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(57) Abstract: A highly insulated converter (100) includes a short shell (112) forming a tubular body for housing a catalyst substrate (126). End cones (116) having a wide-open end and a narrow open end (134) including an inner wall (128) forming a first opening at the wide-open end (132A) for engaging the catalyst substrate (126) and an outer wall (130) extending beyond the inner wall (128) to form a second wider opening at the wide-open end (132B) for engaging the short shell (112). The inner wall and outer walls (128, 130) converge at the narrow open end to form a snout (136). A full-length insulating layer (120) is disposed adjacent the catalyst substrate (126). A partial length insulating layer (122) is disposed between the full-length insulating layer (120) and the short shell (112). The highly insulated catalytic converter (100) has a shortened shell (112) and tailored insulating layers (120, 122), providing a shorter package with stronger end cones that are robust to axial and bending stresses.

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SHORT SHELL HIGHLY INSULATED CONVERTER

TECHNICAL FIELD

The present invention relates to exhaust converters and more particularly relates to a short shell highly insulated catalytic converter.

5 BACKGROUND OF THE INVENTION

It is known in the art relating to catalytic converters to provide a shell, typically steel, for housing a catalyst substrate, such as a cordierite monolith. The shell comprises a generally tubular body portion having an inlet end and an outlet end. The body portion tapers at the inlet and outlet
10 ends to form cone-shaped front and back portions or, alternately, discrete cone pieces are disposed on each end of the tubular body. The converging end of the end cone is tailored to connect with a pipe (or "snorkel tube") for feeding exhaust to the exhaust gas inlet or leading treated gas away from the outlet to the tailpipe. A catalyst substrate is wrapped with an insulating, supporting
15 mat and the wrapped substrate is disposed (that is, stuffed) into the converter body.

Traditionally, adding insulation to a stuffed converter to meet surface temperature requirements would yield a significant increase in overall converter length or a reduction in end cone strength due to shortening of the
20 end cones in order to maintain the desired length. In FIG. 1, a prior art catalytic converter 10 is shown (having a catalytic converter 100 in accordance with the present invention superimposed upon the prior art converter 10 for ready comparison). The prior art catalytic converter 10 comprises a shell 12 having shell length 14. A pair of truncated end cones 16 having squared
25 shoulders 18 are disposed at the inlet and outlet ends of the shell 12. The prior art catalytic converter 10 is highly insulated and has a large packing space. An insulating material (not shown) is disposed within the shell 12

cavity along substantially all of the shell length 14. The truncated end cones 16 maintain the overall length of the converter. However, such a design disadvantageously results in weaker cones.

Alternate methods for maintaining desired converter length while meeting surface temperature requirements include using external heat shielding or smaller catalysts. It is known to use a mat annulus of 8 millimeters or less and shells that are the length of the combined catalyst lengths (i.e., length of the single or dual bed catalyst) or greater.

What is needed in the art is an improved catalytic converter and method for preparing the same. What is further needed in the art is a catalytic converter providing maximum insulation for enhanced temperature control while at the same time minimizing the packaging space required. What is further needed in the art is a catalytic converter meeting surface temperature requirements without requiring a significant increase in overall converter length or resulting in a reduction in end cone strength.

SUMMARY OF THE INVENTION

The present invention provides a short shell highly insulated catalytic converter. The converter comprises a short shell forming a generally tubular body for housing a catalyst substrate. The short shell has a length that is less than the length of the catalyst substrate. An end cone is disposed on each end of the body, the end cone having a wide-open end and a narrow open end. The end cone comprises a pair of inner walls forming a first opening at the wide-open end for engaging the catalyst substrate. The end cone further comprises a pair of outer walls extending beyond the pair of inner walls to form a second wider opening at the wide-open end for engaging the short shell. The inner walls and outer walls converge at the narrow open end to form a snout. A full-length insulating layer is disposed adjacent the catalyst substrate and is selected based upon the amount of overlap of the end cone and the catalyst substrate. The full-length insulating is generally substantially co-extensive with the catalyst substrate. A partial length insulating layer is

disposed between the inner full-length insulating layer and the short shell, the partial length insulating layer being generally co-extensive with the short shell.

