RELIABILITY OF LENTICULAR EXPANSION COMPENSATORS

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Abstract: *Axial lenticular compensators are made to take over the longitudinal heat expansion, shock , vibration and noise, made elastic connections for piping systems. In order to have a long life for installations it is necessary that all elements, including lenticular compensators, have a good reliability. This desire can be did by technology of manufactoring and assembly of compensators, the material for lenses and by maintenance.of compensator*

Keywords: reliability, maintenance, lenticular compensators, life cycles, lens, technology

1. Introduction

In theenergy industry, chemical, petrochemical, aerospace, food, mining andagriculture, they handledsignificant quantitiesof fluids, pressuresandhigh temperatures.

The transportof thesefluids is characterizedbylargevaluesofworking parameters and long distances. Theyrequirepiping systems which is thetechnicalsolutionrequiredtotake overthepipelinelengthvariations.

Variationsin lengthof thepipelineisdue to thenegativeinfluence oflowtemperatures(-160 ºC) orhightemperatures(600 ºC) of thecirculatingfluidandtheambienttemperatureinwhichinstallations mustoperate.

Toavoid damage orevendestructionfacilities(cracking of welded jointsofpipeandpipeelements, leakageloss, so on) due to changes inlength, dilationsthermalcompensation systems were conducted, as follows:

(i) expansionpoundsU, LorZ;

(ii) compensatingslidingtelescopicexpansion(Fig. 1);

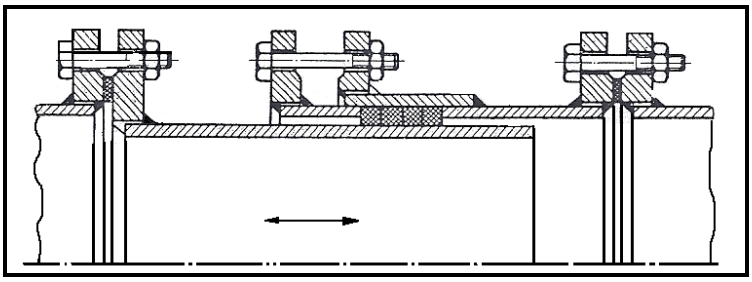

Fig. 1. *Compensatingslidingtelescopicexpansion*

(iii) compensatingexpansionwithsphericalarticulations(Fig. 2);

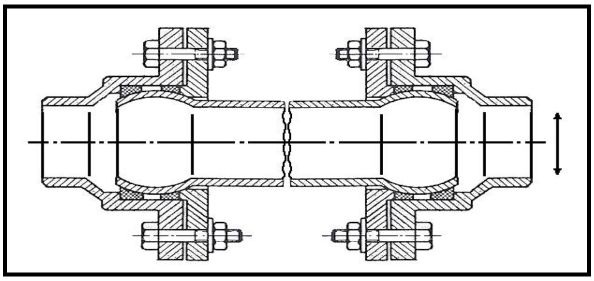

Fig. 2. *Compensatingexpansionwithsphericalarticulations*

(i) expansioncompensatorslenticular (Fig. 3).

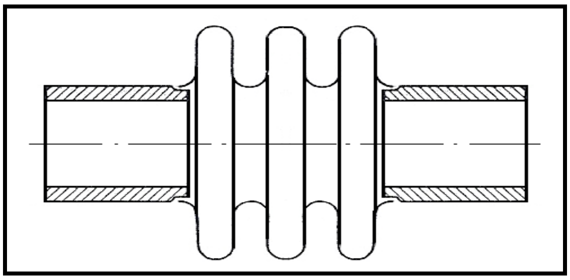

Fig. 3. *Expansioncompensatorslenticular*

Expansion pounds are used to acquire thermal dilations of the ducts which operate at relatively low pressures and fluid temperatures, assuming only axial expansions of pipelines.

Telescopic sliding expansion compensators are generally avoided to be used due to their low **reliability**, caused by rapid degradation of the sealing system seals.

