TELKOMNIKA, Vol. 11, No. 9, September 2013, pp. 4963~4972
ISSN: 2302-4046

Pulse Clean and Regeneration Control Device in Ceramic Filter

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Abstract

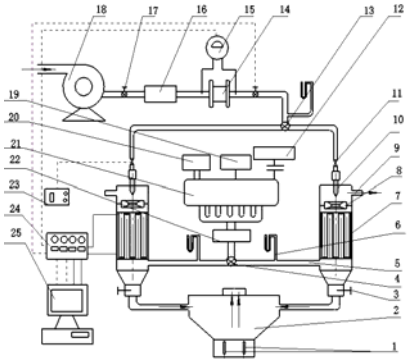
This article developed a 6120-type diesel particulate filter pulse clean and regeneration control system with a high efficiency, simple reliable use. And it has determined the spray nozzle diameter, the injection distance, the injection pressure, the pulse width, the injection time of five factor optimal fit experiment parameter. This control system can flow the type honeycomb ceramics filter to the wall to carry on the test and the research of the filtration and the regeneration. It can realize the filter filtration and the regeneration change work.

Keywords: *diesel engine, particle, ceramic filter, pulse chean and regeneration control, experiment*

1. Introduction

1.1. Composition of the Pulse Clean and Regeneration Control Device in Ceramic Filter

The this article reference [1, 2] elementary theory, designed a set to have the dual function pulse instead to blow the regeneration control device, as shown in Figure 1.



1. electric heating part 2. electric heater 3. control valve 4. cross-over valve 5. engine exhaust air inlet 6. U tube 7. Filters body 8. Eductor 9. Pure gas escape pipe 10. spray nozzle 11. pulse solenoid valve 12. measurements of power machine 13. Cross-over valve 14. Orifice well tester 15. The difference presses transmitting instrument 16. Manostat 17. pulse gas flow amount regulating valve 18. Luo tribulus air blower 19. ratemeter 20. oil consumption

1.2. Principle of the Pulse Clean and Regeneration Control Device in Ceramic Filter

Its principle of work is as follows: Exhaust discharges which by the engine after cross-over valve 4, again 5 enters the wall by the air feeder to flow type honeycomb ceramics filter 7 in the inlet passages. Enters in the ceramic filter the engine exhaust, from has certain factor of porosity and between the permeable honeycomb passageway thin wall flows the ceramics along the radial direction inflow wall to export the channel, the particle is intercepted deposits in filters the body to import the channel on the wall surface, and forms the particle level gradually. This time obtains the purification including the particle gas. The pure gas which purifies in the wall is flowed the type filtration body to export the channel interior along axial to enter the

Received February 9, 2013; Revised May 22, 2013; Accepted June 12, 2013

common air chamber, then 9 disperses into the atmosphere from the exhaust pipe. This filters the process.

Along with filtration process march, particle level gradually accumulation. When the particle level increases to certain thickness, the honeycomb ceramics turnover was mad the channel inside and outside differential pressure increases, the particle penetrates the honeycomb thin wall ability to reduce. If not promptly eliminates already the particle which deposits, will have the filter diesel engine exhaust back pressure unceasingly to enhance, in order to guarantee the engine the performance will lose does not send oversized, will have the regular elimination particle, to limit the diesel engine the highest exhaust resistance. Generally speaking, when the exhaust back pressure surpasses 20Kpa, the diesel engine performance starts obviously to worsen [3]. Therefore must get down the deposition the particle level eliminates. This is the filter regeneration stage. This time, the pulse signal which 23 sends out by the pulse control meter underneath, controls solenoid valve 11 to cause its opening, the compressed air which the Luo tribulus air blower provides after the pulse gas flow amount regulating valve 17, the cross-over valve 13, the solenoid valve 11, the spray nozzle 10 high speed blowout, when the blowout high-velocity current flows after the common air chamber, from the periphery space injection massive air entered the eductor in 8, then enters the peak nest ceramics to filter the body reverse the air vent channel, has from inside to outside pressure in the ceramic filtration body air vent channel interior, causes the ceramic filtration body air vent channel internal pressure rapid ascension.In the gas along the axial downward process in, the gas passed through the pipe wall rapidly along the radial direction to the tube outside the movement, thus will adhere to stick cohere in the filtering element outer wall particle level attacks, will complete the pulse instead to blow the process.