Advantageously, the present highly insulated short shell catalytic converter provides maximum insulation while minimizing packaging space. Advantageously, the present short shell highly insulated catalytic converter keeps the overall length of the unit down and the strength up. By shortening the shell and managing the interfaces of insulating materials, the present catalytic converter provides a much shorter package with stronger end cones that are robust to axial and bending stresses. For example, the present catalytic converter package is about 26 millimeters shorter (for an about 3.4 inch catalyst length, 3 inch diameter) than currently available converters with equivalent end cone strength. Advantageously, the present catalytic converter provides lower skin temperatures, higher bending moment and lower material (steel) cost than similar converters of the same length using traditional stuffed canning designs.

These and other features and advantages of the invention will be more fully understood from the following description of certain specific embodiments of the invention taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, which are meant to be exemplary, not limiting, and wherein like elements are numbered alike in the several Figures:

FIG. 1 is a side view of a short shell highly insulated catalytic converter in accordance with the present invention superimposed upon a highly insulated truncated end cone prior art catalytic converter.

FIG. 2 is a side view in partial cross-section of the short shell highly insulated catalytic converter of the present invention shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the FIGURES, FIG. 1 provides a view of a prior art catalytic converter 10 having superimposed thereon a view of one possible embodiment of a highly insulated short shell catalytic converter 100 in accordance with the present invention. The prior art converter 10 is described in the Background above using reference numerals in the 10 series. An embodiment of the present invention is now described using 100 series numerals. Highly insulated short shell catalytic converter 100 has a body portion comprising a short shell 112 having shell length 114. Non-truncated end cones 116 having rounded shoulders 118 are disposed at the inlet and outlet ends of the short shell 112.

Turning to FIG. 2, the embodiment of the present short shell highly insulated converter of FIG. 1 is shown in partial cross-section. The short shell highly insulated catalytic converter 100 has full-length inner insulating layer 120 and partial length outer insulating layer 122. The full-length insulating layer 120 is provided for the approximate length 125 of the catalyst 126. This allows for protection of the catalyst 126 during in-process handling. The full-length insulating layer 120 disposed adjacent the catalyst substrate 126 is tailored based upon the amount of overlap of the end cone 116 and the catalyst substrate 126, the full-length insulating layer 120 being generally substantially co-extensive with the catalyst substrate 126.

The partial length outer insulation 122 is a shortened layer that is less than the length of the full-length layer 120. Partial length layer 122 is configured so as to be substantially co-extensive with the shortened shell 112. The length 124 of the short shell 112 may be tailored as desired provided the end cones are configured to maintain the required strength and formability. For example, in the embodiment shown in FIG. 2, the short shell 112 and the partial length outer insulating layer 122 each have a length 124 of about 60.2 millimeters. In this embodiment, the full-length insulating layer 120 has a length 125 of about 78.8 millimeters and the catalyst substrate 126 has a length of about 86.4 millimeters. As desired, the full-length and partial length insulating layers, 120, 122 may be provided as separate layers or as one piece

shaped to provide the full-length layer 120 and the partial length layer 122.

Non-truncated end cones 116 have inner walls 128 and outer walls 130, forming a wide-open end 132a, 132b and converging to a more narrow open end 134. Inner walls 128 form a first opening at the wider end 132a for engaging the catalyst substrate 126. Outer walls 130 extend beyond the inner walls 128 to form a wider opening at the wide-open end 132b for engaging the short shell 112. Inner walls 128 and outer walls 130 converge at the narrow open end 134 to form a snout 136 for engaging a pipe, such as an exhaust pipe.

Preferably, end cone insulation 138 is disposed within the gap 140 formed between inner walls 128 and outer walls 130 at the wide-open end 132a, 132b of the end cone 116.

The present short shell catalytic converter 100 may be prepared by stuffing the catalyst 126 by known processes into the short shell 112 through a stuffing cone. An alternate method comprises stuffing the catalyst 126 into an oversized shell, which requires very little force. The oversized shell is then sized down onto the insulated catalyst. Advantageously, this process is less disruptive to the alignment of the two layers of mat support (i.e., full-length insulating layer 120 and partial length insulating layer 122).

A cold bending analysis of a prior art catalytic converter 10 and a short shell catalytic converter 100 prepared in accordance with the present invention was performed using finite element analysis and the commercially available ABAQUS™ modeling software. Both prior art and invention examples comprised 20 node brick model converters prepared from 409 stainless steel. Solid elements were used to allow the weld to be modeled and included in the analysis. A 100 ft-lb. bending moment was applied to the ends of each converter and the Von Mises stress (MPa) was determined. The Von Mises stress was compared to the endurance limit to calculate the maximum bending moment allowed for infinite life. The formulae used were taken from "Mechanical Engineering Design," Shigley, McGraw-Hill, 4th Edition, pp.

