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Comparison of Epoxy and PTFE Teflon Vortex Tube Process Parameters Using Taguchi Technique

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Abstract

Vortex tube could be a machine that separates propellant into hot and cold streams. once high pressure air enters into the vortex chamber through one or a lot of tangential nozzles, a sturdy vortex flow created that splits into 2 regions. The high temperature air close to the boundary of the tube leaves circumferentially through the round shape valve wherever as the air at lower temperature leaves through the cold portal. A conical valve is adjusted with the hand control knob allows for adjusting the degree and temperature of air popping out from the cold end. there's no maintenance, no mess, no explosion hazard, no electricity, and no moving components in exploitation the vortex tube. Vortex tubes behave in avery certain and manageable manner. the sole disadvantage with the vortex tube is its low constant of performance (COP).

The Vortex tube used for experimental work is factory-made exploitation stuff Poly characid Fluoro alkene (PTFE TEFLON RODS) AND EPOXY POLYSTER RODS. AN Experimental work has been administrated to investigate the performance of vortex tube that influences the impact of 5 manageable input variables specifically diameter of the orifices, diameter of the nozzles, length of hot tube, tube diameter and recess pressure over the temperature distinction within the cold facet as output exploitation Taguchi technique. Experiments were conducted at completely different input pressures of air, viz., at 2, four and half-dozen bars and for various diameters of orifices, viz., 5 mm ,6.5mm and 8 mm. The supply for compressed gas input to the vortex tube was reciprocal compressor. the varied Parameters like main impact analysis, analysis of variance (ANOVA) and optimum Cold Temperature were carried out in order to confirm the effects of method parameters and optimum issue settings. Finally, the confirmation check is distributed to verify the accuracy of Taguchi technique.

Keywords: Vortex tube, geometrical parameters, passage diameter ,tube length, Taguchi method.

Introduction

The Vortex Tube is associate economical and low price resolution to a decent reasonably industrial spot cooling and technique cooling wishes. The Vortex tube might be a tool that produces cooling at one end and heating at the other end at an equivalent time. The very gas is forcing through a generation chamber, and by the virtue of high and restricted volume the pressure head of feeding air is get regenerate into the kinetic head that generates the centrifugal spin of air on the inner walls of the tube. The schematic diagram of Vortex tube is shown in figure one. it's no moving parts; pressurised gas is injected tangentially into a swirl chamber and accelerates to a high rate of rotation

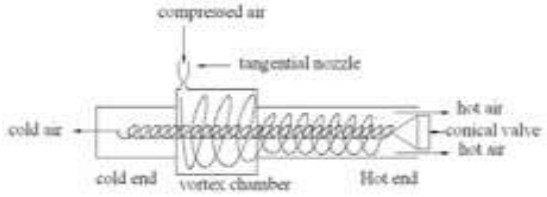

Figure 1: Schematic diagram of Vortex tube

The compressed gas that is provided to the vortex tube and passes through nozzles that area unit tangent to an indoor counter bore. These nozzles set the air during a vortex motion. This spinning stream of air turns 90° and passes down the recent tube within the type of a spinning shell, just like a tornado as a result of the conic nozzle at the tip of the tube, solely the outer shell of the propellent is allowed to flee at that

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finish. the rest of the gas is forced to come back in AN inner vortex of reduced diameter at intervals the outer vortex. A proportion of the recent, high-speed air is allowable to exit at the management valve. the rest of the (now slower) air stream is forced to counter flow up through the middle of the high-speed air stream, abandoning heat, through the middle of the generation chamber finally exiting through the other finish as extraordinarily cold air. For the performance analysis of this type of vortex tube is being created on the premise of some series of different-different mechanical, physical and constructional options

Materials used in fabrication of vortex tube

The Vortex tube used for experimental work is store-bought pattern materials is Poly characid Fluoro gas (PTFE TEFLON RODS) AND EPOXY POLYSTER ROD as shown in figures below .PTFE TEFLON rods having temperature confrontation is 2600c and pressure with stand ready capable of 35bar. The EPOXY POLYSTER RODS having temperature confrontation is 250^0C .

figure 2.vortex tube with PTFE Teflon material.

figure 3.vortex tube with epoxy polyester rod

Experimental study

In this study, a counter flow sort Ranque–Hilsch vortex tube with (L=180 millimeter, D =25mm) L/D magnitude relation up to eight was used. 3 completely different orifices (5mm ,6.5mm ,8mm) with completely different nozzle numbers (11mm, 14mm ,17mm) are factory-made and utilized in the experiments as shown in figure. every one of the nozzles has identical constant sq. cross-sectional .

PTFE Teflon rod

epoxy polyester rod

figure 4. orifices used in the experiments.