In order to describes the solid particle strictly by the peak nest ceramics filtering element filtration and the process which is blown by the compressed gas escapes, once usually supposes [4]: (1) solid particle to arrive the filtering element wall surface, adheres to stick cohere on its wall surface, but no longer returns to in the air current; (2) adheres to stick cohere on the filtering element wall surface the solid particle instead is blowing in the process to be able to blow completely falls down.

This control device biggest merit is: In has not carried on the heating to the filter body in the situation, can cause the filter with the very few compressed air to obtain the regeneration; the particle burner complete is also separated from the filter box body.

This article designs the pulse instead blows the regeneration control device is instead blows gradually to two filter, its characteristic is can cause the engine continuous working, causes the filtration process to carry on continuously. Because the filtration and the regeneration are relate in together.How therefore instead is blowing the difficulty which in the process faces is avoids outside the tube funnel including the particle gas two volumes attracting. Therefore, the people proposed many kinds of avoided method [5-9] which two time volume attracted, in which has mainly considered the injection pressure, the injection distance, the spray nozzle diameter, the injection time and so on the influence.This article in view of these influence factor, has carried on the experimental proof on 6120 diesel engines.

2. Results and Analysis

2.1. Orthogonal Experiment Design

1. Determination experiment inspection target and position level factor

In order to test this instead to blow the regeneration control device regeneration the feasibility and the reliability, this article used 6120 diesel engines to carry on the test experiment. In the test, selected five kind of factors to take the consideration factor. They are: Injection pressure, injection distance, spray nozzle diameter, injection time and pulse width.And each kind of factor all only considered four units place levels come to each kind of factor to carry on the combination test. Inspection target: Instead blows the regeneration efficiency, %.Its bigger showing test equipment instead blows the reproductive properties to be better.

(1) Instead blows the pressure

Kanaoka [10] and so on and so on studies through the survey pressure drop and dust thickness the dust on rigid ceramics filtering element accumulation process which catches, pointed out the filtration rate is bigger, forms the particle level the factor of porosity to be smaller, the particle level elimination efficiency is lower, jumps over the need more intense

counter-blowing pressure. But instead blows the pressure not to be able infinite to elevate, the pressure too is high, easily instead blows the process in the pulse with to restore between the normal filtration process to have a transient process, this process can appear the gas backflow, creates two volumes to attract.

Chooses 0.3MPa, 0.4MPa, 0.5MPa, the 0.6MPa four units place levels

(2) Spray nozzle diameter

Experimental study spray nozzle structures and so on Cui Xiaolan [9] when instead blew the process to the ceramic filter pipe pulse the influence, pointed out the spray nozzle structure quite was big to in the ceramic filter pipe pressure profile influence. Regarding the ascending pipe type spray nozzle, the diameter should choose as far as possible slightly some, the reason lies in the spray nozzle diameter to be bigger, attracts the pure gas quantity from the common air chamber volume to be equal in the gas quantity which spouts from the spray nozzle is smaller, when the spray nozzle diameter is higher than some certain value, in the filter pipe pressure even starts to reduce, this regarding the filter regeneration is very disadvantageous. Simultaneously also pointed out that, regarding the identical throat diameter ascending pipe, tapers as well as the reproduce by pantograph type spray nozzle, the reproduce by pantograph type spray nozzle injection effect is best.Therefore, this article has chosen the reproduce by pantograph type spray nozzle.

Chooses 4mm, 5mm, 6mm, the 7mm four units place levels

(3) Injection time

In this experiment discovered when assigns the time as short as certain degree, the solenoid valve cannot open completely, even motionless. The injection time is decided in the filtration body material and filters the body the design parameter, the excessively long injection time will not be able to reduce the residual resistance, but will only be able to increase the energy consumption and the particle penetration coefficient.