287-308, which is hereby incorporated by reference herein in its entirety. The results of the cold bending analysis are provided in Table 1.

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Tensile strength = 450 MPa

$$S_e^1 = (.5) (450 \text{ MPa}) = 225 \text{ MPa}$$

$$S_e = k_a k_b k_c k_d k_e k_f k_g S_e^1$$

$$k_a = .84 \text{ (surface finish factor)}$$

10 $k_b \text{ through } k_f = 1$

$$S_e = (.84) (225 \text{ MPa})$$

$$S_e = 189 \text{ MPa}$$

$$M_{\max} = (189 / \text{Von Mises stress}) (100 \text{ ft-lb.})$$

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Material	
(409 Stainless Steel, 23 °C)	
Modulus, E (MPa)	2.0 E5
Poisson's ratio, ν	.3
Density (N-s ² /mm ⁴)	7.75 E-9

Table 1

Model	Von Mises Stress (MPa)	Maximum Cyclic Bending moment (ft-lb.)
Prior Art	320	59
Invention	187	101

As shown in Table 1, the short shell catalytic converter prepared in accordance with the present invention advantageously provides a much lower Von Mises stress response as compared with the prior art shortened end cone catalytic converter (187 MPa for the invention versus 320

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MPa for the prior art converter). In addition, the converter of the present invention provided a maximum cyclic bending moment of 101 ft.-lb. compared with only 59 ft.-lb. for the prior art converter.

5 The present highly insulated short shell catalytic converter provides maximum insulation for enhanced temperature control while at the same time minimizing the packaging space required. The present highly insulated short shell catalytic converter further meets surface temperature requirements without requiring a significant increase in overall converter length or resulting in a reduction in end cone strength.

10 While the invention has been described by reference to certain preferred embodiments, it should be understood that numerous changes could be made within the spirit and scope of the inventive concepts described. Accordingly, it is intended that the invention not be limited to the disclosed embodiments, but that it have the full scope permitted by the language of the
15 following claims.

CLAIMS

1. A highly insulated short shell catalytic converter comprising:

a short shell forming a generally tubular body for housing a catalyst substrate, said short shell having a length that is less than
5 that of said catalyst substrate;

an end cone disposed on each end of said tubular body, said end cone having a wide open end and a narrow open end;

said end cone comprising an inner wall forming a first opening at said wide open end for engaging a catalyst substrate and an outer
10 wall extending beyond said inner wall to form a second wider opening at said wide open end for engaging said short shell;

said inner wall and said outer wall converging at said narrow open end to form a snout;

a full-length insulating layer disposed adjacent said
15 catalyst substrate; and

a partial length insulating layer disposed between said said full-length insulating layer and said short shell, said partial length insulating layer being generally co-extensive with said short shell.

2. The highly insulated short shell catalytic converter of claim 1, wherein said full-length insulating layer is tailored based upon overlap of said end cone inner wall with said catalyst substrate and is generally substantially coextensive with said catalyst substrate.

3. The highly insulated short shell catalytic converter of claim 1, further comprising:

an end cone insulation disposed between said inner wall and said outer wall in a gap formed by said inner and outer walls at said wide-open
5 end of said end cone.

4. The highly insulated short shell catalytic converter of claim 1, wherein said converter is prepared by stuffing said catalyst substrate, said full-length insulating layer, and said partial length insulating layer into said short shell.

5. The highly insulated short shell catalytic converter of claim 1, wherein said converter is prepared by stuffing said catalyst substrate, said full-length insulating layer, and said partial length insulating layer into an oversized shell and sizing down said oversized shell onto said insulated
5 catalyst substrate.

6. A method for preparing a highly insulated short shell catalytic converter comprising:

providing a short shell forming a generally tubular body for housing a catalyst substrate, said short shell having a length that is less
5 than a length of said catalyst substrate;

disposing an end cone on each end of said tubular body, said end cone having a wide-open end and a narrow open end;

said end cone comprising an inner wall forming a first opening at said wide open end for engaging a catalyst substrate and an outer
10 wall extending beyond said inner wall to form a second wider opening at said wide open end for engaging said short shell;

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said inner wall and said outer wall converging at said narrow open end to form a snout;

15 disposing a full-length insulating layer adjacent said catalyst substrate; and

disposing a partial length insulating layer between said full-length insulating layer and said short shell, said partial length insulating layer being generally co-extensive with said short shell.

