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A2O Biological Pool Calculator

	Calculated value		Set value
	Back calibration	Known condition	Design criteria

1.A2O Biological Pool Calculation

	Design parameter					
(一)	Water intake					
序号	item	symbol	Formula	Calculated value	unit	remark
	Engineering design scale	$Q_总$=		7000	m^3/d	
	Coefficient of total change	K_z=		1.47		
	Average daily, average hourly flow	Q_h=	$Q_总/24$=	291.6666667	m^3/h	
		Q_s=	$Q_h/3600$=	0.081018519	m^3/s	
	Maximum daily and hourly flow	Q_{max}=	Q_h*K_z=	428.75	m^3/h	
		=	$Q_{max}/3600$=	0.119097222	m^3/s	
(二)	Inlet and outlet water quality					
Water quality parameter	Water intake index (mg/L)	symbol	Effluent index (mg/L)	symbol	Removal rate%	remark
COD_{cr}	400	COD_t	50	COD_{te}	87.5	
BOD_5	120	S_0	10	S_e	91.66666667	90%~95%
TSS	220	T_{SS}	10	T_S	95.45454545	
NH_3-N	25	N_o	5	N_a	80	
TKN	35	N_k	5	N_{ke}	85.71428571	
NO_3^--N	0		10			
TN	35	N_t	15	N_{te}	57.14285714	60%~85%
TP	3	P_t	0.5	P_{te}	83.33333333	
PH	6~9		6~9			
碱度	280	S_{ALK}				
T_{max}	20	℃				
T_{min}	14	℃				

