ador WELDING

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Solution for Auto Exhaust Systems

The use of stainless steels in automobiles started when automobiles came to be equipped with 3 way catalytic converters to meet intensifying regulations over exhaust gas emissions. The requirement to have longer service life accelerated the switchover from hot dip aluminized carbon steel to stainless steel in this application. Today, stainless steel is used in almost all exhaust system parts from the cylinder head gasket to the tail pipe. The consumption of stainless steel in the exhaust system per passenger car varies from model to model but averages about 15kg per car. The stainless steel consumption is expected to increase in the exhaust system of diesel powered automobiles, mainly trucks, to meet the growing social demand for stricter exhaust gas emission regulations.

Exhaust system materials are exposed to a variety of harsh conditions, and must be resistant to such degradation mechanisms as high temperature oxidation, condensate and salt corrosion, elevated temperature mechanical failure, stress corrosion cracking, and inter-granular corrosion.

The exhaust gas emitted from automobiles is one cause of air pollution, and various efforts have been made to prevent this problem. One of the preventive measures is the system shown in the figure. The exhaust gas from a gasoline engine forms condensed water containing the ions of ammonia (NH4-), sulfuric acid (SO42-), chlorine (Cl-), nitric acid (NO3-), carbonic acid (CO32-), etc. when it is cooled. These ions are very corrosive and create a very severe environment for materials. The whole external surface of an exhaust system must also have corrosion resistance to the deicing salts used in cold districts and to atmospheric salt in coastal districts.

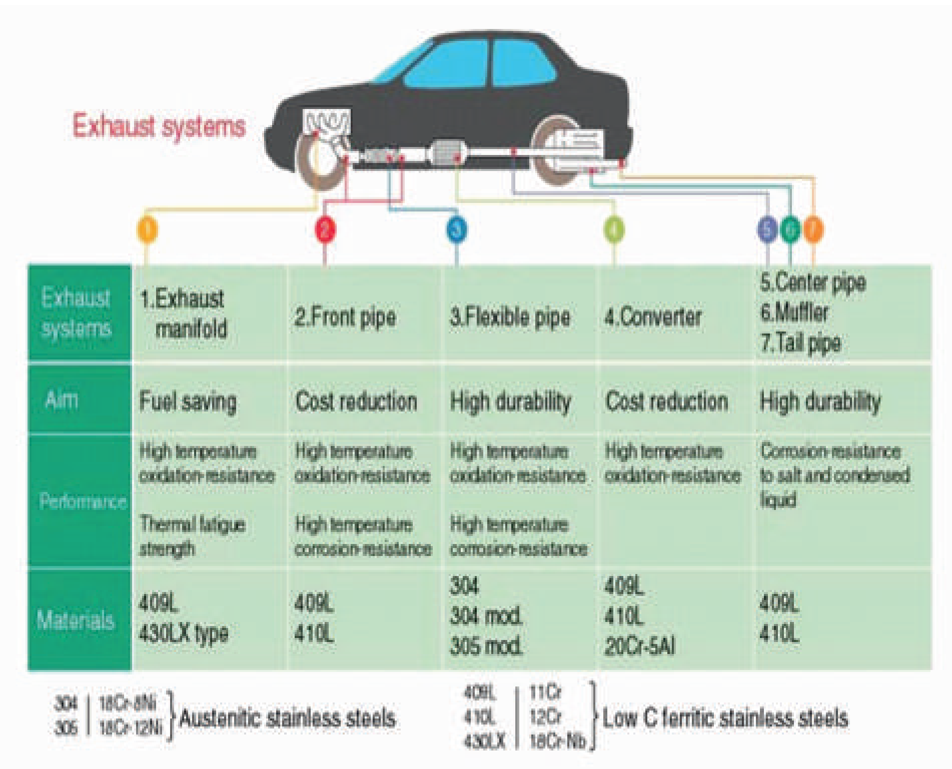
The components downstream from the muffler of an exhaust system must have sufficient corrosion resistance to withstand the internal attack of condensed water containing these corrosive ions and external attack of these salts. The materials mainly used for these components are low-carbon ferritic stainless steel incorporating not less than 11% chromium. The components nearer to the engine in front of the muffler need high oxidation resistance, because they are heated to about 773K (500) during operation. The exhaust manifold, which is heated to the highest temperature, must possess both high-temperature strength and resistance to thermal fatigue. High-chromium stainless steel is now used mainly for these upstream components. As a result, the life of the exhaust system has been substantially extended.