Chooses 50s, 60s, 70s, the 80s four units place levels

(4) Injection distance

And so on Grannell [11] proposed that, under certain working condition, between the pulse spray nozzle and the filter pipe injection is away from extremely importantly: If the injection is away from too short, after the pulse gas gushes in, can have the negative pressure in the filter pipe front part, from this causes to here filter pipe outside to produce two volumes including the dust gas to attract, reduces filters the cake removing effect; But the injection will be away from has grown, will spout the gas from the pulse spray nozzle not to be able all to enter the tube funnel, will create the compressed gas waste inevitably.

Chooses 20mm, 30mm, 40mm, the 50mm four units place levels

(5) Pulse width

The time which the pulse width is refers to which the pulse control meter to have the electrical signal continues. Material [12] indicated that, the pulse solenoid valve opening should generally in 500ms.

Therefore this experiment chooses 46ms, 198ms, 292ms, the 396ms four units place levels. Finally lists the factor position level Table 1.

Table 1. Factor position level table

Factor Column code	injection pressure	injection time	injection from	spray nozzle diameter	pulse width
Position level	MPa	s	mm	mm	ms
	A	D	C	B	E
1	0.3	50	20	4	46
2	0.4	60	30	5	198
3	0.5	70	40	6	292
4	0.6	80	50	7	396

2. Selects the orthogonal array

Because this experimental all factors are four units place levels, therefore selects in the isotopic level orthogonal array four level orthogonal array. Instead blows the regeneration

experiment to be complex, the precision requests high, the result request is accurate, must carry on experiments many times. Therefore uses L16(45) four water glass elected.

3. Filling in experiment planning chart

Decides on 1 separately, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 experimental concrete contents, has completed the same level orthogonal experiment plan design. If on Table 2.

Table 2. Orthogonal Instead Blows the Regeneration Experiment Planning Chart

Factor	injection pressure	injection time	injection from	spray nozzle diameter	pulse width
Column code	MPa	s	mm	mm	Ms
Test number	A	B	C	D	E
1	1 0.3	1 50	1 20	1 4	1 46
2	1 0.3	2 60	2 30	2 5	2 198
3	1 0.3	3 70	3 40	3 6	3 292
4	1 0.3	4 80	4 50	4 7	4 396
5	2 0.4	1 50	2 30	3 6	4 396
6	2 0.4	2 60	1 20	4 7	3 292
7	2 0.4	3 70	4 50	1 4	2 198
8	2 0.4	4 80	3 40	2 5	1 46
9	3 0.5	1 50	3 40	4 7	2 198
10	3 0.5	2 60	4 50	3 6	1 46
11	3 0.5	3 70	1 20	2 5	4 396
12	3 0.5	4 80	2 30	1 4	3 292
13	4 0.6	1 50	4 50	2 5	3 292
14	4 0.6	2 60	3 40	1 4	4 396
15	4 0.6	3 70	2 30	4 7	1 46
16	4 0.6	4 80	1 20	3 6	2 198

2.2. Orthogonal Design Test Result Analysis

Because the filtration parameter is invariable, in order to before guarantee instead blows starts on the filtering element particle level thickness to be as far as possible same, this experiment used the differential pressure instead to blow the way, this experiment established this value is 15.0Kpa.in filtration process, when the tube funnel both sides differential pressure increased to certain value, will use the pulse instead to blow filters the body regeneration.

2.2.1. Visual Observation Analysis

Because the filtration parameter is invariable, in order to before guarantee instead blows starts on the filtering element particle level thickness to be as far as possible same, this experiment used the differential pressure instead to blow the way, this experiment established this value is 15.0Kpa, in filtration process, when the tube funnel both sides differential pressure increased to certain value, will use the pulse instead to blow filters the body regeneration.

