

SAVE FUEL

by fitting

THE AMSTERDAM DRYDOCK - GOT AVERKEN
EXHAUST TURBO COMPRESSOR.

Economy in fuel consumption obtained by the application of the exhaust-turbine principle, saving 15 to 20 % at a low initial cost.

Simple. Easy to operate. Low maintenance cost.

No encroachment on cargo or engine room space.

NEW VESSELS: This installation will increase

the efficiency of the most modern

STEAM RECIPROCATING PLANT.

EXISTING VESSELS: CAN BE EQUIPPED WITHOUT STRUC-

TURAL ALTERATION. Installation takes 2 to 3 weeks.

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AMSTERDAM DRYDOCK COMPANY, AMSTERDAM.
HOLLAND.

Modernization of Marine Steam Engines.

Economy in fuel consumption obtained by the installation of the Götaverken turbo-compressor and by combination of the same with other fuel saving devices.

Of the modernizations which may be carried out on board most steam vessels, the following are especially deserving of mention:

1. The utilization of exhaust steam from the propelling agent through the installation of an exhaust-steam turbine.
2. The raising of the feed-water temperature to about 275° F. through the installation of an additional feed-water heater to which steam is bled from the M.P. receiver.
3. The utilization of exhaust steam for the auxiliaries as against the present method of live-steam as driving medium.
4. If the plant be designed for saturated steam a further saving may be obtained by the introduction of superheat.

The reductions in fuel consumption which may be expected by the improvements mentioned above, based on the total fuel consumption of the plant, are as follows:

	<u>SATURATED STEAM:</u>
Turbo-compressor	19,0 %

+ increased feed-water heating (from 210 to 275° F)	20,5	%
+ exhaust steam-driven auxiliaries	25,0	%
+ superheating of steam to 550° F.	32,0	%
+ alternatively superheating to 600° F	33,0	%

SUPERHEATED STEAM 550° F.

Turbo-compressor	16,5	%
+ increased feed-water heating (from 210 to 275° F)	18,0	%
+ exhaust-driven auxiliaries	23,0	%

SUPERHEATED STEAM 600° F.

Turbo-compressor	15,5	%
+ increased feed-water heating (from 210 to 275° F)	17,0	%
+ exhaust-driven auxiliaries	22,0	%

The above figures give the saving in the heat-consumption of the plant measured from the quantity of condensate, the temperature of the feed-water, and the pressure and temperature of the steam before entering the engine.

Comparative measurements of the coal consumption have shown that so far as concerns engines using saturated steam, savings of from one to three per cent in excess of above have been obtained. This is due to the increased efficiency of the boilers at easier loads.

Under the heading "Saturated steam", the reduction in heat consumption is given as 32 per cent with superheated steam of 550° F. At 600° F. this figure is 33 per cent. This increase may at first sight appear too small, but is due to the fact that as the temperature of the steam rises the quantity through the engine is reduced and consequently also the work carried out by the exhaust turbine.

As the steam temperature is raised from 550° F.

to 600° F. the saving obtained by the Turbo-Compressor is reduced from 16,5 to 15,5 per cent. See under corresponding headings.

Starting from 550° C., a rise in the temperature of the steam to 600° C., should result in a saving of 2,64 per cent of 1 per cent for every 19 degrees increase, provided the saving obtained with the Turbo-Compressor remained unaltered.

THE STEAM TURBO-COMPRESSOR.

The principle of the Turbo-Compressor is shown in fig. I. The heat drop between the L.P.cylinder and the condenser, which is obtained by improving the vacuum in the condenser and increasing the back-pressure for the L.P. cylinder, is utilized in a turbine directly coupled to a Turbo-Compressor.

By means of this compressor a higher pressure and temperature is imparted to the steam, which has passed through the H.P.cylinder before it enters the M .P.cylinder.

The turbine and compressor, which are built together in one unit, are fitted on top of the condenser and are mechanically independent of the reciprocating engine.

The turbine and compressor have always the same direction of rotation independent of that of the reciprocating engine, thus the disengaging of the turbine during manoeuvring becomes unnecessary.