7. The method of claim 6, further comprising:

disposing an end cone insulation between an inner wall and said outer wall in a gap formed by said inner and outer walls at said wide-open end of said end cone.

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8. The method of claim 6, wherein said converter is

prepared by stuffing said catalyst substrate, said full-length insulating layer, and said partial length insulating layer into said short shell.

9. The method of claim 6, wherein said converter is

prepared by stuffing said catalyst substrate, said full-length insulating layer, and said partial length insulating layer into an oversized shell and sizing down said oversized shell onto said insulated catalyst substrate.

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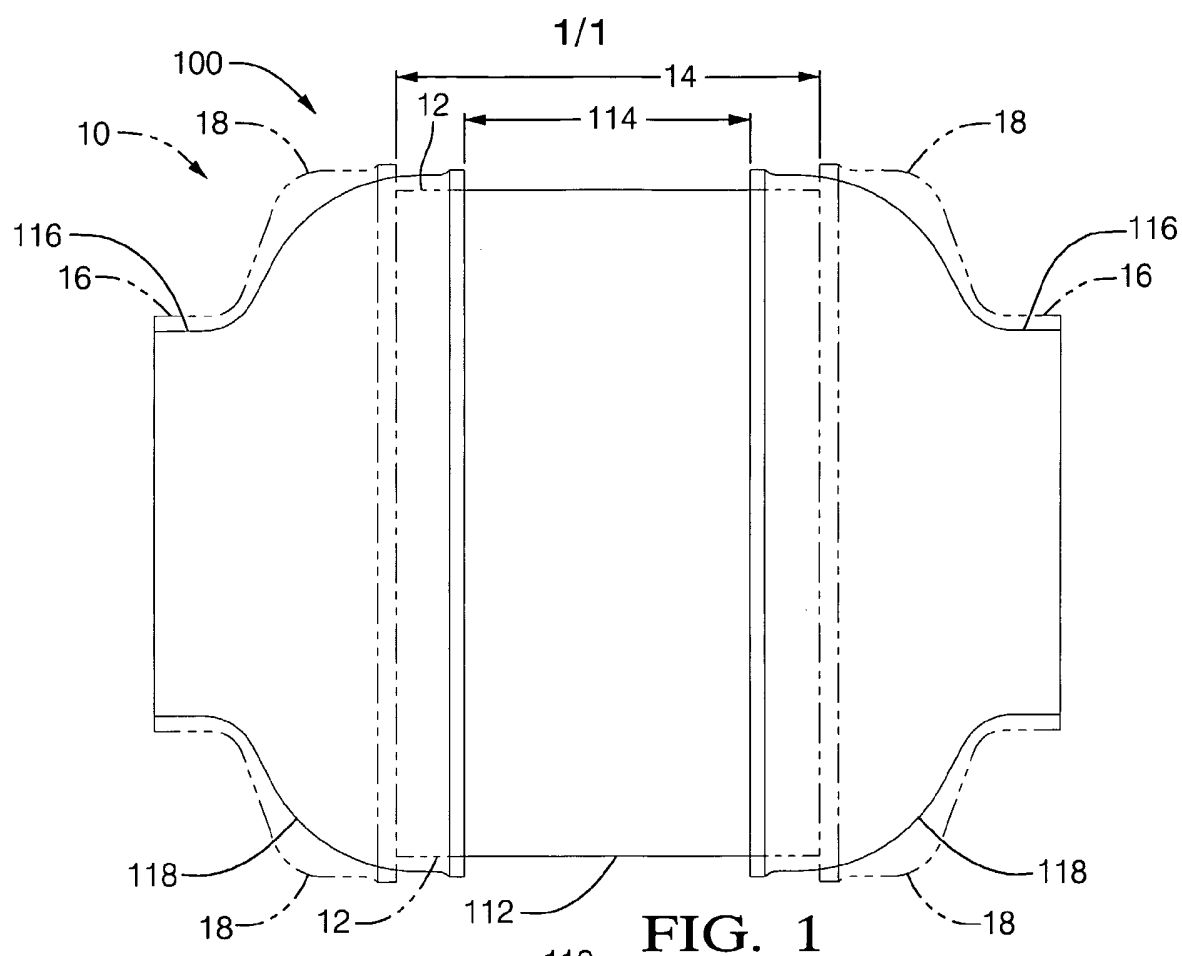