2.2.2. General Computation Analysis

The computation analysis program is as follows: In factor injection pressure A four units place level:

1 level (A1,0.3MPa) causes sum of the result is:

72.2+78.7+81.5+77.2=309.6

2 levels (A2,0.4MPa) cause sum of the result are:

85.4+85.3+85.4+85.2=341.3

3 levels (A3,0.5MPa) cause sum of the result are:

92.6+98.3+92.3+86.3=369.5

4 levels (A4,0.6MPa) cause sum of the result are:

85.5+83.7+83.2+82.0=334.4

The similar method, factor injection time B, the factor injection from C, factor spray nozzle diameter D, the factor pulse width E four units place level causes sum of the result to be possible to calculate, fills in the result in the table. May see from Table 3 analysis result, A, B, C, D, E take A3, B2, C4, D3, E1 separately are good.

Table 3. Orthogonal Instead Blows the Regeneration Test Result Analytical Table

	experimental plan					test result
Factor Column code Test number	injection pressure MPa A	injection time s B	injection from mm C	spray nozzle diameter mm D	pulse width ms E	instead blows the efficiency %
1	1 0.3	1 50	1 20	1 4	1 46	72.2
2	1 0.3	2 60	2 30	2 5	2 198	78.7
3	1 0.3	3 70	3 40	3 6	3 292	81.5
4	1 0.3	4 80	4 50	4 7	4 396	77.2
5	2 0.4	1 50	2 30	3 6	4 396	85.4
6	2 0.4	2 60	1 20	4 7	3 292	85.3
7	2 0.4	3 70	4 50	1 4	2 198	85.4
8	2 0.4	4 80	3 40	2 5	1 46	85.2
9	3 0.5	1 50	3 40	4 7	2 198	92.6
10	3 0.5	2 60	4 50	3 6	1 46	98.3
11	3 0.5	3 70	1 20	2 5	4 396	92.3
12	3 0.5	4 80	2 30	1 4	3 292	86.3
13	4 0.6	1 50	4 50	2 5	3 292	85.5
14	4 0.6	2 60	3 40	1 4	4 396	83.7
15	4 0.6	3 70	2 30	4 7	1 46	83.2
16	4 0.6	4 80	1 20	3 6	2 198	82
Sum of the 1 level result	309.6	335.7	331.8	327.6	338.9	
Sum of the 2 level result	341.3	346	333.6	341.7	338.7	
Sum of the 3 level result	369.5	342.4	343	347.2	338.6	T=1354.8
Sum of the 4 level result	334.4	330.7	346.4	338.3	338.6	$\bar{y}$ =84.68
Deviation S_j	455.18	35	37.85	51.16	0.015	
Superior level	A3	B2	C4	D3	E1	
Factor primary and secondary	A	D	C	B	E	

2.2.3 Compared with the Factor Deviation Sum of Squares, Discovers the Factor Primary and Secondary

A factor each level average value difference is bigger, showed this factor is bigger to the target function, therefore the available factor deviation sum of squares describes the factor to the target the influence size.With yi expressed the test result, T expressed the completely test result sum total, expressed the completely test result total average, sj expresses j row factor deviation sum of squares, namely:

$$T = \sum_{j=1}^{n} y_i \quad (1)$$

$$\overline{y} = \frac{T}{n} = \frac{1}{n}\sum_{i=1}^{n} y_i = \frac{1}{n}\sum_{j:1}^{r_j} M_{ij} \quad (2)$$

$$S_j = \frac{n}{r_j}\sum_{j:1}^{r_j}(m_{ij} - \overline{y})^2 = \frac{n}{r_j}\sum_{j:1}^{r_j}(\frac{y_i}{n}M_{ij} - \overline{y})^2 = \frac{r_j}{n}\sum_{j:1}^{r_j} M_{ij}^2 - \frac{1}{n}T^2 \quad (3)$$

Therefore，T=309.6+341.3+369.5+334.4=1354.8

$$\overline{y} = \frac{T}{16} = 84.68$$

$$S_j = \frac{4}{16}\sum_{j:1}^{r_j} M_{ij}^2 - \frac{1}{16}T^2$$

S1=455.18
S2=35.00
S3=37.85
S4=51.16
S5=0.015
S1>S4>S3>S2>S5
Therefore，A、B、C、D、E Five factor primary and secondary orders are:

Host ⟶ Time

A、D、C、B、E

Instead blows in the regeneration experiment the factor instead to blow the pressure the deviation to be biggest, is 455.18, it is the key aspect; The factor pulse width deviation is smallest, is 0.015, it is the secondary factor; But the factor injection time, the injection distance, the spray nozzle diameter leave the difference maybe 35.00, 37.85, 51.16, then is the general factor.

