Title: COOLING ARRANGEMENT HAVING PROGRESSIVELY LARGER OPENINGS

Abstract: A cooling arrangement (114) for a machine (100) is disclosed. The cooling arrangement including a fan (116) configured to generate airflow (200) and a grille (126) having a plurality of airflow inlet openings (210). The cooling arrangement also including a heat exchanger (124) having a plurality of fin openings (206) sized to be larger than a size of at least one of the inlet opening. The cooling arrangement also including an enclosure (122) having a plurality of airflow exit openings (212) sized to be larger than a size of at least one of the fin opening openings.
Description

COOLING ARRANGEMENT HAVING PROGRESSIVELY LARGER OPENINGS

Technical Field

The present disclosure relates generally to a cooling arrangement and, more particularly, to a cooling arrangement having progressively larger openings.

Background

Machines having a power source, such as an internal combustion engine, may also include a cooling arrangement to cool fluids directed into or out of the power source, the machine, or both. For example, a machine power source may be fluidly connected to a liquid-to-air, air-to-air, or other type of heat exchanger to cool liquids circulated throughout the power source or to cool air directed into the power source. Typically, an enclosure such as a hood partially encloses the power source, heat exchanger, and other various components to protect them from the environment. A grille may be connected to the enclosure upstream of the heat exchanger to provide an inlet for airflow needed to cool the heat exchanger. In various industries (e.g. construction), machines are used in environments where air is often saturated with debris. Debris saturated air can be harmful to machines by obstructing airflow by plugging the fins within the heat exchanger. When debris obstructs airflow to and through a heat exchanger the power source may overheat.

Overheating can be harmful to the power source and therefore cause costly repairs. Productivity may also be hindered because of the need to stop and cool down machines, and this can be costly to an employer/owner as well. Grilles are perforated with openings to prevent passage of larger debris to a
heat exchanger while still allowing airflow. The grille openings, however, may be susceptible to becoming obstructed and passing smaller debris to the heat exchanger, thus leading to overheating.

One method minimizing the congestion of debris on a grille and thereby on a heat exchanger is described in U.S. Patent Application Publication No. 2005/0211487 (the ‘487 publication) issued to Obe et al. on 29 Sept. 2005. Specifically, the ‘487 publication discloses a hood for covering an engine room, the hood having a front face with a plurality of first air vent holes and a right and left side faces having a plurality of second air vent holes. Ambient air is passed through the first and second air vent holes to the radiator. The air vent holes are used to prevent passage of debris. The ratio of the second air vent holes in each side face is set smaller than the ratio of the first air vent holes within the front face. The ratio of the second air vent holes allows the force drawing ambient air in each side to approximate the force drawing ambient air through the first air vent holes. The ratios create a substantially equal velocity of ambient air through the left side, right side, and front face that may be lower than the conventional construction. As a result, the substantially equal velocities may prevent plugging of air vent holes.

Although the ‘487 publication may be somewhat beneficial in preventing accumulation and passage of debris on and through a grille, smaller debris may still pass through the air vent holes into the engine room. This smaller debris may still lodge within the heat exchanger and may still lead to overheating and more frequent inspections and services of the heat exchanger. This may lead to significant time being spent cooling the engine and inspecting the machine, servicing the machine or both due to a congested heat exchanger. This time may be costly to the machine owner, who may use the machine in more productive tasks, for example, a more continual usage of the machine.

The disclosed cooling arrangement is directed to overcoming one or more of the problems described above.
Summary of the Invention

In one aspect, the present disclosure is directed toward a cooling arrangement for a machine. The cooling arrangement may include a fan configured to generate airflow and a grille having a plurality of airflow inlet openings. The cooling arrangement may also include a heat exchanger having a plurality of fin openings sized to be larger than a size of at least one of the inlet opening. The cooling arrangement may also include an enclosure having a plurality of airflow exit openings sized to be larger than a size of at least one of the fin opening openings.

In another aspect, the present disclosure is directed toward a method of flowing through a cooling arrangement. The method may include directing airflow through the cooling arrangement through inlet openings, fin openings, and exit openings. The method may also include sizing inlet openings, fin opening, and exit openings, respectively, progressively larger and shaping inlet openings and exit openings generally hexagonally to increase an open area for airflow.

Brief Description of the Drawings

Fig. 1 is a diagrammatic illustration of an exemplary disclosed machine;

Fig. 2 is a pictorial illustration of an exemplary disclosed cooling arrangement for use with the machine of Fig. 1;

Fig. 3 is a pictorial illustration of exemplary disclosed inlet openings for use with the cooling arrangement of Fig. 2; and

Fig. 4 is a pictorial illustration of exemplary disclosed exit openings for use with the cooling arrangement of Fig. 2.

