

# 过滤试验的正交设计<sup>\*</sup>

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**提要** 通过对过滤试验的正交设计,简单介绍了正交试验设计的优越性和设计方法。

**关键词** 过滤试验 正交设计 设计方法

## 1 问题的提出

过滤过程是给水处理工艺中极为重要的一个环节。在现阶段,它担负着保证出水水质的重任。

影响过滤效果的因素较多,主要有:(1)滤料粒径;(2)滤层厚度;(3)滤速;(4)混凝剂品种;(5)药剂投加量;(6)原水浊度;(7)水温等。

要深入彻底地研究过滤过程,采用上述各影响因素进行过滤试验是必须的。通过分析研究,对上述因素拟采用表1所示各水平等级进行试验研究。

表1 过滤试验的影响因素及水平

因素 水平	粒径 / mm	层厚 / cm	滤速 / m/h	原水浊 度/ NTU	混凝剂投加量/ mg/L			
					FeCl <sub>3</sub>	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	PAM	PAC
1	0.95	10	5	5	2	3	0.05	1
2	1.25	30	10	10	5	6	0.10	3
3		60	15	20	10	10	0.15	5
4								7
5								10
6								15

若要对上述各影响因素水平的组合进行全面试验,则需做

$$n_{\text{Fe,Al,PAM}} = 2(\text{粒径}) \times 3(\text{层厚}) \times 3(\text{滤速}) \times 3(\text{浊度}) \times 3(\text{投药量}) = 162 \text{ 次}$$

$$n_{\text{PAC}} = 2(\text{粒径}) \times 3(\text{层厚}) \times 3(\text{滤速}) \times 3(\text{浊度}) \times 6(\text{投药量}) = 324 \text{ 次}$$

$$\text{共做试验: } n = 162 \times 3 + 324 = 810 \text{ 次}$$

$$\text{若每天做一组试验,则需: } N = 810/365 = 3a$$

显然,这样的试验安排是不合理的,也是不科学的。那么如何科学、合理地安排过滤试验,以最少的试验次数反映出全面试验的信息呢?随机抽样试验

不可能做到,正交试验是科学、合理的试验方法。

## 2 正交试验设计法

### 2.1 正交表

正交试验设计是利用预先设计好的正交表来安排试验。表2是一张 $L_9(3^4)$ 正交表。

表2  $L_9(3^4)$ 正交表

水平 试验号	因素 A	B	C	D
1	1	1	3	2
2	1	2	1	1
3	1	3	2	3
4	2	1	2	1
5	2	2	3	3
6	2	3	1	2
7	3	1	1	3
8	3	2	2	2
9	3	3	3	1

正交表 $L_9(3^4)$ 的代号及含义如下:

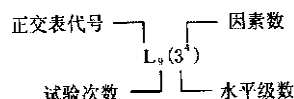


表2表示可安排4个因素,每个因素3个水平的正交试验,每一行为一组试验,需共做试验9次。

### 2.2 正交试验的优越性

#### 2.2.1 试验次数少

采用全面试验,4个因素、3个水平试验需做 $3^4 = 81$ 次,而采用正交试验,则只需9次试验即可。显然试验次数大为减少。

#### 2.2.2 均衡分散

用正交表安排的试验,是均衡分散在全面试验方案当中的,这就使试验具有代表性。它反映在正

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交表中,就是表中任何一列,其各水平所出现的次数相同。

2.2.3 整齐可比

用正交表安排的试验,其每列因素在各个水平上导致的结果之和,其它因素的各水平出现的次数都是相同的,这就使在比较某个因素的各个水平对试验结果产生的效应时,最大限度地排除了其它因素的干扰。它反映在正交表中,就是表中任意两列,所有各种可能的数对出现的次数都相同。

因此,用正交表安排试验,是试验次数最少,同时又能充分反映各因素的各极水平对试验结果的影响,又便于数据分析的试验设计。

3 过滤试验的正交设计

3.1 因素及水平的确定

本次过滤试验,通过分析比较,拟选用表1所示各因素及水平。

为了尽量减少试验次数,同时又能充分反映出各因素对试验结果的影响,结合正交表,除滤料粒径为2个水平级、PAC投加量为6个水平级外,其余均为3个水平级。

3.2 试验设计

3.2.1 滤料粒径

由于粒径选用了2个水平级,加之其对试验结果的影响较大,将其单独列出来,采用2套试验装置,分别装填不同粒径滤料,做平行对比试验。

3.2.2 混凝剂品种

本次试验计划采用4种不同品种的混凝剂进行过滤试验,它们是FeCl<sub>3</sub>、Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>、PAM和PAC,每种混凝剂单独投加。因此,4种混凝剂必须单独安排试验,这样每一组试验就是4个因素的组合试验。

3.2.3 混凝剂投加量

混凝剂FeCl<sub>3</sub>、Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>、PAM为3水平试验,而PAC为6水平试验。因此对于FeCl<sub>3</sub>、Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>和PAM采用L<sub>9</sub>(3<sup>4</sup>)正交表安排试验,而对于PAC采用L<sub>18</sub>(6<sup>1</sup>×3<sup>6</sup>)正交表来安排试验。

3.2.4 水平号的确定

为了消除系统误差和人为因素的干扰,在确定各因素的水平号时,采用随机抽样法确定出各因素

的水平号,如表3所示。

3.2.5 重复试验

为了进一步消除试验中的系统误差,拟进行重复试验。但在正交试验设计中,与其简单地重复试验,不如采用不同组合的新的正交试验。为此,对FeCl<sub>3</sub>、Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>和PAM重新排列水平号,如表4所示,再按新水平号安排正交试验。

表3 过滤试验各因素水平号

水平 因素 水平号	滤速 v / m/h	层厚 L / cm	原水浊度 / NTU	混凝剂投加量/ mg/L			
				FeCl <sub>3</sub>	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	PAM	PAC
1	5	10	20	2	3	0.15	1
2	10	60	5	10	6	0.10	7
3	15	30	10	5	10	0.05	15
4							3
5							10
6							5

表4 过滤试验各因素水平号

水平 因素 水平号	滤速 v / m/h	层厚 L / cm	原水浊度 / NTU	混凝剂投加量/ mg/L		
				FeCl <sub>3</sub>	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	PAM
1	5	10	20	2	3	0.15
2	10	60	5	10	6	0.10
3	15	30	10	5	10	0.05

如此安排后,每种混凝剂做试验18次,全部试验共做18×4=72次即可完成。这也就是说如若每天做一组试验,则2个半月即可完成这部分试验工作。用2个半月完成3年的工作,这无疑节省了大量的人力、财力和时间。

4 结语

在工程试验中,正交试验设计不仅节省了人力和财力,更重要的是节省了时间,这无疑在科学研究过程中提高了效率,争取了时间,是一项值得推广应用的试验设计方法。

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