2.2.4. Revision Test

Because experimental factor integer and enumeration just right same, must carry on the revision test, otherwise cannot carry on the variance analysis, because does not have the erroneous row.

Supposes the orthogonal array to have P row.Altogether has n processing combination, each processing combination duplicates m experiment, with yij (i=1,2, ...n; j=1,2, ...m) expressed ith experiments the jth revision test result.

The total deviation sum of squares is:

$$S_T = \sum_{i=1}^{n}\sum_{j=1}^{m}(y_{ij} - \overline{y})^2 = \sum_{i=1}^{n}\sum_{j=1}^{m} y_{ij}^2 - \frac{T^2}{mn},\ f = mn - 1 \quad (4)$$

Here:

$$\overline{y} = \frac{T}{mn}, T = \sum_{i=1}^{n}\sum_{j=1}^{m} y_{ij} \quad (5)$$

$$f = mn - 1 = 48 - 1 = 47$$

Therefore，T=929.2+1023.7+1108.3+1003.5=4064.7

$$\overline{y} = \frac{T}{16 \times 3} = \frac{4064.7}{48} = 84.68$$

Each row deviation sum of squares is:

$$S_j = \frac{r_j}{mn}\sum_{n=1}^{r_j} M_{mn}^2 - \frac{T^2}{mn},\ f_j = r_j - 1 \quad (6)$$

$$fj = rj - 1 = 5 - 4 = 1$$

Therefore,

$$S_j = \frac{4}{48}\sum_{n=1}^{r_j} M_{mn}^{2} - \frac{T^2}{48} \quad (7)$$

Here Mij is j row numerical code is i completely test result and:

$$S1 = \frac{1}{12}(929.22+1023.72+1108.32+1003.52) - \frac{4064.7}{48} = 1355.75$$

$$S2 = \frac{1}{12}(1007.32+1037.82+1027.32+992.32) - \frac{4064.7}{48} = 103.35$$

The similar method obtains: S3=112.87;S4=152.08;S5=0.047

$$f_j = 16 \times 3 = 48 \quad , \quad S_T = \sum_{j=1}^{p} S_j + S_e \quad (8)$$

Here:

$$S_e = \sum_{i=1}^{n} \sum_{j=1}^{m} (y_{ij} - \overline{y_i})^2 \quad (9)$$

$$S_T = 345928.09 - \frac{T^2}{48} = 1724.21$$

$S_e = S_T - S_1 - S_2 - S_3 - S_4 - S_5$ =1724.21-1355.75-103.35-112.87-152.08-0.047=0.11

$$\overline{y_i} = \frac{1}{m}\sum_{j=1}^{m} y_{ij} \quad (10)$$

$$f_e = f - \sum_{i=1}^{p} f_i \quad (11)$$

$$f_e = f - f_1 - f_2 - f_3 - f_4 - f_5 = 47 - 3 - 3 - 3 - 3 = 32$$

Makes the F-test

$$F_j = \frac{s_j / f_j}{s_e / f_e} \sim F(f_j, f_e) \quad (12)$$

Because: Sl=Sf+Sl , fl=ff+fl
Because this experimental S spatial =0, therefore Sl = Sf
Therefore:

$$F_j = \frac{S_j / f_j}{S_e / f_e} \sim F(f_j, f_e) \quad (13)$$

$$F_1 = \frac{S_1}{3 \times 0.11} = \frac{1355.75}{3 \times 0.11} = 13291.67$$

$$F_2 = \frac{S_2}{3 \times 0.11} = \frac{103.35}{3 \times 0.11} = 1031.23$$

The similar method obtains: F3=1104.57; F4=1490.98;F5=0.47
The computed result will fill in Table 4 and the table 5.

