HUNGARIAN JOURNAL
OF INDUSTRIAL CHEMISTRY
VESZPRÉM
Vol. 30. pp. 257 - 259 (2002)

THE INFLUENCE OF WATER SOLUBLE VARNISHES ON THE CATALYST DURING ENAMELLING PROCESS

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Received: August 21, 2002

During the drying process of enamel wires production, enamel varnishes liberate large amounts of vapour from solvents and diluents, as well as other products from the destruction of the varnish base. An appropriate method for their destruction is catalytic combustion. This requires certain characteristics of the catalysts. The use of the new so-called water soluble enamel varnishes, increases the possibilities for catalyst poisoning.

The catalytic activity of Pd-laid catalyst in destructive oxidation of organic substances in the presence of water vapour was studied on a large-scale production trials. It was established that the greater quantity of water vapour does not decrease the conversion degree. On the contrary, it is slightly increased (by 9-10 %). These contribute to not only diluent economy and environmental protection, but as well retain the existing technology of enamel wires.

Keywords: catalytic combustion, catalyst poisoning, water vapour, water-soluble varnish

Introduction

During drying and polycondensation processes of enamel wires production, enamel varnishes liberate fairly large amounts of vapour from solvents and diluents, as well as other products from the destruction of the varnish base, mainly cresols and di-, and tetramethylbenzenes. These are strong toxins and environmental pollutants. [1] An appropriate method for their destruction is catalytic combustion. The obtained heat, through recirculation of the exhaust gasses, is used in the drying process. [2] This requires certain characteristics from the catalysts, i.e. action at comparatively high temperatures as well as in the presence of multicomponent mixtures of substances, some of which may act as contact poisons. These problems become more important with the use of the new so-called water soluble enamel varnishes, where the quantity of water vapour in the exhaust gases inevitably increases.

The literature shows at length that during exploitation, the activity of the catalyst is changed under the influence of various factors. Generally, this means decrease of the active surface because of sintering or blocking due to precipitation as well as poisoning. The most important factor for deactivation is poisoning. It is a process, which lead to catalytic activity decrease and in diffusion limited reactions to activation energy and selectivity changes. It is known that the action of the poison is specific for a particular catalyst and a particular reaction.

It is interesting to point out that at times, when the concentration of the poison is not high, instead of deactivating a certain catalyst or reaction, it may have an opposite activating effect [3].

In the SICME (Italy) and PGZ (Hungary) horizontal enamel machines, the catalytic elements of KATEC Company (Germany) are widely used for air purification process. They have a square shape and look like a metal air filter. The active phase, palladium is laid on a chromium steel crimped band. According to the database of the producer, soot or high molecular compounds could deactivate the catalyst. It is sensitive to halogens, sulphur dioxide, and phosphorous compounds. The catalyst loses about 25 % of its activity after around 8000 hours use [4].

The literature review shows that a number of oxide catalytic systems are sensitive to the comparatively weak contact poisons of H_2O and CO_2 [5]. What is more, a reversible poisoning is detected after the initial action of the poison has ceased. Comparatively few data exist on the influence of these poisons on platinum and other catalysts containing noble metals. It is pointed out that usually, water in a reduction conditions acts as a poison on the metal type catalyst [5].

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Table 1 Dependence of combustion degree from the concentration and temperature

Machine type	Varnish type	C_{in}, (mg/m^3)	C_{out} (mg/m^3)	T_{in} (°C)	T_{out} (°C)	ΔT (°C)	Combustion degree, (%)
PGZ	P-940	8.29	4.81	450	525	75	41.98
PGZ	P-940	7.38	4.46	450	520	70	39.50
PGZ	HB-91	5.07	2.42	450	515	60	52.26
PGZ	HB-91	4.95	3.36	450	510	60	52.32
SICME	P-940	7.60	4.79	450	520	70	36.97
SICME	P-940	8.10	5.18	450	520	70	36.00
SICME	HB-91	5.18	2.85	450	500	60	44.98
SICME	HB-91	5.34	2.95	450	500	60	44.75

Because of this, as well as the development of a new class of water soluble enamel varnishes which meet ecological aims, it is of interest to investigate the catalytic activity of palladium laid catalysts in the destructive oxidation of organic substances in the presence of water vapour.

Experimental

The investigation was carried out with varnishes P-940, esterimide, and the water soluble HB-91, produced in test series, containing dry substance, respectively 27.5 % and 41.0 %, with PGZ and SICME horizontal machines working with catalyst used for over a year. Their activity in the combustion reaction was assessed by determining the total amount of burning organic substances in recycled air, expressed as a content of total organic carbon, before and after the catalyst at equal constant volume velocity, by the absorption method [6].

Results and Discussion

Results are shown on *Table 1*. Clearly the concentration of burning toxic substances in the air using the HB-91 decreases compared to the estherimide varnish, as well as showing smaller temperature differences ($T_{in} - T_{out}$) in the catalyst layer at the adiabatic temperature increase. The comparatively small temperature difference points to a certain degree of deactivation of the catalysts over the one-year period of work. The main conclusion is that the greater quantity of water vapour does not decrease the catalytic combustion degree, i.e. the degree of activity. On the contrary, it is slightly increased (by 9-10 %).

This can only be explained by the regeneration of the catalyst surface owing to the coke deposits from carbohydrates of unknown composition laid on it, as well as some high-molecular compounds released by the decomposition of the varnishes.

In support of this conclusion, the results of other authors regarding the regeneration of Pt catalyst may be referred to. Usually, a catalyst containing laid on coke is regenerated by its combustion in airflow at high temperatures. To obtain the necessary oxygen concentration, it is suggested that the air be diluted with inert gases, or steam where the reaction of the latter with carbon plays an essential role [6].

Table 2 Characteristics of the water varnish enamelling process

Varnish	Dry mass (%)	Wire diameter (mm)	Wire velocity (m/s)	Productivity (kg/h/pass)	Energy expense (kWh/day/ pass)	Varnish expense (g/kg)
BH-91	41	0.016 ±0.02	1.83/1.80	1.173	57.09	170
P–940	27.5	0.016 ±0.02	1.83/1.83	1.173	51.36	157

Productivity, energy and varnish expenses for both varnish experiments are given on *Table 2*. In comparison, it can be seen only a slight increase of the energy expenses when working with the water-soluble varnish. This could be explained by the lower heat amount released in the catalyst layer, which can be completely compensated by the electrical heaters if necessary.

According to these and to the good quality characteristics of the produced wires we consider that the enameling process with the studied water-soluble varnish does not infringe the catalytic combustion of the exhaust gases and fully correspond to the existing technology.

Conclusions

The investigation is of interest in view of the possibility of using water soluble enamel varnishes for production of enamel wires. It was established that the greater quantity of water vapour does not decrease the destruction oxidation degree. On the contrary, it is slightly increased (by 9-10 %). These contribute to not only diluent economy and environmental protection, but correspond with the existing technology of enamel wires.

Acnowledgement

The author expresses her thanks to Professor Dr.D. Klisurskii from the Bulgarian Acad. of Science for the valuable discussions and support.

SYMBOLS

C_{in}, C_{out}	the inlet and outlet concentration of combustible organic substances, expressed as total organic carbon
T_{in}, T_{out}	the inlet and outlet temperature of the catalyst layer

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