To increase the reliability of such an activity, it is necessary a compensating preventive maintenance (greasing continuous) or corrective maintenance (replacement) of gaskets, an activity which is quite hard.

Expansion compensators with ball joints are also used quite limited, because they can retrieve only the plane perpendicular to their axis (Fig. 2) and the tightness is not good enough in order to prevent fluid losses.

Reliability spherical sealing is low, leading to an overall low **reliability** of the compensator.

2.Reliability oflenticularexpansioncompensators

2.1. General presentation

*Lenticularexpansioncompensators*are mostlyusedto acquirethermaldilationsofpipelines, first of alldue totheirhigh**reliability**andtheirperfecttightness. Itmay also coverdifferentareas: acquiringthermalexpansion, shock absorberandvibration, make connectionselasticpiping systems.

The main elementof thistypeofcompensator**elementelasticexpansionisthe lenticular**(lens, bellows, tears) that mustbeexecutedcorrectly, to haveageometryverywellstudied, tohaving theirsuddenchangesof directioninsectionthicknessorprofile.

Ingeneral, the lensesaresimplecircularortoroidalelementsthat arewelded, of which theweldingprocess is done either byhandorelectricweldinginprotectivegasmedium(WIG-Wolfram, Inert, Gas):

(i) circumferential (Fig. 4);

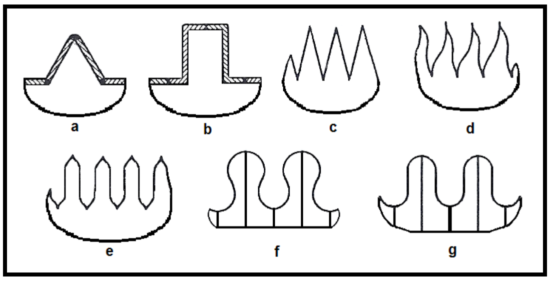

Fig. 4.

(ii) longitudinal (Fig. 5).

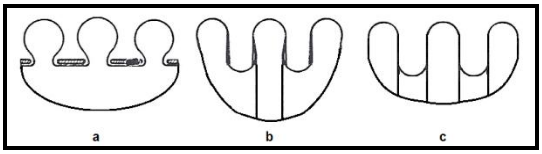

Fig. 5.

Reliabilityoflenticularcompensatorsexpansionisinfluencedbythe following:

(i) the reliability of the lens (geometric shape, technology implementation, material fabrication);

(ii) execution quality welds, transverse and longitudinal;

(iii) preventive maintenance work, applied during the operation of pipeline systems.

Lenticularexpansioncompensatorcanbeconsideredasa set ofthree elements, the lensbarrelstacksandflatflangesornecks, elementsconnected in seriesthrough thecircularwelding seams(Fig. 6).

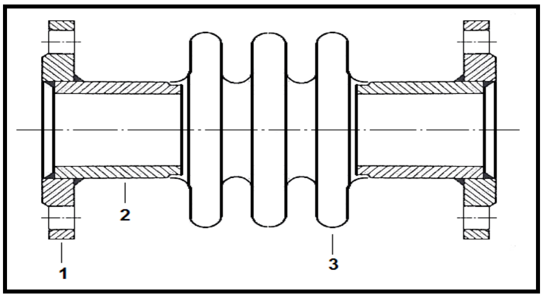

Fig. 6. *- flangepayment, 2 - socketpipe, 3 - elastic elementlenticular*

2.2. Experimental researchon thereliability ofexpansioncompensatorslenticular

ReliabilitycompensatorR$_c$(t) isgivenby theproductreliabilitycomponents, the lensR$_l$, R$_t$pipe, flangeR$_f$astherelationshipwe haveknownforcomponentsconnectedin series:

$$R(t)=\prod_{i=1}^{n} R_i(t) \tag{1}$$

or

$$R_c = R_1 R_t R_f \tag{2}$$

Note: Itisthe working assumption thatthe mechanical strength ofcircularand longitudinalweldsisequalto that ofothercomponents.

