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[Continued on next page]

(54) Title: DIGESTER VESSEL FOR A CONTINUOUS DIGESTER

(57) Abstract: The invention concerns a pressurized digester vessel for a continuous digester, where the different parts Z1, Z2, Z3 of the digester are dimensioned according to the local temperature loads that are established in the different zones. It is possible through this design to achieve savings of up to 10% for a continuous digester.

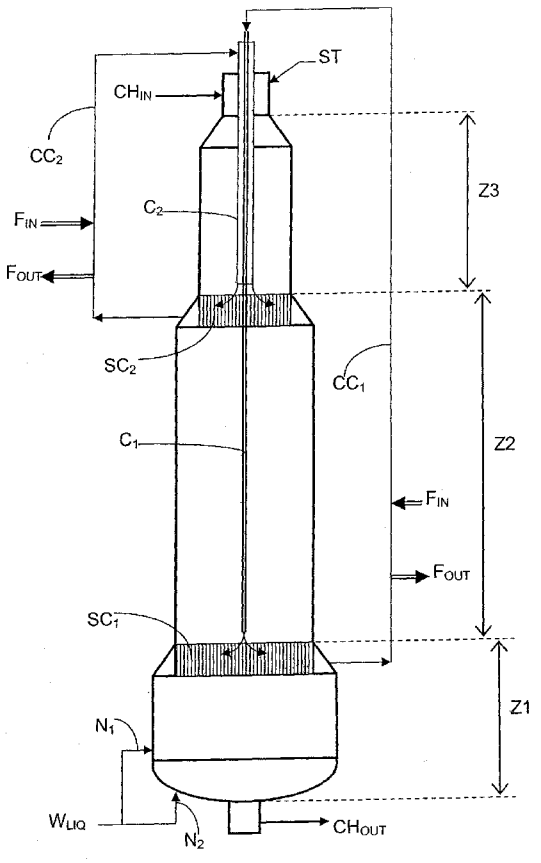


Fig. 1

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— *with international search report (Art. 21(3))*

Digester vessel for a continuous digester

Technical area

The present invention concerns a digester vessel for a continuous digester used during the manufacture of cellulose pulp according to the introduction to claim 1.

The prior art

It is conventional when manufacturing these digester vessels that the vessel be classified as a single pressure vessel, and the dimensioning is carried out against the background of the highest permitted pressure and the highest permitted temperature in the digester.

The total cost for a typical digester vessel in a digester that can produce 3,000 tonnes of pulp per day is just over SEK 15 million, assuming that the material 2205 is used, with a consumption of material of just over 40 m^3 of steel, a cost of SEK 50 per kg, and that the vessel is classified as one single vessel.

This classification of the digester vessel as one single pressure vessel does not, however, take into consideration the fact that the continuous digester will enclose, once operation has been established, several different treatment zones, each one of which has a different temperature. This means that certain parts of the digester vessel will be overdimensioned.

Other temperatures may be established in these zones during start-up and close-down of the continuous digester, if the process is not monitored and adjusted, and this has not been considered with respect to the strength of the digester vessel. The pressure that is established during start-up can, for example, be reduced, and this affects directly the load on the material. Furthermore, these operating conditions are of such short duration relative to the established operating condition of the continuous digester, that they may be permitted as short-duration conditions, and not as design conditions, from the point of view of classification.

The purpose of the invention

A first purpose of the invention is to reduce the cost of the digester vessel, where savings as large as up to 10% of the total cost may be obtained.

A second purpose is to reduce the consumption of material, which is positive from the point of view of efficient use of a limited resource, reducing the lifecycle cost of the digester vessel, and reducing the load on the environment.

The invention will be described in more detail in the following embodiments, presented as examples, of a modern continuous cooking plant of normal size.

Description of drawings

Figure 1 shows in principle a digester vessel for a continuous digester;

Figure 2 shows in detail how two zones are united, and

Figure 3 shows another alternative how two zones are united.

Detailed description of the invention

A typical digester is shown in Figure 1 where it is assumed for purposes of comparison that it is a conventional digester with a capacity of 3,000 tonnes of pulp per day. The digester vessel has an excess pressure of at least 2 bar, the temperatures in the treatment zones of the digester exceed 80°C, and the temperatures differ by more than 10°C between at least two treatment zones.