Detailed Description

Fig. 1 illustrates a machine 100 having a power source 102. Machine 100 may perform some type of operation associated with an industry
such as mining, construction, farming, power generation, or any other industry known in the art. For example, machine 100 may embody a mobile machine such as a loader, a backhoe, an excavator, a motor grader, a dump truck, or another suitable mobile machine. For the purposes of this disclosure, machine 100 is depicted and described as a loader. Machine 100 may alternatively embody a generator set or another stationary operation-performing machine.

Power source 102 may include multiple components that cooperate to produce a power output directed to move machine 100. In particular, power source 102 may include an engine block 104 that defines a plurality of cylinders 106, a piston 108 slidably disposed within each cylinder 106, and a cylinder head 110 associated with each cylinder 106. It is contemplated that power source 102 may include additional or different components such as, for example, a valve mechanism associated with cylinder head 110, one or more fuel injectors, and other components known in the art. For the purposes of this disclosure, power source 102 is depicted and described as a four-stroke diesel engine. One skilled in the art will recognize, however, that power source 102 may be any other type of combustion engine such as, for example, a gasoline or a gaseous fuel-powered engine.

Cylinder 106, piston 108, and the cylinder head 110 may form a combustion chamber 112. In the illustrated embodiment, power source 102 includes four combustion chambers 112. However, it is contemplated that power source 102 may include a greater or lesser number of combustion chambers 112 and that combustion chambers 112 may be disposed in an "in-line" configuration, a "V" configuration, or another suitable configuration.

As also shown in Fig. 1, power source 102 may be associated with one or more systems that facilitate the production of power. In particular, power source 102 may include a cooling arrangement 114. Cooling arrangement 114 may cool a heat transferring medium (e.g. air, oil, and/or coolant) circulated throughout power source 102. It is contemplated that machine 100 may include
additional systems such as, for example, an air induction system, a fuel system, a lubrication system, a transmission system, a control system, a hydraulic system, and other such systems known in the art. The additional systems may also utilize cooling arrangement 114 to cool their respective fluids.

Cooling arrangement 114 may include a fan 116, one or more heat exchanger 124, an enclosure 122, and a grille 126. Heat exchanger 124 may be located at a back-end of machine 100 between grille 126 and power source 102. Heat exchanger 124 may be configured to cool the heat transferring medium circulated throughout power source 102, machine 100, or both. Fan 116 may be configured to generate airflow 200 across heat exchanger 124 and be disposed between power source 102 and heat exchanger 124. Specifically, fan 116 may be secured to the downstream side of heat exchanger 124, pulling air first through grille 126 and then through the heat exchanger 124. It is contemplated that fan 116 may be located between grille 126 and heat exchanger 124, if desired.

Enclosure 122 may partially enclose power source 102, heat exchanger 124, and fan 116. Air flow generated by fan 116 may exit through enclosure 122 after passing through heat exchanger 124. Grille 126 may be disposed within enclosure 122 upstream of heat exchanger 124. It is further contemplated that other arrangements and locations are known in the art for enclosure 122, heat exchanger 124, fan 116, and grille 126, and may be used, if desired. For example, enclosure 122, heat exchanger 124, fan 116, and grille 126 may all be disposed at a forward end of machine 100.

Heat exchanger 124 may function as a primary heat exchanger facilitating the transfer of heat to or from a heat transferring medium circulated throughout power source 102. For example, heat exchanger 124 may include a tube and shell type heat exchanger, a plate type heat exchanger, or any other type of heat exchanger known in the art. Heat exchanger 124 may be a liquid-to-air exchanger connected to power source 102 via a supply conduit 118 and a return conduit 120. It is contemplated that heat exchanger 124 may function as the main
radiator of power source 102 dedicated to conditioning only the heat-transferring medium supplied to engine block 104. Alternatively, heat exchanger 124 may also condition a heat transferring medium supplied to an engine oil cooler, a transmission oil cooler, a brake oil cooler, or any other component of machine 100 carrying a heat transferring medium. The heat-transferring medium may be a low-pressure fluid. Exemplary low-pressures fluids may include, water, glycol, a water-glycol mixture, a blended air mixture, a power source oil such as transmission oil, engine oil, brake oil, or any other fluid known in the art for transferring heat.

As shown in Fig. 2 heat exchanger 124 may further include multiple fins 202 disposed horizontally across the inlet face 204 of heat exchanger 124. That is, fins 202 may be connected to conduits/tubes (not shown) that the heat transferring medium may flow through. Fins 202 may be spaced at a predetermined distance separating each fin 202 and creating fin openings 206. That is, in one example, fin openings 206 may be the vertical distance or sizing between fins 202. Fins 202 and fin openings 206 may help facilitate the transfer of heat from the heat-transferring medium. Specifically, airflow 200 generated by fan 116 may move across fins 202 and through fin openings 206 pulling heat away from heat exchanger 124. In one example, fin openings 206 of heat exchanger 124 may be about 4 mm. It is contemplated that other configurations of fins 202 may exist within heat exchanger 124, for example, a vertical or V-wave configuration may be used in place of the horizontal configuration.