The mass flow rates at the cold and hot shops of the counter flow Ranque–Hilsch vortex tube are measured by use of a rotameter. The temperatures of the pressurised gas at the recess, and also the cold and hot shops were measured by use of a measuring device with ±0.5 0C exactness tolerances, and also the obtained temperature values are regenerate into Kelvin (K) unit.

Temperature probes of the measuring device were placed into the opening that was trained at the middle of the counter flow Ranque– Hilsch vortex tube and far from the cold and also the hot shops. an effect valve has been mounted on the recent outlet of the tube so as to regulate the mass rate of the recent air. Before beginning the experimental studies, the management valve on the recent outlet was unbroken in totally open position.

Taguchi technique applied to vortex tube

By applying taguchi technique, the performance of vortex tube are optimized merely. the quantity of iterations to conduct the experiment are reduced. the possibility issue decreases. in our experiment, we have a tendency to tend to used static vogue considering no noise factors. the number fifty quantitative relation relies on "smaller is better", since we have got to optimize the result to induce minimum cold temperature.

A). ORTHOGONAL ARRAYS (OAS):

In selecting associate acceptable OA, the pre-requisites square measure (ross, 1988; roy, 1990): choice of technique parameters and or interactions to be evaluated. choice of vary of levels for the chosen parameters.

The determination of that parameters to analysis hinges upon the merchandise or technique performance characteristics or responses of interest (ross, 1988). many ways square measure steered by taguchi for determinant that parameters to include in associate experiment. these square measure (ross, 1988):

. act
. flow charting
. cause-effect diagrams

Taguchi orthogonal arrays square measure experimental designs that usually would like exclusively a fraction of the full-factorial combos. many orthogonal arrays square measure on the market in various forms, like aliquot factorial and plackett-burman designs. the arrays square measure designed to handle as many factors as potential throughout a certain vary of runs. the columns of the arrays square measure balanced and orthogonal. this implies that in each strive of columns, all issue

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combos occur an identical vary of times. orthogonal designs allow u. s. of america to estimate the results of each issue on the response severally of all various factors. taguchi has given traditional organization of yankee states for two level and three level factors which is able to accommodate handful vary of things for experimentation. depending on the number of things planned and levels for the factors, appropriate OA will be chosen from. in our gift work, we've got chosen l-27 array to hold out experiments.

Contribution experimental work

A). DESCRIPTION

The arrangement of the experimental system moreover because the activity devices of a vortex tube unit of measurement shown inside the below figure. The system consists of a vortex tube chamber with the tangential water nozzle or vortex generator, cold passageway plate, cone shaped valve, measuring device, water valve, mechanical device severally. throughout the take a glance at, the propellant was discharged from associate mechanical device through the gauge with the help of a sway valve before returning into the RHVT at a given water pressure. inside the RHVT, the air is separated into two streams with low and high temperatures.

The cold air leaves the RHVT through the cold passageway plate place in near the water nozzles, whereas the recent air at liberty at the highest of the recent tube equipped with the cone shaped valve. The temperatures unit of measurement noted by victimization measuring system. the road diagram of the experimental started is shown below Figure .

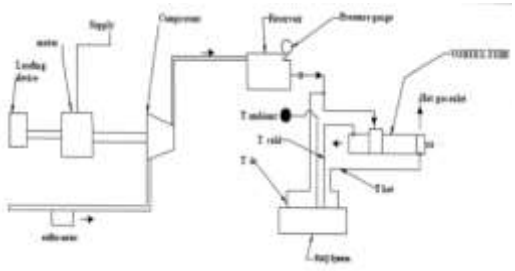

Figure 5. Line diagram of Experimental setup.

The experimental setup consists of two stage machine, gauge, vortex tube and temperature instrument. a sway valve at the machine reservoir exit controls the water air to the vortex chamber. The water pressure is measured victimization gauge. The temperatures of the air at cold end and shut air unit of measurement measured victimization measuring system. Experimental work has been distributed to analysis the cooling impact of vortex tube at whole whole totally different combos of pressures, passageway diameters, nozzle diameters, Vortex tube diameters, and lengths of the Vortex tube. The temperature of air at cold and hot ends was measured with digital additionally as analog thermometers to avoid errors. All the instruments were label before the measurements were really determined recorded. The operative parameters noted throughout the experiment for each vortex tube vogue were:

. atmospheric pressure near water to vortex tube in bars.

. Cold air temperature in oC.