The dimensions (diameter * height) for the zones of this representative digester are:

Z1 = 10.8 * 13.5 meter

Z2 = 10.5 * 15.5 meter

Z3 = 5.2 * 13.3 meter

If the digester is designed as specified by the Pressure Equipment Directive, EN13445, using material quality 1.4462 and a design temperature of 200°C, the following material values are obtained:

- Rupture limit; R_m: = 640 MPa for t > 12 mm
- Tensile Yield limit; $R_{p0,2}$ = 445 MPa for t > 12 mm
- Tensile Yield limit at 200°; $R_{P0.2t}$ = 315 MPa

A continuous cooking process has been established in the digester where the process temperatures in the three zones correspond to:

Z1 = 100°C
Z2 = 150°C
Z3 = 200°C

Zone Z1 in this assumed digester is a wash and cooling zone before output from the digester, where the cooked pulp is washed and cooled with washing filtrate W_{LIQ}, which is added through the nozzles N_1, N_2 at the bottom of the digester, and by liquid that is introduced through the central pipe C_1 in the digester circulation CC_1 from the strainer SC_1. The temperature of the liquid in the circulation CC_1 may be modified, as is indicated, by withdrawing a flow F_{OUT} in the form of at least one of heat and liquid, and by supplying a flow F_{IN} in the form of at least one of cooling and liquid. A temperature of 100°C is established in Zone Z1 in this case.

Zone Z2 in this assumed digester is the cooking zone itself, where an even cooking temperature is established. The temperature of the chips may be adjusted before cooking by the addition of cooking fluid that is introduced through the central pipe C_2 in the cooking circulation CC_2 from the strainer SC_2.

The temperature of the liquid in the circulation CC_2 may be modified, as is indicated, by withdrawing a flow F_{OUT} in the form of at least one of heat and liquid, and by supplying a flow F_{IN} in the form of at least one of cooling and cooking fluid. A temperature of 150°C is established in Zone Z2 in this case.

Zone Z3 in this assumed digester is a heating zone in which the chips CH_{IN} that are fed into the digester are heated by the addition of saturated or overheated steam ST. The temperature of the chips can be adjusted also before the input using various treatments located prior to the digester. A temperature of 200°C is established in Zone Z3 in this case.

If the digester is divided according to the invention into three parts or zones of temperature, where the process temperatures in the zones given above are used as design temperatures for the three parts, the following design yield strengths are obtained:

- Tensile Yield limit Zone 1 (100°C) $R_{p0.2t}$: = 360 MPa

- Tensile Yield limit Zone 2 (150°C) = 335 MPa
  $R_{p0.2t}$
- Tensile Yield limit Zone 3 (200°C) = 315 MPa
  $R_{p0.2t}$:

The thickness of metal is proportional to the yield strength according to:

$$t_{min} = \frac{K}{R_{p0.2}}$$

which would give the following relationship:

$$\frac{t_{mim,nu\ var\ ande}}{t_{min,ny}} := \frac{R_{p0.2ny}}{P_{p0.2nu\ var\ ande}} \Rightarrow t_{min,ny} = t_{min,\ nu\ var\ ande} \cdot \frac{R_{p0.2nu\ var\ ande}}{R_{p0.2ny}}$$

Zone 1:

The thickness of metal is reduced to:

$$t_{min,ny} = t_{min,nu\ var\ ande} \cdot \frac{315}{360}$$

which is 87.5% of the previous thickness.

Zone 2:

$$\frac{315}{335} = 0.940,$$

which is 94% of the previous thickness.

Zone 3:

The same thickness as that used when the complete digester has been dimensioned for 200°C.

The following dimensions are obtained for the metal thickness of the digester vessel if the complete digester is dimensioned according to 200°C, in comparison with the assumed digester with a capacity of 3,000 tonnes of pulp per day:

- Zone 1: approximately 13.5 m with a diameter of 10.8 m and with a metal thickness of 32 mm
- Zone 2: approximately 15.5 m with a diameter of 10.5 m and a thickness of metal of 27

mm, with a vertical conical part with height 13 m and a mean diameter of 7.7 m and an approximate (mean) metal thickness of 20 mm

- Zone 3: approximately 13.3 m with a diameter of 5.2 m. This zone, however, will not be the subject for a savings in cost according to this calculation model.