In order to make possible the rise in pressure between the H.P. and M.P. cylinders, the M.P. receiver is divided into two compartments. This division is in most cases carried out by inserting a special liner in the H.P. slide-valve-housing and by placing a valve-chest on top of

the M.P. receiver. This valvechest contains non-return valves, which automatically allow the steam to pass direct from the H.P. exhaust to the M.P. inlet when the compressor is disengaged. When the compressor is in action, these valves are kept closed by the difference in pressure set up by the compressor.

Fig. 2 shows the installation of a Turbo-Compressor for an engine using saturated steam.

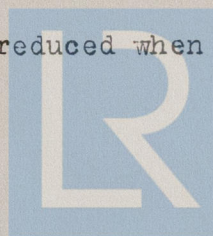
Reduction in Engine size.

When the Turbo-Compressor is adopted for new engines these may be designed smaller than is otherwise the case. In order to judge how far the size of an engine may be reduced one is guided by the following:

The maximum indicated mean pressure at 75 per cent cut off in the H.P. cylinder referred to the L.P. cylinder may for all ordinary engine be taken as $7.2 \frac{P}{V^{\frac{3}{2}}}$ where P is the boiler pressure. This mean pressure should not be exceeded when installing a Turbo-compressor, but the maximum cut off limited to 65 per cent.

Trials with and without Turbo-compressor show that with the same engaged, the IHP rises from 1706 to 2164 without altering the cut-off of the H.P. cylinder. (for detailed description of these trials with diagrams see Journal of Commerce, Sept. 6th 1934) The No. of revs. per min. increases by about 8 per cent, thus giving the rise in the mean pressure as 17.5 per cent.

The back pressure in the H.P. cylinder is somewhat lower than for an engine without Turbo-compressor, and thus the cut-off should be slightly reduced when the Compressor is



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engaged in order to prevent excessive losses due to incomplete expansion. The 17.5 per cent. increase in the mean pressure, which may be obtained with unaltered cut-off, should be reduced to 13 per cent.

In order to establish economical running conditions the mean pressure in an ordinary triple-expansion engine should not exceed 70-80 per cent of the maximum, or from 5.0 to 5.75 $\sqrt[3]{P}$. With the Turbo-compressor engaged the mean pressure may be increased by 13 per cent, or from 5.7 to 6.5 $\sqrt[3]{P}$.

This means a reduction in the size of a new engine of about 12 per cent.

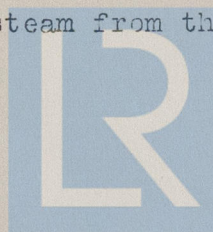
The reduction in the weight of the engine thus obtained is practically equal to the weight of the Turbo-compressor with appertaining pipes and valves.

Feed-water Heating.-

The figures previously given for the saving obtainable by increased feed-water heating assume a temperature of the feed-water of 210° F, which is raised to 275° F by steam bled from the M.P.receiver. Should the temperature be below 210° F the saving would be higher than the figure given.

Exhaust Steam-Driven Auxiliaries.-

The steam-consumption of the auxiliaries is usually large and from 10 to 15 per cent of the steam consumption of the main engine. In spite of this it is often asserted that the steam consumption of the auxiliaries have very little influence on the total fuel-consumption of the main engine, as the exhaust steam from the auxiliaries is



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utilized for feed-water heating. This conception is quite incorrect, as preheating of the feedwater may be arranged more economically by bleeding steam from the L.P. receiver, which steam has already done work in the H.P. and M.P. cylinders.

When installing an exhaust-steam turbine a certain amount of the exhaust steam from the L.P. cylinder can be utilized for driving the auxiliaries. The auxiliaries may be arranged as shown in fig. 3, where an exhaust steam turbine drives some of the auxiliaries (the circulating-water pump and the feed-water pump) and an electric generator, which delivers power to the other auxiliaries, and for lighting; or all auxiliaries can be arranged for electric drive, for which the power is generated in an exhaust steam-driven dynamo.

When modernizing marine engine plants some of the existing auxiliaries, such as the circulating-water pump and the fan for the forced draft, may be arranged for electro-motor drive by means of a silent chain.