water treatment

—	A2O Biological Reaction Tank (anaerobic/anaerobic/aerobic)					
(一)	Determine whether the A2O process can be used					
序号	project	symbol	Formula	Calculated value	unit	remark
	BOD5/TN (carbon nitrogen ratio)	k_1=	S_0/N_t=	3.428571429		≥4
	BOD5/TP (carbon-phosphorus ratio)	k_2=	S_0/P_t=	40		≥17
(二)	A2O biological reaction tank volume calculation (sludge loading method)		BOD5,N and P were removed from the water			
	A2/O biological reaction tank design flow	Q=	$Q_总$=	7000	m^3/d	
	BOD5 sludge load	N=		0.08	$kgBOD_5/(kgMLSS·d)$	0.1~0.2
	Mixed liquid suspension solid concentration MLSS	X=		3500	mgMLSS/L	3000~4000mg/L
	Sludge reflux ratio	R=		1		100%reflux
	Denitrification rate	η_N=	N_t-N_{te}/N_t=	0.571428571		60%~85%
	Mixture reflux ratio	$R_内$=	$\eta_N/(1-\eta_N)$ =	1.333333333		100%~400%
		=	value	2		200%
	Effective volume of A2O biological reaction tank	V=	$\frac{Q(S_o-S_e)}{NX}$ =	2750	m^3	
		=	value	2750	m^3	The residence time needs to be determined
	Total residence time of A2O biological reaction tank	HRT=	V/Q=	0.392857143	d	
		=	24×HRT=	9.428571429	h	
	The ratio of anaerobic/anoxic/aerobic residence time	k_3=		1:2:8		
	Anaerobic zone residence time	HRT_1=	HRT*1/(1+2+8) =	0.857142857	h	
	Anoxic zone residence time	HRT_2=	HRT*2/(1+2+8) =	1.714285714	h	
	Aerobic zone residence time	HRT_3=	HRT*8/(1+2+8) =	6.857142857	h	
	Anaerobic zone effective volume	$V_厌$=	V*1/(1+2+8) =	250	m^3	
	Effective volume of anoxic zone	$V_缺$=	V*2/(1+2+8) =	500	m^3	
	Aerobic zone effective volume	$V_好$=	V*8/(1+2+8) =	2000	m^3	
(三)	Check nitrogen and phosphorus load					
	Total nitrogen load in aerobic section	k_N=	$\frac{QN_t}{XV_好}$ =	0.035	kgTN/(kgMLSS·d)	<0.05, Meet the requirements
	Total phosphorus load in anaerobic section	K_P=	$\frac{QP_t}{XV_厌}$ =	0.024	kgTP/(kgMLSS·d)	<0.06, Meet the requirements
(四)	Calculation of residual sludge volume					
	Total sludge yield (increase) coefficient	Y=		0.6	kgMLSS/$kgBOD_5$	0.3~0.6
	The proportion of MLVSS in MLSS	f=		0.7	kgMLVSS/kgMLSS	0.7~0.8
	Endogenous metabolic coefficient (sludge oxidation rate)	K_d=		0.05	d^{-1}	
	Biological sludge production	P_x=	$YQ(S_o-S_e)-k_dVfX$=	125125	g/d	
		=		125.125	kg/d	
	Production of non-biological sludge	P_s=	$Q(T_{ss}-T_s)$×50%/1000=	735	kg/d	
	Surplus sludge production	ΔX=	P_X+P_S=	860.125	kg/d	
(五)	Alkalinity check					
	Nitrogen content in biological sludge	k_4=		0.124		At 12.4%
	Daily nitrogen removal by microbial assimilation (synthesis)	N_w=	P_x×k_4=	15.5155	kg/d	For biological cell synthesis
		=	N_w×1000/Q=	2.2165	mg/L	
	The amount of NH3-N that has been oxidized	N_{NH}=	$N_t-N_a-N_w$=	27.7835	$mgNH_3$-N/L	
	Amount of denitration required	N_N=	$N_t-N_{te}-N_w$=	17.7835	$mgNO_3$-N/L	
	The amount of nitrate nitrogen that needs to be removed	N_T=	Q×N_N/1000=	124.4845	$kgNO_3$-N/d	
	The oxidation of 1mgNH3-N consumes alkalinity	S_{ALK1}=		7.14	mg/$mgNH_3$-N	
	Oxidizing NH3-N consumes total alkalinity	S_{ALK2}=	S_{ALK1}×N_{NH}=	198.37419	mg/L	
	Removal of 1mgBOD5 produces alkalinity	S_{ALK3}=		0.1	$mg/mgBOD_5$	
	Remove the total alkalinity produced by BOD5	S_{ALK4}=	S_{ALK3}×(S_o-S_e) =	11	mg/L	
	Reduction of 1mgNO3-N produces alkalinity	S_{ALK5}=		3.57	mg/$mgNO_3$-N	
	Reduction of NO3-N produces total alkalinity	S_{ALK6}=	S_{ALK5}×N_N=	63.487095	mg/L	
	Residual alkalinity	S_{ALK7}=	$S_{ALK}-S_{ALK2}+S_{ALK4}+S_{ALK6}$=	156.112905	mg/L	>100mg/L($CaCO_3$计)
(六)	Size calculation of A2O biological reaction cell					
	Number of reaction pools	n=		2	group	
	Single reaction pool capacity	$V_单$=	V/n=	1375	m^3	
	Effective water depth of a single reaction tank	H=		5	m	
	Effective area of a single reaction	$S_单$=	$V_单$/H=	275	m^2	
	The number of corridors of a single push	n_1=		2	pcs	
	Gallery width	B=		9	m	
	Width of single reaction cell	W=	B×n_1=	18	m	
	Length of a single reaction poo	L=	$S_单$/W=	15.27777778	m	
		=	value	62.5	m	
	Check the width to depth ratio	k_4=	B/H=	1.8		1~2
	Check the aspect ratio	k_5=	L/B=	6.944444444		5~10
	Reaction tank superelevation	H_1=		0.5	m	0.5~1.0m
	Total reaction tank height	H_2=	$H+H_1$=	5.5	m	
(七)	Calculation of inlet and outlet pipes in reaction tank					
	Design flow of the main inlet pipe of the reaction tank	Q_0=	Q_s=	0.081018519	m^3/s	
	Inlet pipe velocity	v=		0.8	m/s	0.7~2.0m/s
	Cross-sectional area of water inlet pipe	S=	Q_0/v=	0.101273148	m^2	
	Inlet pipe diameter	D=	$\sqrt{\frac{4S}{\pi}}$ =	0.359089097	m	
		=	value	0.6	m	DN600
	Check pipe flow rate	v_1=	$\frac{Q_0}{\frac{1}{4}\pi D^2}$ =	0.286544398	m/s	0.7~2.0m/s
	Design flow of return sludge pipe	Q_1=	R×Q_0=	0.081018519	m^3/s	
	Flow rate of return sludge pipe	v=		0.8	m/s	0.7~2.0m/s
	Cross-sectional area of return sludge pipe	S=	Q_0/v=	0.101273148	m^2	
	Diameter of return sludge pipe	D=	$\sqrt{\frac{4S}{\pi}}$ =	0.359089097	m	
		=	value	0.6	m	DN600
	Design flow of inlet hole of a single biological reaction tank	Q_2=	(1+R) Q_0/n=	0.081018519	m^3/s	Through the inlet shaft
	Inlet velocity	v_2=		0.6	m/s	
	Water inlet crossing area	A=	Q_2/v_2=	0.135030864	m^2	
	Long side of water inlet hole	$L_孔$=	$\sqrt{A}$ =	0.36746546	m	Suppose it's a square hole
		=	value	0.6	m	
	Weir discharge	Q_3=	$(1+R+R_内)Q_0/n$=	0.162037037	m^3/s	
	Outlet weir width	$B_堰$=	B=	9	m	
	The water head above the weir	H=		0.083	m	The value ensures the weir flow
	Flow coefficient	m=	$0.405+\frac{0.0027}{H}$ =	0.43753012		
	Weir discharge	$Q_堰$=	$mB_堰\sqrt{2g}H^{3/2}$ =	0.41707783	m^3/s	≈Q_3
	Discharge rate of water outlet	Q_4=	Q_3=	0.162037037	m^3/s	
	Outlet flow rate	v_3=		0.6	m/s	
	Water outlet area	$A_出$=	Q_4/v_3=	0.270061728	m^2	
	Outlet hole side length	$L_{孔出}$=	$\sqrt{A}$ =	0.519674637	m	
		=	value	0.9	m	