Grille 126 may be coupled to enclosure 122 and, together, configured to pivot upwards giving access to heat exchanger 124. Grill 126 may have a handle 208 to facilitate pivoting and resemble a corrugated structure, although, it is contemplated that grille 126 may resemble other known structures, if desired. Grille 126 may have numerous inlet openings 210 extending from left to right and top to bottom therein. Inlet openings 210 may be hexagonal in configuration, and sized such that debris passing through inlet openings 210 may
also pass through fin openings 206 of heat exchanger 124. That is, the sizing of inlet openings 210 may allow airflow 200 through grille 126 and prevent passage of debris too large to pass through fin openings 206. In conjunction with the about 4 mm fin openings 206 example, inlet openings 210 may be sized slightly smaller. That is, the sizing of inlet openings 210, the inlet size 300, may be about 4 mm, as shown in Fig. 3.

Inlet size 300 is determined from the smallest bisecting dimension. For hex openings, inlet size 300 may be the distance between two opposing faces of one inlet opening 210, for circular openings, inlet size 300 may be the diameter of one inlet opening 210. Inlet openings 210 may be disposed at a spacing angle 304 of 30 degrees. Spacing angle 304 may be the angle between two bisecting lines crossing at the center on an inlet opening 210, one bisecting line may be horizontal and the other may be measured counterclockwise from the horizontal. Inlet openings 210 may be spaced relative to each other to produce the maximum possible open area while remaining structurally sound. That is, grille 126 may substantially withstand any normal operating conditions when configured with the maximum possible open area. The open area is calculated from the total open space occupied by the openings divided by the total open space and area of the space between each opening. As shown in Fig. 3, in the 4 mm inlet size 300 example, an inlet spacing 302 may be about 5 mm between the centers of inlet openings 210. Furthermore, the open area of the grille may be, in one example, about 63 percent open.

Enclosure 126, as shown in Fig. 2 may have a plurality of exit openings disposed in a right face 214, a left face 216, and a top face 218 of enclosure 126. Specifically, exit openings 212 may be located downstream of heat exchanger 124 with respect to airflow 200. Exit openings 212 may be hexagonal in configuration and sized larger than inlet openings 210 and fin openings 206. As shown in Fig. 4, in one example, exit openings 212 may have an exit size 400 of about 6 mm and be disposed at a spacing angle 404 of 30
degrees. Exit openings 212 having an exit size 400 of about 6 mm may have an exit spacing 402 of about 8 mm between centers of exit openings 212, creating an open area within the portions of the hood having exit openings of about 65 percent. Exit size 400, exit spacing 402, and spacing angle 404 may be determined in the same fashion as inlet size 300, inlet spacing 302, and spacing angle 304, respectively.

It is contemplated that other configurations and sizes of fin openings 206, inlet openings 210, and exit openings 212 may be used in place of the description above or examples stated. That is, heat exchanger 124 may have a different number of fins per inch, thus changing the size of fin openings 206. Inlet openings 210 and exit openings 212 may be sized according to fin openings 206, specifically, inlet openings 210 may be smaller than fin openings 206 and exit openings 212 larger than fin openings 206. It is contemplated that exit openings 212 may be much larger than fin openings 206, if desired. Furthermore, it is contemplated that heat exchanger 124, including fins 202 and fin openings 206, may be omitted from cooling arrangement 114 while retaining still the progressively larger relationship between inlet openings 210 and exit openings 212, if desired. It is further contemplated that spacing angle 304, 404 and inlet and exit spacing 302, 402 may vary as the configurations of inlet and exit openings 210, 212 vary.

**Industrial Applicability**

The cooling arrangement of the present disclosure may be applicable to a variety of machines where airflow is needed to reach a heat exchanger, and congestion or plugging of the spaces between the fins of an associated heat exchanger may be harmful. The disclosed cooling arrangement provides a progressively larger airflow path. The airflow path may both prevent the passage of debris through a grille and help debris that does pass to not congest the heat exchanger. The operation and function of cooling arrangement 114 will now be described.
An airflow 200 generated by fan 116 and/or movement of machine 100 may pass through grille 126 to cool heat exchanger 124 via inlet openings 210. Airflow 200 may then pass through fin openings 206 within heat exchanger 124 and exit cooling arrangement 114 via exit openings 212 within enclosure 122. Airflow 200 may carry debris, dust, or other particles that may congest heat exchanger 124. Cooling arrangement 114 may prevent the congestion of heat exchanger 124. That is, inlet openings 210 of grille 126 may prevent or restrict debris larger than the inlet openings 210 from passing. The flow of debris small enough to pass through inlet openings 210 may be improved as debris passes through the heat exchanger 124 and exit cooling arrangement 114 because of the progressively larger subsequent openings (206, 212). That is, because fin openings 206 are larger than inlet openings 210 and exit openings 212 are larger than fin openings 206, debris may more easily pass through the heat exchanger 214 and not congest heat exchanger 214.

