

Notes on the design and build of a Lempor exhaust

Introduction

Whilst the author was the project manager for the manufacture and installation of this exhaust, others in the team provided the basic calculations, the design itself and the CAD and manufacturing drawings required for the project. It is their skills in these areas that resulted in the exhaust performing to specification first time.

Calculations

A number of complicated calculations that I do not understand are required to determine the performance of the finished exhaust and these were carried out by another member of the ASTT team. From these calculations a set of detailed dimensions can be obtained that allow the design of the Lempor to be determined in CAD, again I do not have these skills and they were carried out by yet another member of the team. The final exhaust dimensions are critically dependant on the locomotive dimensions and required performance for a particular locomotive. This in turn determines the critical dimensions of a number of components that must be met during the manufacturing process

Design

The design is done in CAD to produce a set of drawings for the individual components required in it to meet the design specification and from this a General Assembly drawing can be produced.

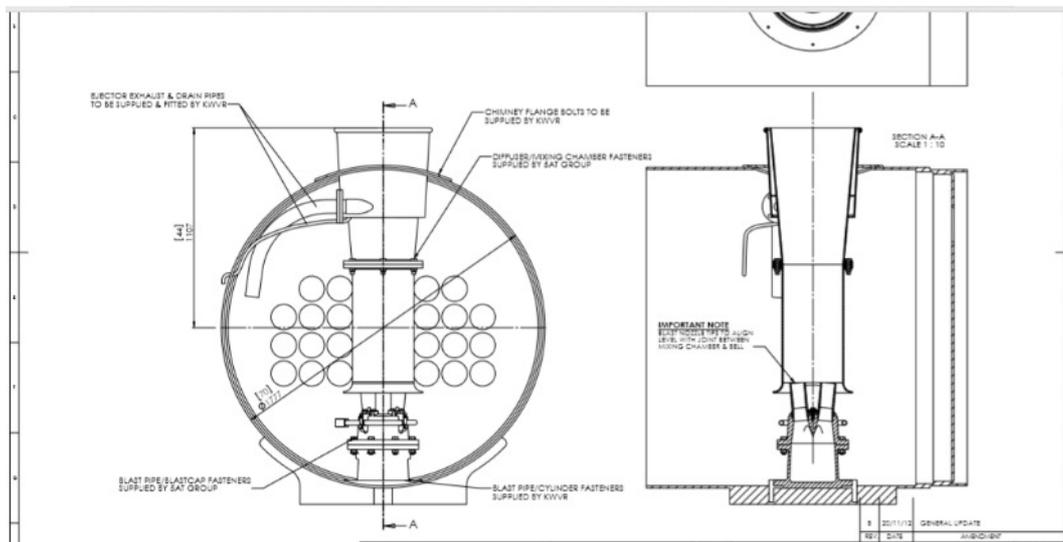


Fig 1 General Assembly drawing for the Lempor



Fig 2 The installed Lempor exhaust

Manufacturing Drawings

The CAD drawings are used as the basis for a set of manufacturing drawings for each individual component and can be cross-checked to ensure that the individual parts will in fact assemble together correctly and within defined tolerances. A great deal of cross-checking at this stage is required and indeed has to be checked throughout the manufacturing process