	Design flow of outlet pipe	Q_5=	Q_3=	0.162037037	m^3/s	
	Flow rate of outlet pipe	v_4=		0.8	m/s	
	Cross-sectional area of outlet pipe	S=	Q_5/v_4=	0.202546296	m^2	
	Outlet pipe diameter	D=	$\sqrt{\frac{4S}{\pi}}$ =	0.50782867	m	
		=	value	0.8	m	DN800
	Check pipe flow rate	v_5=	$\frac{Q_5}{\frac{1}{4}\pi D^2}$ =	0.322362448	m/s	0.7~2.0m/s
(八)	Aeration system design and calculation					
	BOD5 decomposition rate constant	k=		0.23	d^{-1}	
	BOD5 test time	t=		5	d	
	Remove BOD5 oxygen demand	D_{o1}=	$\frac{Q(S_0-S_e)}{1000(1-e^{-kt})}$ =	1126.779969	kgO_2/d	
	BOD oxygen equivalent in residual sludge	D_{o2}=	1.42×P_X=	177.6775	kgO_2/d	Synthetic cells, no oxygen consumption
	Carbon oxygen demand	D_{o3}=	$D_{o1}-D_{o2}$=	949.1024693	kgO_2/d	
	Removing NH3-N oxygen demand	D_{N1}=	4.6Q(N_t-N_a)/1000=	966	kgO_2/d	
	Residual sludge NH3-N oxygen equivalent	D_{N2}=	4.6×12.4%×P_X=	71.3713	kgO_2/d	Synthetic cells, no oxygen consumption
	Nitrifying oxygen demand	D_{N3}=	$D_{N1}-D_{N2}$=	894.6287	kgO_2/d	
	Nitrogen removal by denitrification produces oxygen	D_{N4}=	2.86×N_T=	356.02567	kgO_2/d	
	Actual total average oxygen demand in aerobic ponds	AOR=	$D_{O3}+D_{N3}-D_{N4}$=	1487.705499	kgO_2/d	
		=	AOR/24=	61.98772914	kgO_2/h	
	Actual total maximum oxygen demand of aerobic pool	AOR_{max}=	1.4×AOR=	2082.787699	kgO_2/d	
		=	AOR_{max}/24=	86.78282079	kgO_2/h	
	Remove 1kgBOD5 oxygen demand	AOR_{BOD}=	$\frac{1000\ AOR}{Q(S_0-S_e)}$ =	1.932085064	kgO_2/kgBOD	
	Water dissolved oxygen saturation at 20℃	$C_{s(20)}$=		9.17	mg/L	Refer to Appendix XII
	T℃ water dissolved oxygen saturation	$C_{s(14)}$=		10.17	mg/L	Refer to Appendix XII
	Standard atmosphere	$p_标$=		101300	Pa	
	Pressure correction factor	ρ=		1		Local pressure is higher than standard pressure
	Concentration of dissolved oxygen in aerobic tank	C_L=		2	mg/L	
	Ratio of oxygen transfer rate between sewage and clean water	α =		0.82		
	Ratio of saturated dissolved oxygen in sewage to clean water	β=		0.95		
	Microporous aerator from the bottom of the pool	H_4=		0.2	m	According to installation requirements
	Installation depth of microporous aerator	H_5=	$H-H_4$=	4.8	m	
	Pressure at the outlet of microporous aerator	p_b=	$p_标$+9800×H_5=	148340	Pa	
	Oxygen transfer efficiency of microporous aerator	E_A=		0.2		It is determined by device performance parameters
	The percentage of oxygen when the air leaves the pool	O_t=	$\frac{21(1-E_A)}{79+21(1-E_A)}$ =	0.175365344		
	Aerobic tank dissolved oxygen saturation	$C_{sm(14)}$=	$C_{s(14)}(\frac{p_b}{2.066\times10^5}+\frac{O_t}{0.42})$ =	11.54846563	mg/L	
	Aerobic tank standard state total average oxygen demand	SOR=	$\frac{AOR\times C_{s(20)}}{\alpha(\beta\rho C_{sm(T)}-C_L)\times1.024^{(T-20)}}$ =	2138.106259	kgO_2/d	Converted from actual demand
		=	SOR/24=	89.0877608	kgO_2/h	
	Aerobic pool standard state total maximum oxygen demand	SOR_{max}=	1.4×SOR=	124.7228651	kgO_2/h	
	Average hourly capacity of aerobic tank	G_s=	SOR/0.3E_A=	1484.796013	m^3/h	
		=	G_s/60=	24.74660022	m^3/min	
	Average hourly capacity of a single aerobic tank	G_{1S}=	G_s/n=	742.3980066	m^3/min	
		=	G_{1S}/60=	12.37330011	m^3/min	Fan selection reference
	Aerobic tank maximum hourly gas supply	G_{smax}=	1.4×G_s=	2078.714419	m^3/h	
		=	G_{smax}/60=	34.64524031	m^3/min	
		=	G_{smax}/3600=	0.577420672	m^3/s	
	Maximum hourly capacity of a single aerobic tank	G_{smax1}=	G_{smax}/n=	1039.357209	m^3/min	
		=	G_{smax1}/60=	17.32262016	m^3/min	Fan selection reference
		=	G_{smax1}/3600=	0.288710336	m^3/s	
	Gas supply per m3 of sewage when blast aeration is used	G_{sp}=	24×G_s/Q=	5.090729188	m^3/m^3 sewage	≥$3m^3/m^3$ sewage
	Resistance of air supply pipeline	h_1=		0.001	Mpa	It depends on the situation
	Local resistance of air supply pipe	h_2=		0.001	Mpa	It depends on the situation
	Aerator flooding head	h_3=	0.01×$(H-H_4)$ =	0.048	Mpa	1m water head is 0.01MPa
	Aerator resistance	h_4=		0.004	Mpa	Acuities were 0.004 ~ 0.005 MPa
	Surplus water head	Δh=		0.005	Mpa	0.003 ~ 0.005 MPa
	Required wind pressure in aerobic zone	$p_气$=	$h_1+h_2+h_3+h_4+\Delta h$=	0.059	Mpa	
		=	$p_气$×1000=	59	kPa	Fan selection reference
	Individual aerator ventilation	q=		2	m^3/h	Data provided by the manufacturer
	Single aerator service area	S_q=		0.3~0.75	m^2	Data provided by the manufacturer
	The number of aerators in one group of aerobic zones is configured	n_3=	G_{1max}/q=	519.6786047	pcs	
	Surface area of a single group of aerobic zones	F_o=	$V_好$/H/n=	200	m^2	
	Single cell aerator service area	$Fo_单$=	F_o/n_3=	0.38485325	m^2	≤$0.75m^2$
	Wind speed of the branch pipe for air drying of a single aerobic pool	$v_风$=		10	m/s	10~15m/s
	Air drying pipe diameter	$d_风$=	$\sqrt{\frac{4G_{smax}}{\pi v_风}}$ =	0.271144767	m	
		=	取值	DN500		
	The air volume of the branch pipe needs to be supplied by both sides	G_{smax2}=	G_{smax1}/n_1=	0.144355168	m^3/s	
	Both sides of the air supply branch pipe diameter	$d_{支2}$=	$\sqrt{\frac{4G_{smax2}}{\pi v_风}}$ =	0.135572383	m	
		=	value	DN250		
(九)	Anoxic tank stirring equipment calculation					
	Number of anoxic pool groups	n_4=		2	group	
	Single anoxic pool volume	$V_{缺单}$=	$V_缺/n_4$=	250	m^3	
	Each m3 sewage mixing power required	$p_{搅拌}$=		5	w	$2~8w/m^3$
	Stirring power required for a single hypoxic tank	$p_{搅拌1}$=	$p_{搅拌}$×$V_{缺单}$=	1.25	kw	Mixing equipment selection reference
(十)	Mixed liquid reflux equipment calculation					
	Return flow rate of the mixture	Q_R=	Q×$R_内$=	14000	m^3/d	
		=	Q_r/24=	583.3333333	m^3/h	
	The number of return pumps in each group aerobic tank	n_5=		1	set	Consider a second one
	Flow rate of a single return pump	$Q_{R单}$=	$Q_R/(n_5×n)$ =	291.6666667	m^3/h	Reflow pump selection reference