Consumption of sheet metal

Conventional design:	Design according to the invention,
Zone 1:	
$10.8\pi \cdot 0.032 \cdot 13.5 = 14.657 m^3$	$10.8\pi \cdot 0.032 \cdot 0.875 \cdot 13.5 = 12.825 m^3$
Zone 2:	
$10.5\pi \cdot 0.027 \cdot 15.5 + 7.7\pi \cdot 0.020 \cdot 13 = 20.094 m^3$	$20.094 \cdot 0.94 = 18.888 m^3$

Saving in sheet metal volume:

Zone 1: $14.657 - 12.825 = 1.832\ m^3$

Zone 2: $20.094 - 18.888 = 1.206\ m^3$

Total savings in sheet metal volume:

$1.832 + 1.206 = 3.038\ m^3$

The cost of steel of quality 1.4462 (2205) is approximately SEK 50 per kg and its density is 7850 kg/m^3, which gives a savings in cost of $3.038 \times 7850 \times 50 \approx$ SEK 1,192,000

ALTERNATIVE STEEL QUALITY FOR THE DIGESTER VESSEL

With exactly the same design of the digester but using steel of quality 1.4162, LDX 2101 instead of 1.4462 (2205), the new construction would be as follows:

Zone 1: $14.657 \cdot \frac{295}{365} = 11.846\ m^3$

Zone 2. $20.094 \cdot \frac{295}{325} = 18.239\ m^3$

Savings in sheet metal volume:

Zone 1: $14.657 - 11.846 = 2.811\ m^3$

Zone 2: 20.094 -18.239 =1.855 m^3

Total savings in sheet metal volume:

2.811+1.855 = 4.666 m^3

The cost of steel of quality 1.4162 (LDX 2101) is approximately SEK 30 per kg, and its density is 7850 kg/m^3, which gives a savings in cost of 4.666x7850x30 ≈ SEK 1,099,000.

The examples above have shown that a substantial saving in cost can be obtained with different qualities of material in the digester vessel. It has been assumed in the example that a cooking process is used in which the zones Z1, Z2 and Z3 establish temperatures of 100, 150 and 200°C, respectively, during operation. The invention can, however, be implemented for all cooking processes in which there are at least two separate zones of temperature.

For example, also a digester vessel can be optimised in the same way, if Z3 is a low-temperature impregnation zone in a single-vessel cooking plant as defined by the concept of "*Japanese Cooking*" developed by Metso Fiber Karlstad, where as low a temperature as possible is striven after for the impregnation, such that the chips are well-impregnated and the level of rejection in the cooked pulp is reduced to a minimum. A patent was applied for in respect of the "*Japanese Cooking*" technique by Kamyr AB together with the Japanese company Jujo as long ago as 1971 (JP, A,65874171; JP,B,108820).

A further variant is that the two zones Z1 and Z2 or Z2/Z3 used as examples here may have an essentially similar temperature level, which differs from that of the third zone. It is obvious that the savings are proportional to the degree of difference in the design temperatures of the various parts.

Figure 2 shows how an upper digester vessel wall 30 in one zone Z3 can be united with an underlying digester vessel wall 20 through a conventional welded joint 1. It is appropriate that the transition is located at an increase in diameter of the pressure vessel in association with the digester flow, where a strainer section SC_2 is located between the parts for withdrawal of cooking fluid.

The various parts in this embodiment are constituted by parts of the digester vessel with gradually increasing diameter when viewed from the upper part towards the lower part.

Figure 3 shows a further variant in which an upper digester vessel wall 30 in one zone Z3 can be united with an underlying digester vessel wall 20 through a conventional flange joint, where the walls are provided with flanges 3 that are held together with a bolted joint 2.