Then the automaton pressure is increased to four bar and so the readings unit of measurement taken in associate passing similar manner. The procedure is followed up to 6 bar. The readings unit of measurement tabulated as shown. once taking the readings with all the diaphragms, the recent tube is changed that as whole totally different Lengths. The experiment is distributed in an exceedingly similar manner for all hot tubes. **the software used for analysis and optimization is MINITAB 16.**

Results and conclusions

A). CHOICE OF ORTHOGONAL ARRAY AND PARAMETER ASSIGNMENT

For this experimental work the five methodology parameters each at three levels square measure determined. it's fascinating to have three minimum levels of methodology parameters to mirror truth behavior of output parameter of study. the strategy parameters unit renamed as factors which they unit given at intervals the adjacent column. the degree of the individual methodology parameters/factors unit given in Table .

Table 1:method Parameters and their Levels

Factors	Parameters	Levels		
		L1	**L2**	L3
A	Length of the tube	120	150	**180**
B	Inner diameter of orifice	5	6.5	**8**
C	Inner diameter of hot tube	11	14	**17**
D	Inner diameter of the Nozzle	11	14	**17**
E	**Pressure**	**2**	**4**	**6**

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As per Taguchi experimental vogue philosophy a set of three levels assigned to each technique parameter has two degrees of freedom (DOF). this offers a whole of ten DOF for five technique parameters designated throughout this work. for each trial inside the L27 array, the degree of the tactic parameters unit indicated in Table.

B). EXPERIMENTAL RESULTS:

The Vortex tube experiments were conducted to check the impact of method parameters over the output response characteristic with the method parameters. The experimental results for temperature are given in Table a pair of. twenty seven experiments were conducted victimisation Taguchi experimental style methodology and every experiment was merely continual twofold and also the average is calculated for main impact values. within the gift study all the styles, plots and analysis are distributed victimisation Minitab applied mathematics code.

Table 2 Taguchi's L27 Standard Orthogonal Array with PTFE TEFLON materials

Trial No.	Temperature(°C)	S/N Ratio
1	8	**-48.9741**
2	5	**-48.8809**
3	3	**-48.8182**
4	5	**-48.8809**
5	-1	**-48.6914**
6	-3	**-48.6273**
7	8	**-48.9741**
8	4	**-48.8496**
9	-1	**-48.6914**
10	3	**-48.8182**
11	-2	**-48.6594**
12	-5	**-48.5627**
13	7	**-48.9432**
14	5	**-48.8809**
15	2	**-48.7867**
16	8	**-48.9741**
17	6	**-48.9121**
18	4	**-48.8496**
19	8	**-48.9741**
20	4	**-48.8496**
21	2	**-48.7867**
22	10	**-49.0357**
23	7	**-48.9432**
24	3	**-48.8182**
25	4	**-48.8496**
26	2	**-48.7867**
27	**-2**	**-48.6594**

Table 3 ***Taguchi's L27 Standard Orthogonal Array with epoxy polyester materials***

Trial No.	Temperature(°C)	S/N Ratio
1	29.5	-29.3964
2	27.5	-28.7867
3	26	-28.2995
4	19.5	-25.8007
5	17.5	-24.8608
6	15.6	-23.8625
7	20.5	-26.2351
8	19.5	-25.8007
9	17	-24.6090
10	17	-24.6090
11	15.5	-23.8066
12	14.25	-23.0763
13	23.5	-27.2346
14	21.5	-26.6488
15	20	-26.0206
16	23.5	-27.4214
17	21.5	-26.6488
18	20.5	-26.2351
19	24.5	-27.7833
20	21	-26.4444
21	18.5	-25.3434

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22	16.5	-24.3497
23	14.25	-23.0763
24	10	-20.0000
25	19.5	-25.8007
26	17.5	-24.8608
27	16.5	-24.3497

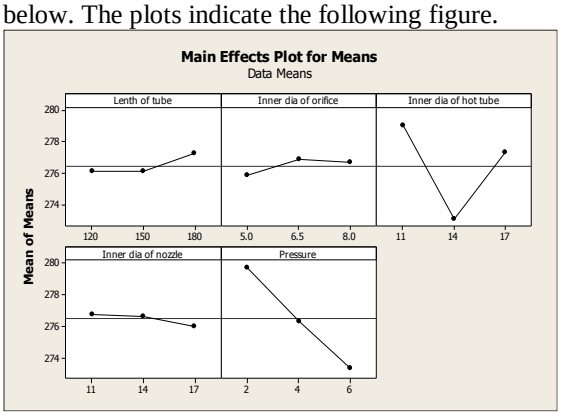
A-Length of the tube; B-Inner diameter of the orifice; C-inner diameter of the hot tube; D-inner diameter of the nozzle; E-Pressure

Analysis and discussion of results

The Vortex tube experiments were conducted by victimisation the constant quantity approach of the Taguchi's methodology. the consequences of individual vortex tube method parameters, on the chosen quality characteristic –temperature, are mentioned during this section. the typical worth and main impact magnitude relation of the response characteristic for every variable at completely different levels were calculated from experimental knowledge. the most effects of method variables each for data were planned. The response curves (main effects) square measure used for examining the constant quantity effects on the response characteristic. The analysis of variance (ANOVA) of {raw knowledge| data |information} and main impact analysis data is applied to spot the numerous variables and to quantify their effects on the response characteristic. the foremost favorable values (optimal settings) of method variables in terms of mean response characteristic square measure established by analyzing the response curves and also the multivariate analysis tables.