	Calculated value
	Set value
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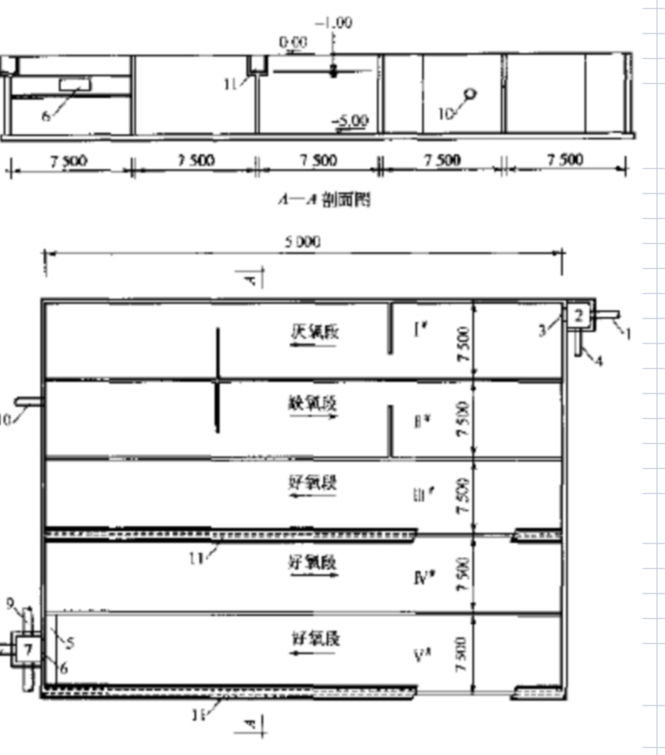