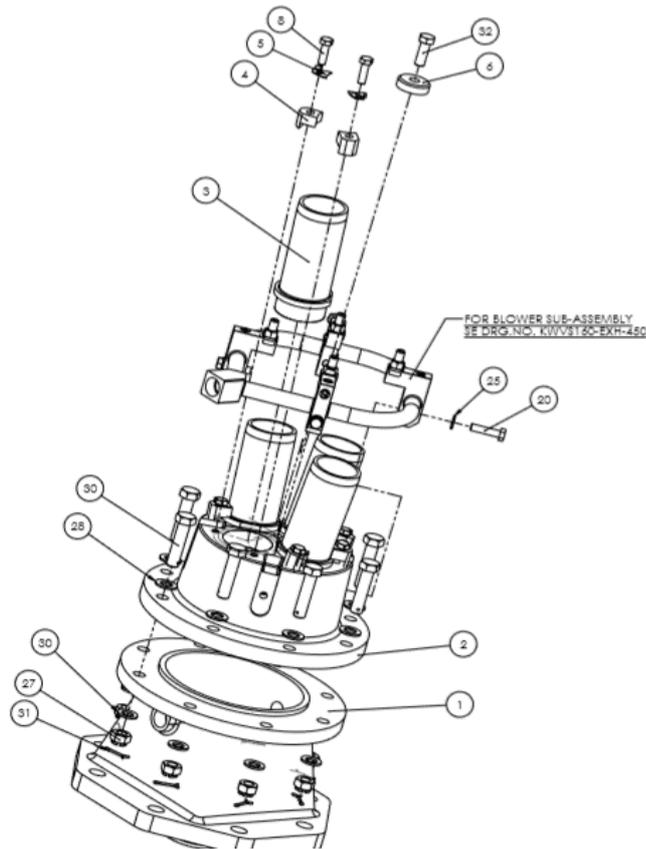


Fig 3 Blast pipe, Blast cap, Nozzles and Blower ring assembly showing all the components necessary for the assembly to be fitted to the locomotive

All the components in this drawing were supplied with the exhaust and were partly pre-assembled and supplied as the Blast pipe and the Assembled Blast Cap.

Patterns

From these drawings the required patterns for the cast components can be manufactured and the complete set delivered to the foundry for assembly into component moulds which can then be cast.



Fig 4 Pattern set on the way to the foundry

Castings

Two main castings are required, one for the Blast Pipe in cast iron and one for the Blast Cap in cast steel as this will require detailed machining later that is critical to how the exhaust will behave.



Fig 5 Blast Cap Pattern parts being assembled into the casting mould

Engineering challenges

A number of aspects relating to the manufacture caused a certain amount of head scratching before solutions were found to problems as they occurred.

Also, because of the weight of the major components moving them around and setting them up on milling machines and lathes required some more inventive thinking

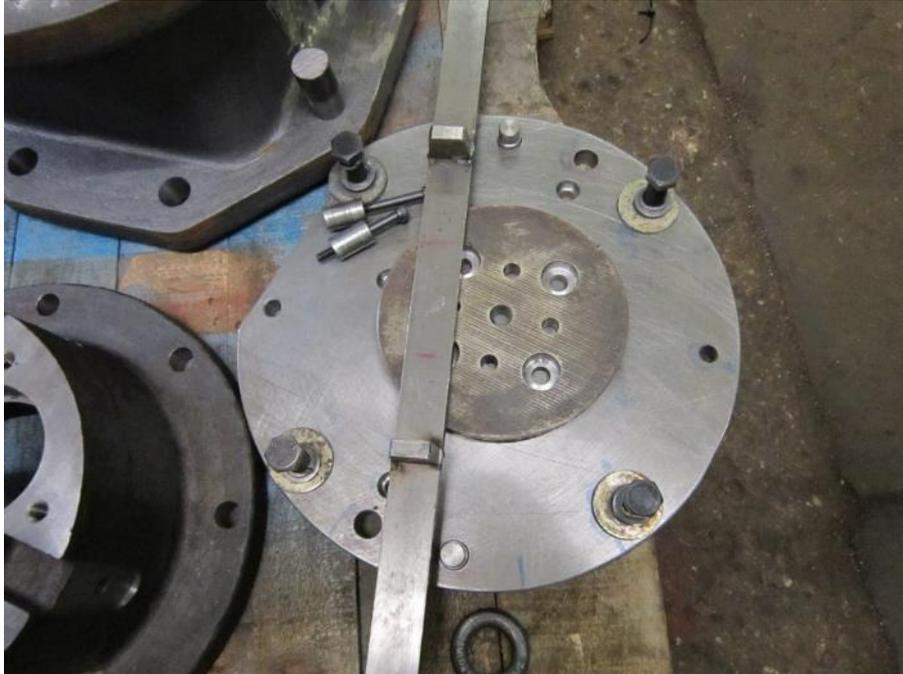


Fig 6 Jig to allow precise milling of the nozzle mounting holes at 8 degrees



Fig 7 Blast pipe being mounted on the lathe for machining. Note the plate mounted on the lathe to accept the blast pipe, this allowed it to be removed and refitted as required during the manufacturing process.

Blast Pipe

This is the main component that provides the interface between the locomotive exhaust passages and the Lempor and the locomotive dimensions are critical here as no two locomotives, even of the same class, are the same in the detail that is required. This is made of cast iron and must ensure an airtight seal to the locomotive.