Table 4. Revision Test instead Blows the Regeneration Test Result Analytical Table

	experimental plan					test result			
Factor	injection	injection	injection	spray nozzle	pulse	instead blows the efficiency %			Sum y_i
Column code	pressure	time	from	diameter	width				
	MPa	s	mm	mm	ms				
Test number	A	B	C	D	E				
1	1 0.3	1 50	1 20	1 4	1 46	72.2	72.3	72.3	216.8
2	1 0.3	2 60	2 30	2 5	2 198	78.7	78.7	78.7	236.1
3	1 0.3	3 70	3 40	3 6	3 292	81.5	81.5	81.6	244.6
4	1 0.3	4 80	4 50	4 7	4 396	77.2	77.2	77.3	231.7
5	2 0.4	1 50	2 30	3 6	4 396	85.5	85.4	85.3	256.2
6	2 0.4	2 60	1 20	4 7	3 292	85.3	85.2	85.3	255.8
7	2 0.4	3 70	4 50	1 4	2 198	85.4	85.4	85.4	256.2
8	2 0.4	4 80	3 40	2 5	1 46	85.2	85.2	85.1	255.5
9	3 0.5	1 50	3 40	4 7	2 198	92.6	92.6	92.5	277.7
10	3 0.5	2 60	4 50	3 6	1 46	98.3	98.3	98.2	294.8
11	3 0.5	3 70	1 20	2 5	4 396	92.3	92.2	92.3	276.8
12	3 0.5	4 80	2 30	1 4	3 292	86.3	86.3	86.4	259
13	4 0.6	1 50	4 50	2 5	3 292	85.5	85.6	85.5	256.6
14	4 0.6	2 60	3 40	1 4	4 396	83.7	83.8	83.6	251.1
15	4 0.6	3 70	2 30	4 7	1 46	83.2	83.2	83	249.7
16	4 0.6	4 80	1 20	3 6	2 198	82	82	82.1	246.1
Sum of the 1 level result	929.2	1007.3	995.5	983.1	1016.8				
Sum of the 2 level result	1023.7	1037.8	1001	1025	1016.1	T=4064.7			
Sum of the 3 level result	1108.3	1027.3	1028.9	1041.7	1016	$\bar{y}$ =84.68			
Sum of the 4 level result	1003.5	992.3	1039.3	1014.9	1015.8	S_T=1724.21			
Deviation Sj	1355.75	103.35	112.87	152.08	0.047	f =47			

2.2.5. Variance Analysis

In the orthogonal array each row deviation sum of squares Sj happen to is in the difference analysis various factors deviation sum of squares, the degree of freedom reduces 1 for the horizontal number. The variance analysis sees Table 5 to show.

Table 5. Variance Analytical Table

variance origin	sum of squares	degree of freedom	mean-square deviation	F
A	1355.75	3	451.92	13291.67
B	103.35	3	34.45	1013.23
C	112.87	3	37.62	1104.57
D	152.08	3	50.69	1490.98
E	0.047	3	0.016	0.47

error	0.11	32	0.034

F0.95（3，32）=2.92 F0.99（3，32）=4.46

Obviously factor A, B, C, D are highly remarkable, E is not remarkable. Because the factor pulse width is not remarkable, the injection distance, the injection pressure, the spray nozzle diameter, the injection time are highly remarkable, therefore the inspection position level tendency, possibly the most superior plan is: The injection pressure is 0.5MPa, the injection distance is 60mm, the spray nozzle diameter is 6mm, the injection time is 60s and the pulse width is 46ms.

3. Conclusion

3.1. Full Text Summary

At present the diesel engine post-processing technology already obtained the extensive research, but because the vehicle quite was high with the diesel engine emissions particle post-processing system application request, because the existing diesel engine post-processing system all sorts of reasons all left the promoted use the request to have section of distances. This article develops one kind of efficiency high, the cost low, the use simple reliable, affects the small diesel engine exhaust particle post-processing control system to the diesel engine performance. This test equipment can satisfy two filter the change filtration work.