图 6-11 A²/O 脱氮除磷工艺计算图（单位：mm）
1—进水管；2—进水井；3—进水孔；4—回流污泥管；5—集水槽；6—出水孔；7—出水井；8—出水管；9—混合液回流管；10—混合液回流管；11—空气管廊

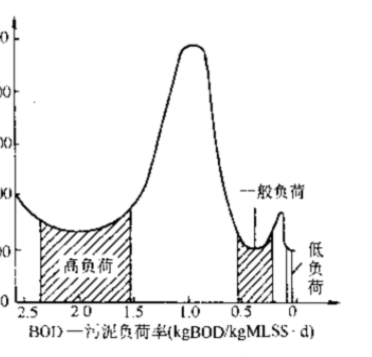

图 4-7 BOD—污泥负荷与 SVI 值之间的关系

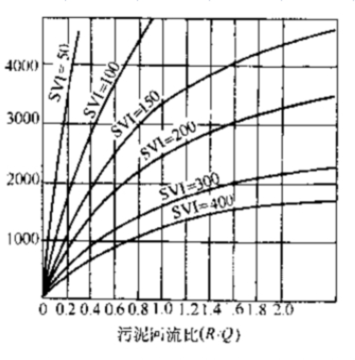

图 4-8 SVI 值、MLSS 及污泥回流比三者之间的关系

水中氧的溶解极限(mg/L) 表 5-30

水的性质	水的温度（℃）						
	0	5	10	15	20	25	30
	氧的溶解极限(mg/L)						
淡水	14.6	12.8	11.3	10.2	9.2	8.4	7.6
海水	11.3	10.0	9.0	8.1	7.4	6.7	6.1

附录十二 氧在蒸馏水中的溶解度（饱和度）

水温 T/℃	溶解度 /(mg/L)	水温 T/℃	溶解度 /(mg/L)	水温 T/℃	溶解度 /(mg/L)
0	14.62	5	12.80	10	11.33
1	14.23	6	12.48	11	11.08
2	13.84	7	12.17	12	10.83
3	13.48	8	11.87	13	10.60
4	13.13	9	11.59	14	10.37

水温 T/℃	溶解度 /(mg/L)	水温 T/℃	溶解度 /(mg/L)	水温 T/℃	溶解度 /(mg/L)
15	10.15	21	8.99	27	8.07
16	9.95	22	8.83	28	7.92
17	9.74	23	8.63	29	7.77
18	9.54	24	8.53	30	7.63
19	9.35	25	8.38		
20	9.17	26	8.22		