A). MAIN EFFECTS PLOT FOR MEANS:WITH PTFE TEFLON

the main effects plot for the means is shown in below. The plots indicate the following figure.



B) MAIN EFFECTS PLOT FOR MEANS WITH EPOXY POLYSTER

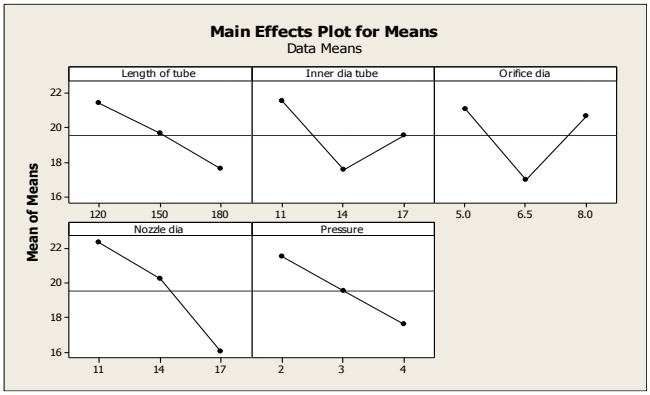


Table 3 .Analysis of Variance for Means(raw data) with ptfe teflon

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Lenth of tube	2	7.407	7.407	3.7037	4.00	0.111
Inner dia of orifice	2	4.963	4.963	2.4815	2.68	0.183
Inner dia of hot tube	2	165.852	165.852	82.9259	89.56	0.000
Inner dia of nozzle	2	3.185	3.185	1.5926	1.72	0.289
Pressure	2	187.185	187.185	93.5926	101.08	0.000
Lenth of tube*Pressure	4	2.815	2.815	0.7037	0.76	0.602
Inner dia of orifice*Pressure	4	1.926	1.926	0.4815	0.52	0.729
Inner dia of nozzle*Pressure	4	7.704	7.704	1.9259	2.08	0.248
Residual Error	4	3.704	3.704	0.9259		
Total	26	384.741				

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Table 4 .Analysis of Variance for Means (raw data) with epoxy

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Length of tube	2	65.681	65.681	32.8406	57.03	0.000
Innerdia tube	2	71.604	71.604	35.8018	62.17	0.000
Orifice dia	2	89.076	89.076	44.5379	77.34	0.000
Nozzle dia	2	183.823	183.823	91.9115	159.60	0.000
pressure	2	68.642	68.642	34.3212	59.60	0.000
Residual error	16	9.214	9.214	0.5759		
total	**26**	**488.040**				

C). CONFIRMATION EXPERIMENT :

In order to validate the results obtained, 2 confirmation experiments were conducted for the response characteristic (Temperature) at best levels of the method variables. the typical values of the characteristic were obtained. The results square measure given in Table one. The values of temperature obtained through confirmation experiments square measure among the ninety fifth of confirmation experiment of response characteristic. it\'s to be seen that this best price is among the desired vary of method variables. Any extrapolation ought to be confirmed through further experiments, by victimization 2 composite materials square measure results square measure obtained.

Table 4. Confirmation Experiment with teflon

Performance measures/Response	Optimal set of parameters	Actual value(°C)
Temperature	**A2B1C2D3 E3**	**-5**

Table 5. Confirmation Experiment with epoxy

Performance measures/Response	Optimal set of parameters	Actual value(°C)
Temperature	A3 B2 C2 D3 E3	11

Conclusions

The effects of the method parameters viz. Length of the tube, Inner diameter of vortex tube, Diameter of passage way, Inner diameter of nozzle and compressed gas pressure on response characteristic viz. Temperature was studied. The best sets of method parameters were obtained for Temperature victimization Taguchi's style of experiment methodology. The outline of the 2 composite materials results of foretold best values of the responses are given as under: by scrutiny the 2 materials are the foremost important values obtained by PTFE TEFLON ROD.

Table 6. Predicted Optimal Values and Results of Confirmation Experiment with Teflon

Response	Optimal set of parameters	Predicted value(°C)	Actual value(°C)
Temperature	**$A_2B_1C_2D_3E_3$**	**-4.7**	**-5**

Table 7. Predicted Optimal Values and Results of Confirmation Experiment with epoxy

Response	Optimal set of parameters	Predicted value(°C)	Actual value(°C)
Temperature	A3B2C2D3E3	11.36	11

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