Had proven through the orthogonal experiment when the spray nozzle diameter for φ6mm, the injection distance is 50mm, the injection pressure is 0.5Mpa, the pulse width is 46ms, the injection time is 60s, this kind of ceramic filter pulse instead blows the control system the effect to be best, simultaneously had also proven carries on the regeneration method using the compression gas to the diesel engine exhaust particulate filter the feasibility and the validity. Instead blows the regeneration technology to be reliable, the regeneration efficiency is high, has the widespread application value.

3.2. Forecast

The 21st century, our country soon joins the WTO organization, our country's automobile industry needs and the world automobile industry trail connection, the diesel engine particle filtration technology promotion imperative. According to the above the ceramic filter instead blow the regeneration technology to have its unique merit, this article thought that. The ceramic filter instead blow the regeneration control technology the development to have the broad prospect.

The test result indicated, this article proposed the diesel engine exhaust particle post-processing system technical plan is feasible, has to a certain extent overcome the past some post-processing technology existence question and the insufficiency.

As a result of the time and the test condition and so on the objective factor limit, this article has only done some foundational work in this aspect, is unable to carry on the further development to this article research work. Based on this article findings, the author thought may carry on the vehicle to carry the practical design, carries on the up to ten thousand kilometer vehicles path solid vehicle experiment.

References

[1] Adarsh Krishnamurthy, Wei Li, Sara McMains. *Simulation and optimization of the water-jet cleaning process.* Proceedings of the ASME 2009 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference. California. 2009: 1-9.
[2] Taroh Uchiyama, Satoshi Enamito, Kazuhiko Takesa. *Reserch Center Asahi Glass Co. Development Particulate Trap System with Cross Flow Ceramic Filter and Reverse Flow Cleaning Regeneration2*. 940463
[3] Guha, Anirban Barron, Ronald M Balachandar, et al. An experimental and numerical study of water jet cleaning process. *Journal of Mtitorials Processing Technology*. 2011; 211(4): 610-618.
[4] Feng Bohua. Chen turns over a new leaf, Li Bunian and so on. Chemical engineering handbook. Beijing: Chemical engineering publishing house. 1991.
[5] Ji Zhongli, Ding Fuxin. Outside ceramic filter tube funnel transient state flow field. *Chemical Industry Journal*. 2008; 51(2): 165-168.

[6] Renning Guo, Lin Xu, Qi Sunet, et al. Study of Influence on Internal Flow Field in Geometry of Fan-shaped Nozzles with Water Jet Cleaning. *Energy Procedia*. 2011; (13): 5665-5670.
[7] Vreeburg JHG, Boxall JB. Discolouration in Potable Water Distribution Systems:A Review. *Water Research*. 2007; 41(5): 519-529.
[8] Choi JG, Chung JW. Experimental Study on the Nozzle Effect of the Pulse Cleaning for the Ceramic Filter Candle.*Powder Techology*. 2001; 114(1-3): 129-135.
[9] Cui Xiaolan, Ji Zhongli, Chen Honghai. Spray nozzle design parameter to ceramic filter pipe internal pressure profile influence rule. *Petroleum University Journal (Natural Sciences Version)*. 2005; 25(3): 65-67.
[10] Kanaoka C, Kishima T, Furuuchi M. *Accumulation and Release of Dust from Rigid Ceramic Filter Element*. High Temperature Gas Cleaning, Germany. 1996; 183-188.
[11] Osama Elsayed Gouda, Eng Mohamed Dessoky, Ali Hassan. Comparison between Oil Immersed and SF6 Gas Power Transformers Ratings. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(1): 43-54.
[12] Ali Mohammadi, Sajjad Farajianpour, Saeed Tavakoli, S Masoud Barakati, Fluctuations Mitigation of Variable Speed Wind Turbine through Optimized Centralized Controller. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2012; 10(4): 659-669.