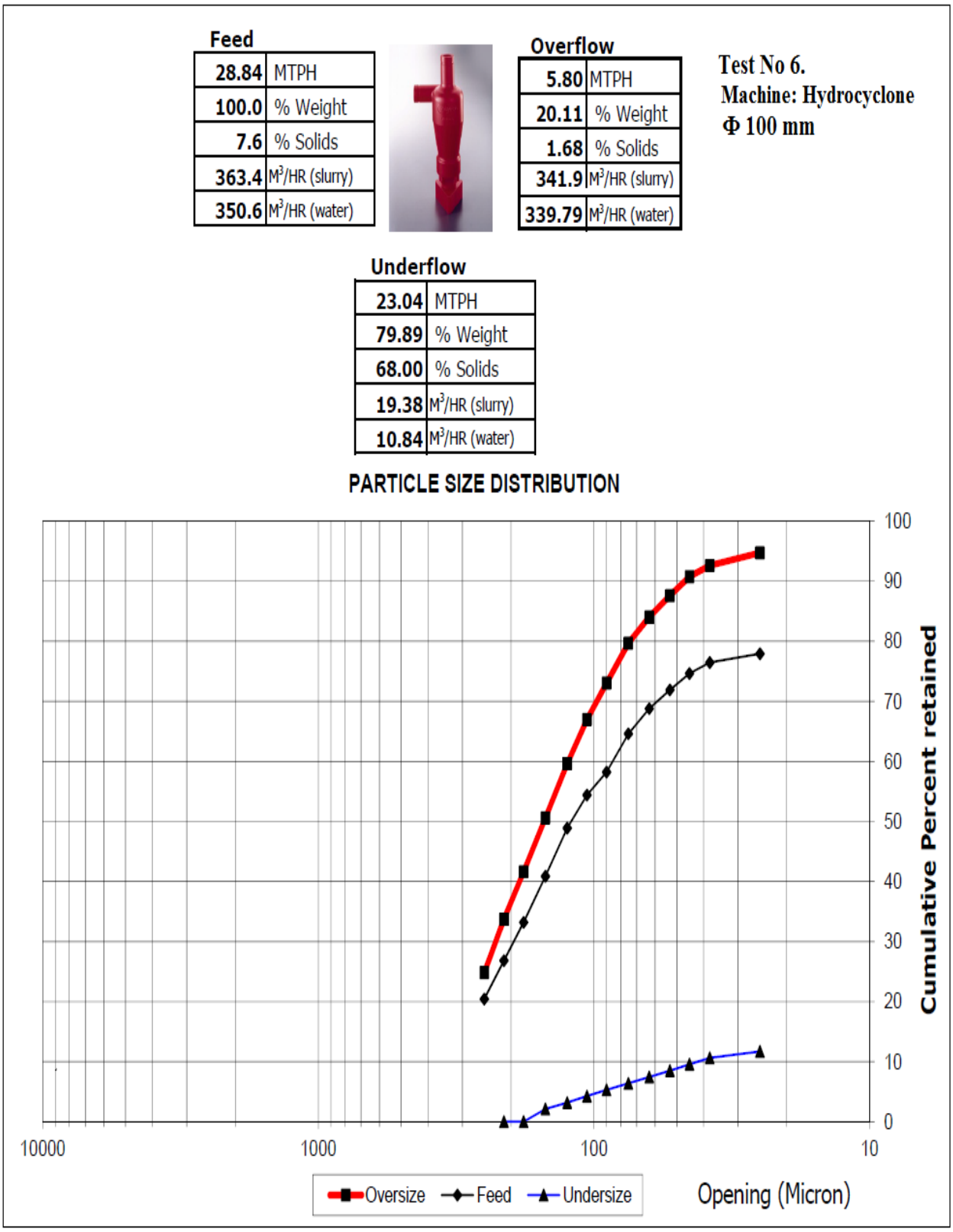


Fig 13. Test № 6 – Mass Balance and Particle Size Distribution

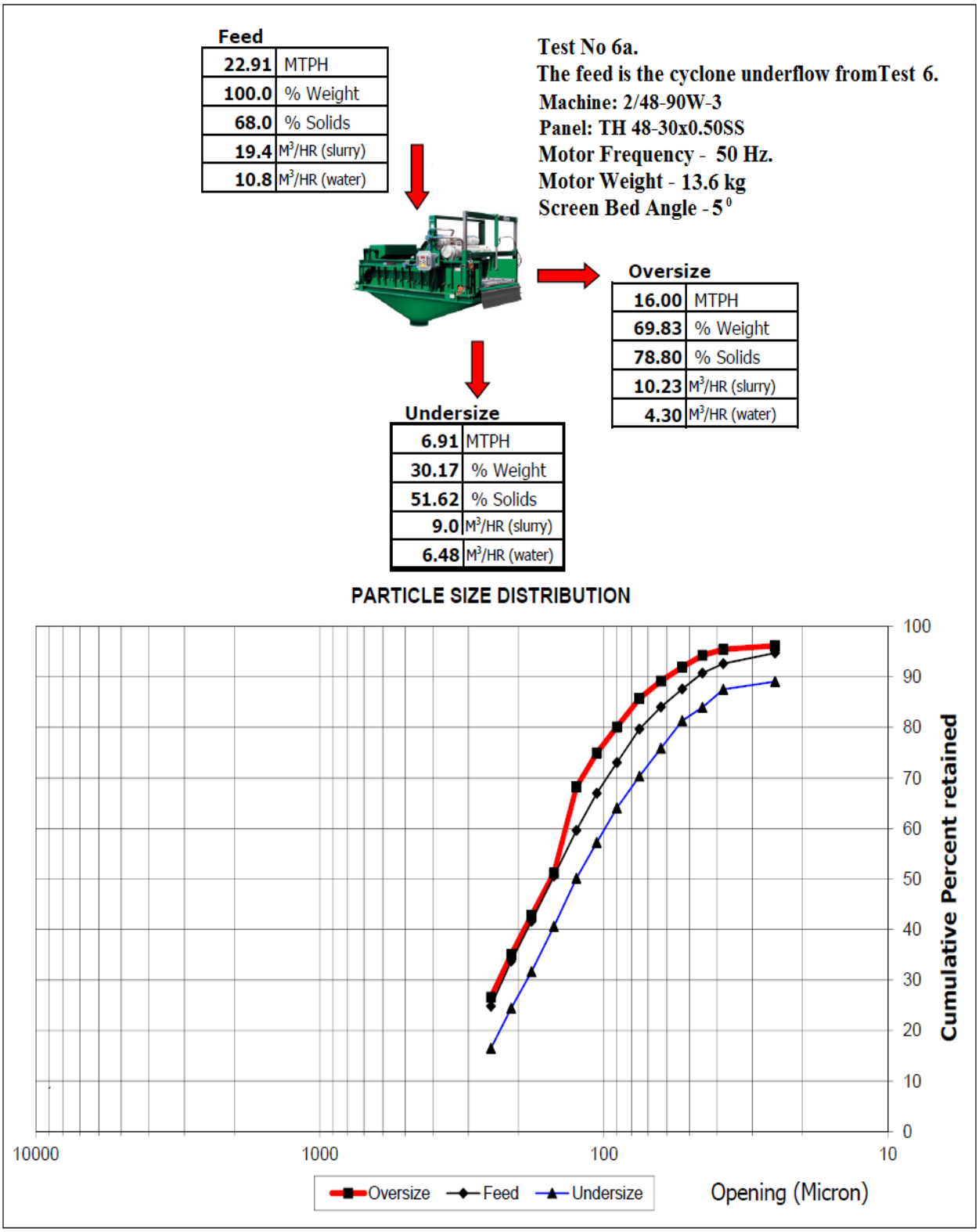


Fig 14. Test № 6a – Mass Balance and Particle Size Distribution

The summarized test results are presented in Table 2.

Table 2. Derrick HI-G Dryer Fines Recovery System Test Results

Test №	Equipment Type	Feed	Cyclone underflow/Screen oversize		Cyclone overflow/Screen undersize	
		Solids, (%)	Weight, (%)	Solids, (%)	Weight, (%)	Solids, (%)
1	Φ 100 mm cyclone	7.6	80.9	67.8	19.1	1.4
1a	Dewatering Screen	67.8	73.2	77.4	26.8	44.8
2	Φ 100 mm cyclone	7.6	77.9	68.1	22.1	1.5
2a	Dewatering Screen	68.1	77.2	76.3	22.9	47.6
3	Φ 100 mm cyclone	7.6	78.1	78.2	22.0	1.3
3a	Dewatering Screen	78.2	72.7	78.6	27.3	42.9
4	Φ 100 mm cyclone	7.6	80.9	66.7	19.1	1.4
4a	Dewatering Screen	66.7	56.6	79.9	43.4	48.1
5	Φ 100 mm cyclone	7.6	78.1	67.3	21.9	1.3
5a	Dewatering Screen	67.3	82.4	80.3	17.7	52.5
6	Φ 100 mm cyclone	7.6	79.9	68.0	20.1	1.4
6a	Dewatering Screen	68.0	69.8	78.8	30.2	52.3

The test results indicate the following:

• Test 1 and 1a show that the Derrick Hi-G dryer can dewater the material with 22.6% moisture in screen oversize product at 40 Hz frequency.

• Test 4 and 4a show that the moisture content in the final product can be improved by lowering the motor weights (reduced G force) at 40 Hz. 20.1% moisture in screen oversize was achieved.

• Test 5 and 5a show that increasing the screen angle to 5 deg helps in decreasing the moisture further (19.7%).

• Tests with 50 Hz frequency produced inferior results compared to that of 40 Hz frequency.

The moisture content of the final dewatered product would likely to be improved on a longer (3.0 m long) dewatering screening machine as compared to 2.4 m long laboratory machine.

4. Conclusions

Derrick HI-G Dryer Fines Recovery System is suitable for dewatering of technological flotation tailings. The solids content of screen undersize is increased more than 4 times – from 18 % in technological tailings to 80 % into the screen undersize. In the same time the solids in the cyclone overflow are 1.4 Wt%. It appears that the Derrick HI-G Dryer Fines Recovery System can be a basic device in new tailings pond elimination technology.

Acknowledgements

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5. References

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http://www.derrickcorp.com