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CLAIMS

1. A digester vessel for a continuous digester used in the manufacture of cellulose pulp, where the digester vessel has an inlet at the top of the digester vessel and an outlet at the bottom of the digester vessel, where wood material is fed into the inlet such that it can undergo treatment inside the digester vessel in at least two different treatment zones (Z1, Z2, Z3) established in the digester vessel, where the digester vessel is placed under an excess pressure of at least 2 bar and where the temperature in the treatment zones exceeds 80°C and differs between at least two treatment zones by more than 10°C, **characterised in** that the wall thickness of the digester vessel has been dimensioned in each treatment zone (Z1, Z2, Z3) according to the heat load that is established in that zone, with the purpose or reducing the consumption of material, whereby the digester vessel is classified as at least two different parts, an upper part and a lower part of the digester vessel, with different temperature loads for these two parts.

2. The digester vessel according to claim 1, **characterised in** that the digester vessel is classified as at least three different parts (Z1, Z2, Z3), an upper part (Z3), a central part (Z2) and a lower part (Z1) of the digester vessel, with different temperature loads between neighbouring parts of the digester vessel.

3. The digester vessel according to either of the preceding claims, **characterised in** that the different parts are separated from each other through digester flows, where a strainer section (SC_1, SC_2) is located between the parts for the withdrawal of cooking fluid.

4. The digester vessel according to claim 3, **characterised in** that the various parts are constituted by parts of the digester vessel with gradually increasing diameter when viewed from the upper part towards the lower part.