Cooling arrangement 114 may be beneficial to owners and operators of machine 100 by minimizing down time, thereby increasing productivity. That is, because cooling arrangement 114 may decrease overheating, cooling arrangement 114 may alleviate the need to shut down machine 100 to allow power source 102 to cool. Significant time and costs saved because there may be less of a need to inspect heat exchanger 124 and cool machine 100.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed grille without departing from the scope of the disclosure. Other embodiments of the grille will be apparent to those skilled in the art from consideration of the specification and practice disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.
Claims

1. A cooling arrangement (114) for a machine (100), comprising:
   a fan (116) configured to generate airflow (200);
   a grille (126) having a plurality of airflow inlet openings (210);
   and
   a heat exchanger (124) having a plurality of fin openings (206)
sized to be larger than a size of at least one of the inlet openings; and
   an enclosure (122) having a plurality of airflow exit openings
(212) sized to be larger than a size of at least one of the fin openings.

2. The cooling arrangement of claim 1, wherein the exit openings
are disposed downstream of the heat exchanger and the plurality of inlet openings
are disposed upstream of the heat exchanger.

3. The cooling arrangement of claim 2, wherein the plurality of
exit openings are located in top (218), left (216), and right (214) faces of the
enclosure.

4. The cooling arrangement of claim 3, wherein a vertical
distance between fins defines a said fin opening and said fin openings are about 4 mm.

5. The cooling arrangement of claim 1, wherein the plurality of
inlet and exit openings are generally hexagonal.

6. A method of flowing through a cooling arrangement (114),
comprising:
directing airflow (200) through the cooling arrangement through generally hexagonally shaped inlet openings (210);

directing airflow through fin openings (206) sized to be larger than a size of at least one of the inlet openings; and

directing airflow through generally hexagonally shaped exit openings (212) sized to be larger than a size of at least one of the fin openings.

7. The method of claim 13, wherein directing airflow through cooling arrangement includes directing airflow sequentially through inlet openings, fin openings, and exit openings.

8. The method of claim 13, wherein directing airflow includes restricting debris through inlet openings and allowing debris that passes through inlet openings to flow through fin openings and exit openings.

9. A machine (100), comprising:
   a power source (102);
   a fan (116) configured to generate airflow (200);
   a grille (126) configured to partially enclose the power source and having a plurality of airflow inlet openings (210); and
   a heat exchanger (124) having a plurality of fin openings (206) sized to be larger than a size of at least one of inlet opening; and
   an enclosure (122) having a plurality of airflow exit openings (212) sized to be larger than a size of at least one of fin opening openings.

10. The machine of claim 18, wherein the exit openings are disposed downstream of the heat exchanger and are generally hexagonally shaped and the plurality of inlet openings are disposed upstream of the heat exchanger and are generally hexagonally shaped.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60K B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 660 244 A (MATSUDA KENJI [JP]) 26 August 1997 (1997-08-26) the whole document</td>
<td>1-10</td>
</tr>
<tr>
<td>A</td>
<td>US 2 854 104 A (MARCY JR ALFRED R ET, AL) 30 September 1958 (1958-09-30) the whole document</td>
<td>1,5,10</td>
</tr>
<tr>
<td>A</td>
<td>US 4 940 100 A (UEDA YOSHITERU [JP]) 10 July 1990 (1990-07-10) the whole document</td>
<td>1-10</td>
</tr>
<tr>
<td>A</td>
<td>FR 2 356 533 A (FORTSCHRITT VEK [DG]) 27 January 1978 (1978-01-27) the whole document</td>
<td>1-10</td>
</tr>
</tbody>
</table>

D

Further documents are listed in the continuation of Box C.

X 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 document but published on or after the international filing date

'L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

'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.

'A' document member of the same patent family

Date of the actual completion of the international search

14 November 2008

Date of mailing of the international search report

27/11/2008

Name and mailing address of the ISA/Authorized officer

European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Lindner, Volker
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 2854104 A</td>
<td>30-09-1958</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 5005217 Y2</td>
<td>10-02-1993</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 2728848 A1</td>
<td>05-01-1978</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PL 199297 A1</td>
<td>28-03-1978</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SU 638297 A1</td>
<td>25-12-1978</td>
</tr>
</tbody>
</table>