In addition to these efforts to improve corrosion resistance, it is also necessary to gain economic improvements by reducing the weight of the complete exhaust system. Material development is being carried out at present to achieve this result.

The fuel economy of internal combustion engines and the cleanliness of the associated emissions can be improved by increasing the temperature of the exhaust gas, which currently can be in excess of 900°C. The main function of catalytic converter is to accelerate transformation of toxic components such as CO, NO2 into non - toxic components. For each 1°C increase in conversion temperature, the efficiency of conversion increases by 0.3%, thus helping to reduce greenhouse gas emissions. Consequently, the design of emission system components calls for a new generation of materials that can meet the high demands of improved fuel efficiency and emissions reduction. Stabilized ferritic stainless steels represent the best cost / benefit solution for exhaust system components: it gives designers optimal combinations that work both in elevated temperatures and complex corrosive environments.

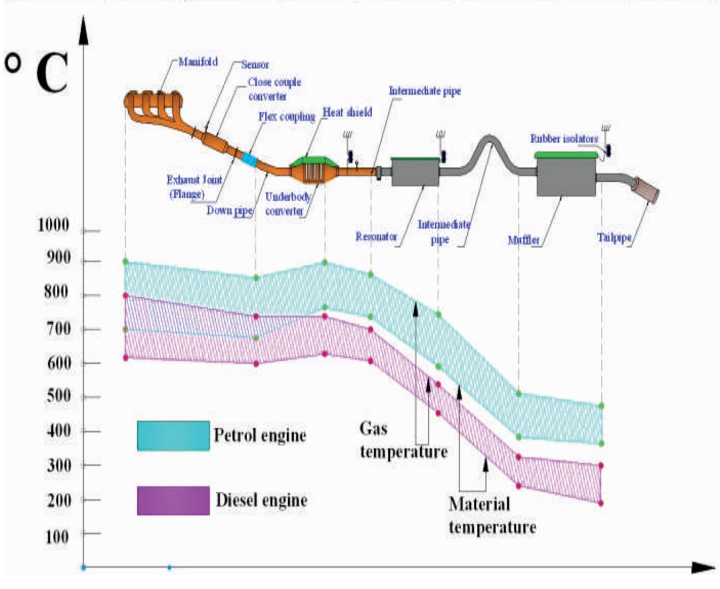
The exhaust system components are manifold, close coupled and underbody catalytic converters, flexible bellow, muffler, resonator, connecting pipes, flanges, and tailpipe. The part of the exhaust system containing the manifold, converter and the flex joint is named as hot end since this part of the system is relatively hot due to the hot exhaust gas passing through these components. The part consists of intermediate pipe, resonator and the muffler is named as cold end since the gas tends to cool down from the exit of the flex tube. The temperature of the hot end of the gasoline operated vehicle can be as high as 1050°Cwhile the highest temperature of the cold end is about 650°C. Material selection of an exhaust system depends on several parameters like usage temperature, geographical region and application. A typical example of an exhaust system and the thermal histogram of the exhaust system for diesel and gasoline applications are given below:

Stainless Steels used in Exhaust Systems



Exhaust system components and main materials used

Part No.	1	2	3	4	5	6	-
Part Name	Exhaust Manifold	Front Pipe	Flexible Pipe	Catalytic Converter	Center Pipe	Main Muffler	Tail End Pipe
Service Temperature (°C)	750 - 950	600 – 800			400 - 600	100 – 400	
Required Properties	High temperature strength Thermal fatigue life Oxidation resistance Workability		High temperature strength Workability Salt Damage Resistance		Salt damage resistance	Corrosion resistance at inner surface (condensate) Corrosion resistance at outer surface (salt damage)	
Current Materials	Type 409L Type 430L Type 434 Type 444		Type 304	Type 409L Type 436L Type 434	Type 409L	Type 409L	Type 409L Type 430L Type 436L