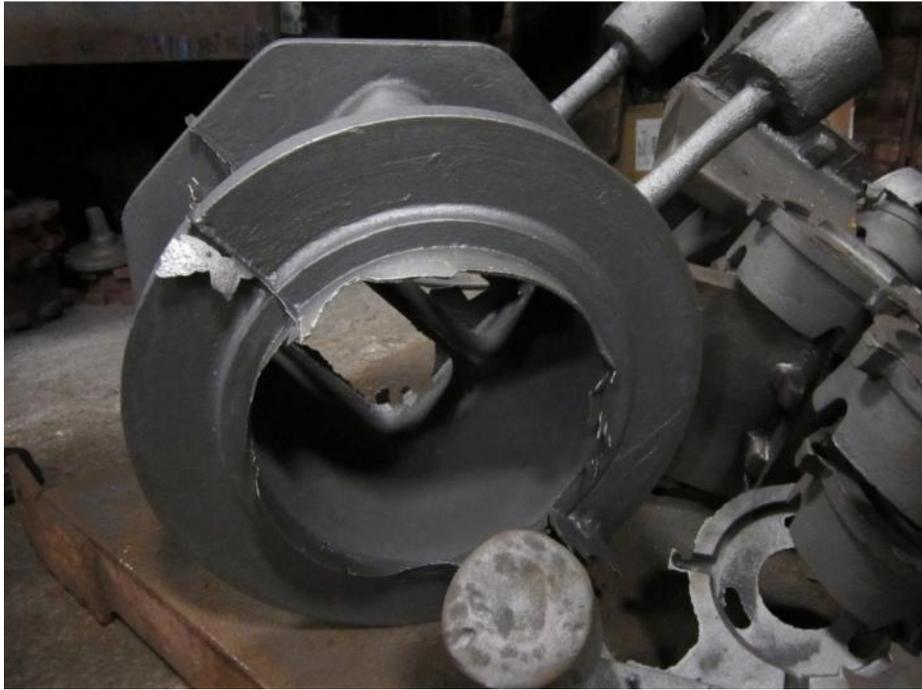


Fig 8 Blast pipe casting fresh from the mould



Fig 9 Blast pipe after initial machining, note the weight!!

Blast Cap

This is the most critical part of the exhaust as it supports the main nozzles and the blower ring, both of which need to align accurately to the chimney assembly. The nozzles are inserted at an angle of 8 degree from the vertical so that the exhaust gasses impinge on the wall of the mixing chamber to ensure maximum gas entrainment and thus airflow through the whole boiler. It must also be an airtight fit to the blast pipe.



Fig 10 Blast cap after first milling of nozzle holes and top surface

Because the nozzles are set at 8 degrees to the vertical this proved to be an engineering challenge until a jig was devised by the contractor and then manufactured. This allowed accurate milling of the Blast Cap to achieve the required angle for each nozzle. The jig also allowed the Blast Cap to be rotated 90 degrees during milling which proved to be a highly accurate technique that made the repeatability possible across all 4 nozzles.

Nozzles

These are the heart of the Lempor, their internal converging/diverging shape must provide the correct flow patterns and the outside shape must ensure that they fit tightly into the Blast Cap and remain secure throughout the life of the exhaust. The internal machining again proved a challenge and needed yet more engineering ingenuity by the contractor.



Fig 11 Nozzle blanks with outside machining done



Fig 12 Finished nozzles mounted in the blast cap

Blower ring

Conventional blower rings are merely a curved bit of steel pipe with holes drilled into it. For the Lempor arrangement a more sophisticated version had to be designed and manufactured to fit between the main nozzles to ensure maximum blower effectiveness.



Fig 13 Blower ring assembly without nozzles fitted to the blast cap



Fig 14 Complete Blast cap, nozzles and blower ring

Mixing Chamber

This is where the critical exhaust and air mix takes place and the accuracy of the alignment of this to the nozzle positions will determine the performance of the exhaust. It is a converging tube with a skirt on the bottom to improve air flow into the chamber and is connected at the top to the diffuser.



Fig 15 Mixing chamber and skirt assembly (upside down)

Diffuser

This is a diverging tube that carries the exhaust gases out of the chimney. When this is combined with the Mixing chamber the result is a large converging / diverging tube arrangement that is yet another critical part of the exhaust performance. Note the outer ring to allow exhaust steam from ancillary equipment to escape without affecting the Lempor



Fig 16 Diffuser assembly on weld NDT test

Installation

As can be seen from the above, the alignment of the complete nozzle and chimney assemblies is critical for the exhaust to perform correctly and so an alignment tool is required to ensure that the Blast Cap, nozzles, mixing chamber and diffuser are correctly aligned during installation on to the locomotive.



Fig 17 Alignment tool fitted to the blast pipe



Fig 18 Alignment tool showing the bottom alignment (left) and top alignment (right) of the chimney assembly to the Blast pipe, Blast cap and nozzle assembly