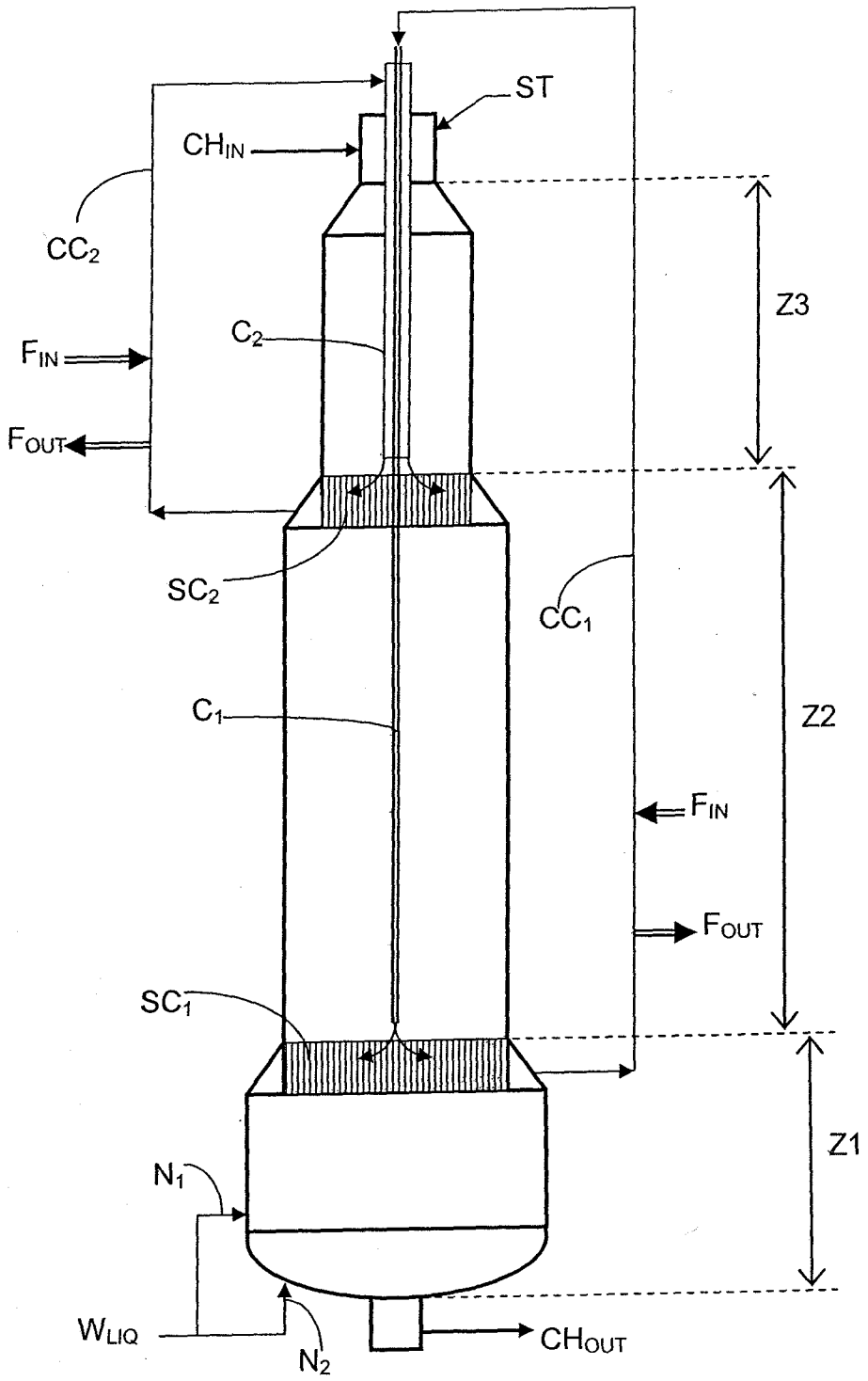

ST
CH_{IN}
CC_2
C_2
F_{IN}
F_{OUT}
SC_2
CC_1
C_1
F_{IN}
F_{OUT}
SC_1
N_1
W_{LIQ}
N_2
CH_{OUT}
Z3
Z2
Z1

Fig. 1

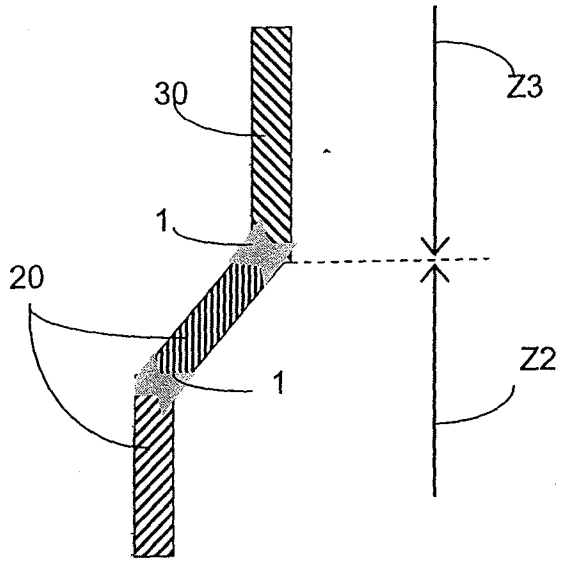


Fig. 2

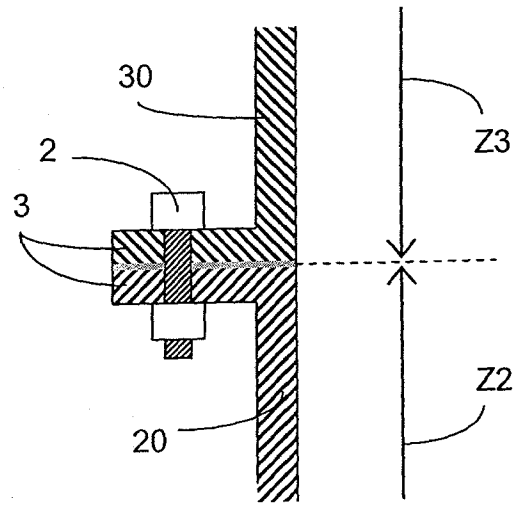


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/050313

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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)

IPC: D21C, F16J

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Loveys, P.C. 'Design and construction of a large continuous digester'. Australian Welding Journal, 1973, Sept/Oct, No. 7, p. 73-80; page 73, column 1 - 2; page 73, column 2 - 3	1-4
A	US 6193848 B1 (SHOCKLEY ET AL), 27 February 2001 (27.02.2001), column 3, line 64 - column 4, line 5, abstract	1
A	US 20050045298 A1 (BAKER), 3 March 2005 (03.03.2005), paragraphs [0010], [0024]	1-4

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2009	25-06-2009
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Karin Bengtsson/EÖ Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2009/050313

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5985096 A (MARCOCCIA ET AL), 16 November 1999 (16.11.1999), whole document --	1-4
A	GERLACH, H.D., 'Optimized Pressure Vessel Design with Special Respect to Operating Conditions', Int. J. Pres. Ves. & Piping 1988, Vol. 31, p. 285-293; abstract -- --------	1-4

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F16J 12/00 (2006.01)

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