FIG. 1

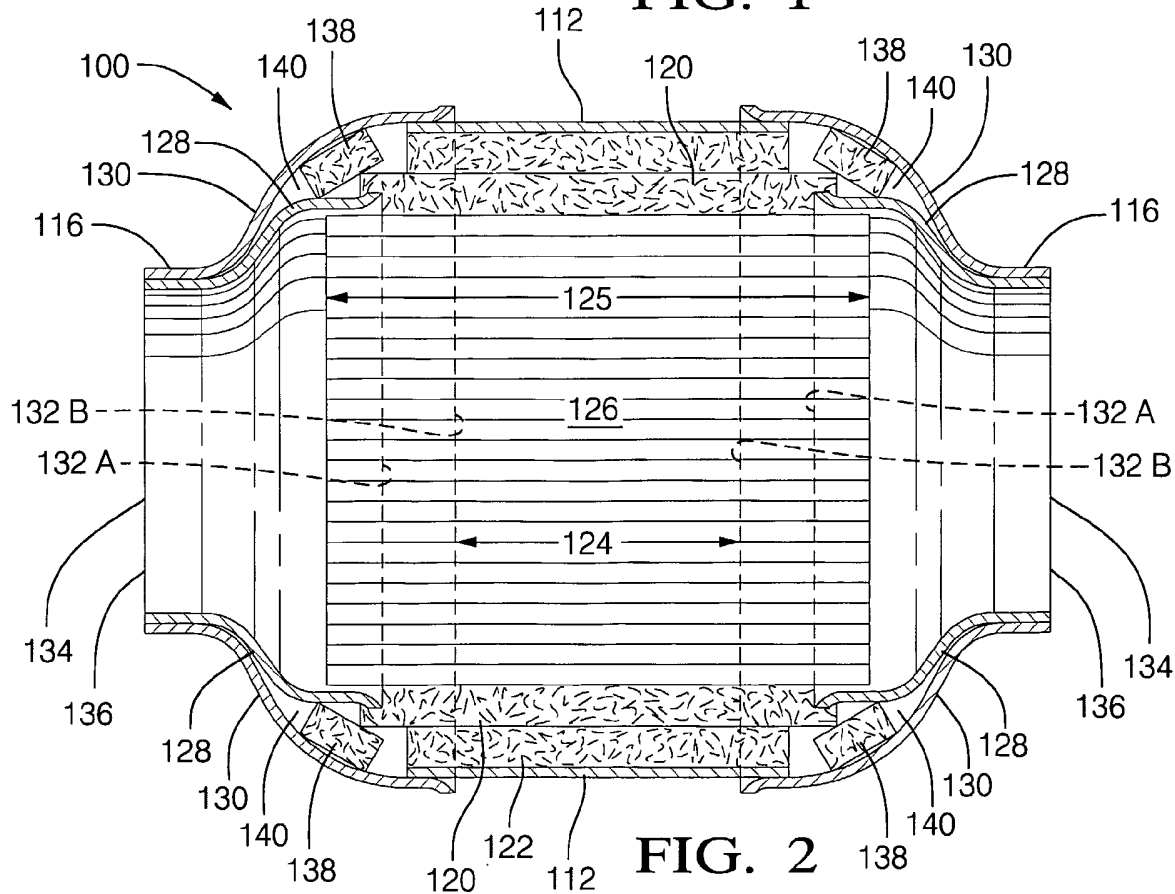


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/21879

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : F01N 3/28, 7/14; B01D 53/34

US CL : 422/177, 179, 180; 29/890

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 422/171, 174, 177, 179, 180; 29/890; 60/299, 300

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,142,864 A (ROSYNSKY et al) 06 March 1979, see entire document.	1-9
Y	US 5,250,269 A (LANGER) 05 October 1993, see entire document.	1-9
Y	US 5,666,805 A (BLOEDEL-PAWLIK et al) 16 September 1997, see entire document.	1-9
Y	US 5,693,295 A (FOSTER) 02 December 1997, see entire document.	1-9
Y	US 6,158,120 A (FOSTER et al) 12 December 2000, see entire document.	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

23 September 2002 (23.09.2002)

Date of mailing of the international search report

03 OCT 2002

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks

Box PCT

Washington, D.C. 20231

Facsimile No. (703)305-3230

Authorized officer

Hiên Tran

Telephone No. 308-0661

INTERNATIONAL SEARCH REPORT

PCT/US02/21879

Continuation of B. FIELDS SEARCHED Item 3:

EAST

Search terms: insulating, end cones, catalyst substrate