Material Grade Vs Mechanical Properties

MATERIAL GRADE	HARDNESS	HARDENABILITY	DUCTILITY	WELDABILITY	STRENGTH	CORROSION RESISTANCE	BRITTLENESS	REMARKS *
409L	↑	↔	↔	↑	↑	↔	↔	Excellent Formability Heat resistance
432L	↑	↔	↔	↑	↑	↑	↔	High Yield strength and Hardness
439L	↑	↔	↔	↑	↑	↑	↔	High thermal conductivity. Heat resistance,low thermal expansion coefficiency
436LM	↑	↔	↔	↑	↑	↑	↔	Excellent in corrosion resistance, drawability and weldability due to the addition of Ti and Nb
430 J1L	↑	↔	↔	↑	↑	↑	↔	It has superior corrosion resistance, drawability, weldability and high temperature oxidation resistance.

↑ INFLUENCES | ↓ OPPOSSES | ↔ NEUTRAL

There are benefits of Nb regarding oxidation resistance at high temperatures. It has been demonstrated that Nb containing ferritic grades have better high temperature performance when compared to Ti single-stabilized or austenitic grades. This is because Nb forms a thin, homogeneous and adherent oxide layer in the surface of the steel, avoiding spalling and re-oxidation of the material during the exhaust system thermal cycling (the typical on/off operation of the car's engine). It also results in lower loss of material which can be translated into higher life cycles of the component, meaning a longer life, reduced frequency of replacement and long term cost savings. Study on metal loss of different stainless steels at 950°C shows that with increase in Nb content, higher temperature oxidation resistance improves as Nb forms less porous and more adherent oxides which results in less spalling and less re-oxidation.

ADOR SOLUTIONS

Solid wire:

Miginox 430LNb :

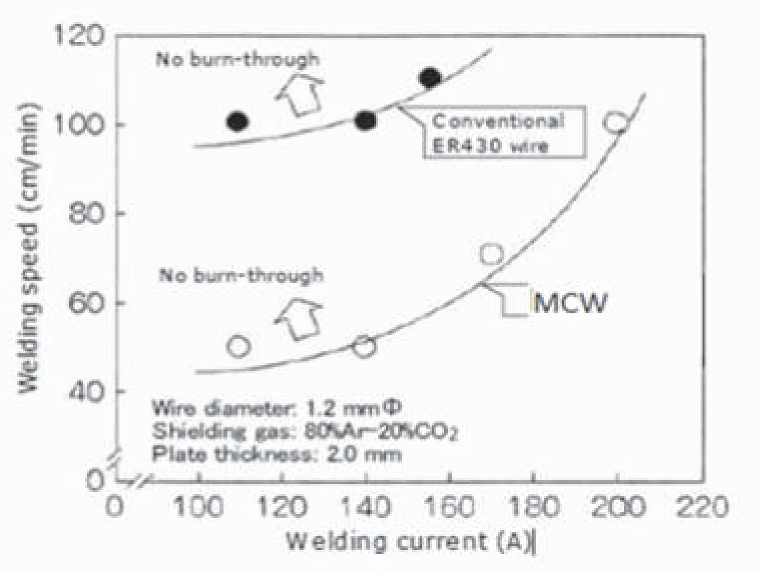
- Superior wire of unique chemistry stabilized with Nb.
- Minimizes the consumption of nozzles and avoids the excess of projections during welding.
- Best welding performance with shielding gases 98Ar+2O2 and 1-5CO2 mixed with Ar.

Autoweld 400 :

- Ferritic Stainless Steel solid wire.
- High corrosion and heat resistance.
- Suitable for joining and cladding of typical 17% Cr steels.
- Best suited for ferritic martensitic chrome steels.

Metal cored wire:

Metal cored wires offer higher productivity in terms of higher welding current densities and hence higher welding speeds. It gives much higher range of welding parameters to weld without the danger of burn through. The above comes with an additional advantage of better root gap bridging ability. The above point is best illustrated in the graph below.



Miginox MC 409 :

- Ti stabilized metal cored wire that gives minimal / no slag.
- Operates at higher current densities.
- High deposition rate gives very good productivity.

Both the solid and metal cored wires are supplied in layer wound condition in plastic spools with 12.5 / 15 kg wire per spool.

Recommended welding parameters:

Plate Thickness, mm	Welding Current, A
3-5	80-90
6-9	90-105
10	90-110

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