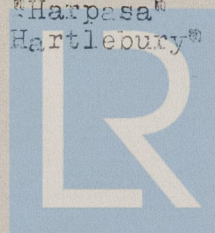
If the auxiliaries be arranged as indicated above, live steam is only required for the main and the steering engine.

Up to the present, the following vessels have been equipped with the Götaverken Turbo-compressor:

Conversions:

"Braheholm"
"Maplewood"
"Japan"
"Beldagny"
"Gretafield"
"Brockwood"
"Kambole"
"Hellen"

"Golden Sea"
"Hektor"
"Harlingen"
"Hardingham"
"Harbledown"
"Harpasa"
"Hartlebury"



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1. S/S: "Japan". Turbo-Compressor only. (HP feed-water heater fitted before installation of Turbo-Compressor).

Comparative coal-consumption trials at sea, for 12 hours without and 12 hours with Turbo-Compressor engaged show the following results obtained with coal of about 13000 B.Th.U. effective heating value:

Coal consumption per IHP per hour without T-C 1.64 lbs.

with 1.29

Saving obtained by Turbo-Compressor = 21.3 per cent

If the consumption be based on coal of better quality (Best Welsh 14500 B.Th.U.) the figures become 1.47 lbs and 1.156 lbs per IHP per hour respectively.

2. S/S: "Kambole". Turbo-Compressor plus H.P. feed-water heater. At comparative trials with and without compressor, when the total heat-consumption of the plant was measured, the saving obtained with the compressor was 20.74 per cent. (All details of these trials were published in the Journal of Commerce, 25th June 1934).

3. S/S:"Hellen". - Turbo-Compressor plus H.P. feed-water heater. Steam for auxiliaries bled from the main-engine behind the compressor.

Comparative coal-consumption trials at sea, with and without the Turbo-Compressor engaged, gave as result a saving of 25 per cent with the Turbo-Compressor.

The Owners write that in service, at a speed of 10 knots, the coal-consumption before the alteration was 31 tons per 24 hours but after the installation of the Turbo-Compressor the consumption has been reduced

to 23 tons per 24 hours at the same speed. The saving is thus 8 tons per 24 hours.

In addition, two boilers only are now in use against three before the alteration, and the number of firemen has been reduced by two. The cargo-capacity of the vessel has been increased by 5 per cent.

Superheated steam.

4. S/S: "Maplewood". Turbo-compressor only.

During comparative trials without and with compressor, when the total heat-consumption of the plant was measured, a saving of 16.87 per cent in the ballast and 15.62 per cent in the loaded condition was obtained.

The steam temperatures were: In ballast 569° F without and 551° F with compressor, in the loaded condition 566° F without and 553° F, with compressor. (For all details of these trials see the Shipbuilder & Marine Engine Builder, September 1933).

5. S/S: "Beldagny". Turbo-Compressor, improved feed-water heating, exhaust-steam driven auxiliaries.

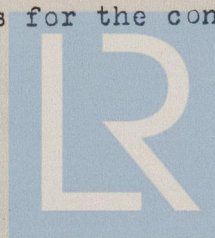
The coal-consumption trials before the alteration gave a figure of 1.59 lbs. per IHP per hour. After the alteration this figure was reduced to 1.14 lbs.

The saving obtained was thus .45 lbs per hour or 28.3 per cent.

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The coal used on these trials had an effective heating value of 13200 B.Th.U.

Based on coal with an effective heating value of 14500 (Best welsh) the figures for the consumption be-



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come 1.448 lbs. and 1.036 lbs per IHP per hour respectively.

The feed-water temperature was 165° F before and 266° F after the alteration.

The boilers were fitted with superheaters in the uptake and funnel, and these were retained. The steam temperature at the engine stop-valve was 486° F before and 450° F after the alteration.

NEWBUILDING:

Turbo-Compressor only.

During comparative trials without and with compressor, when the total heat consumption of the plant was measured, a saving of 18.6 per cent was obtained.

The steam temperatures were:

Without compressor 540° F.
With 537° F (For all details of these trials see Journal of Commerce and Shipping Telegraph)

In new vessels supplied with Turbo-Compressors a figure for the coal consumption on round trips of 1 lb per IHP per hour, auxiliaries included, has been attained. (Best Welsh Coal).



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