Compensatorisnecessaryforreliabilityand hencereliability$R_c$lenticularelastic elementisgreaterthanthe minimumallowablereliabilityrequiredby theuser foran industrial installationinwhichitismounted.

Reliabilityoflenticularcompensatorsexpansiondepends on:

(i) the number andnature offatigueload cycles;
(ii) materialqualitylenticularelements;
(iii) the working fluidpressureandtemperature;
(iv) lensgeometry(shape, wall thickness, stepheight);
(v) chemicalaggressivenessofthe working fluid;
(vi) the ratio betweenthe numberof lensesandtheir diameter;
(vii) manufacturing technologyofthe lens(longitudinal seamorseamscircular) andmountingtechnologycompensatorscomponents(flanges, pipe, elastic elements).

2.2.1. Influence ofto tirednessload cycleson thereliability ofcompensators

Principalapplicationissubmittedcompensator, theentirelife cycleisdue totiredness loadsof cycliccompressionandtension.

Lenticularcompensatorsisthe mainfailurecrackinthe wall ofthe lensthatappearsafteravariablenumber ofcyclesofdemand, determined byobserving thebehavior ofthe compensatorduringinstallationoroperation oflaboratory tests.

There havebeenlaboratorytestedunder conditionsofaxialcompressionandtensioncompensatinglenticularfivenominaldiameters, Dn=150, 200, 300, 400, 450 , witha total ofthreelenseseach, andlensthicknes s=2mmmaterialfabrication,W1.4541austeniticstainlesssteel sheet, obtainingthe resultsin Table1.

Alternatingcyclesweresymmetricaland pulse.

Tensile strengthforapulsatingcycleisgreaterthanthatforasymmetricalalternatingcycle:

$$\sigma_0 = 1{,}5\sigma_{-1} \tag{3}$$

Tensionsintroducedintothe material, whichcausedby tirednesscrackingandbreaking thelensisnotonlythe mechanicalbut alsothermalin nature. Thus, theausteniticstainlesssteelwhichrunslenscompensators, thermaltirednessisa majorshow, becausethesematerials havealowthermalconductivityandhighthermal expansion.

Table1: *Testcompensatorstorequestperiodicvariables*

No.	Dn	δ_1 displacement alens(mm)	δ displacement total (mm)	nature cycles	N number cycles
1	150	3,5	10,5	σ_{-1}	2340
2	200	3,5	10,5	σ_0	4560
3	300	3,5	10,5	σ_{-1}	2620
4	400	3	9	σ_{-1}	2560
5	450	5	15	σ_{-1}	2480

Thefatiguebehaviorlenticularcompensatorsexpansionis determined byfactors:

(i) the maximumtensionapplied;
(ii) large variationofthe applied tension;
(iii) a high number ofcycles;
(iv) the concentration of tension;
(v) the corrosive effects ofthe working fluid;
(vi) the working fluidtemperature;
(vii) residual stressesfrommaterialsusedin theimplementationof lenses,flangesandpipes.

Fig. 7 presentsthe cycleoftensionvarying effectsproducedinpoints1, 2, 3, 4expansioncompensatorlenssurfacewithDn=300 .

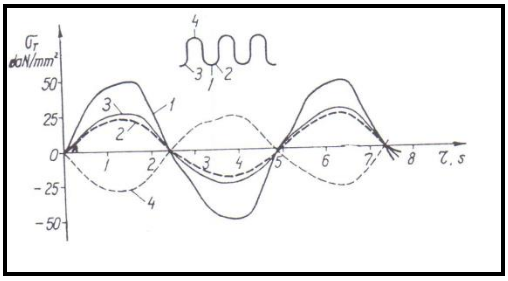

Fig. 7.

The diagramshows thatthe greatesttensionisdevelopedat the baseandtoplenses(points1 and4). The values ofthesetensiondrops tohalfinareasofthelensattachment(2 or3points), so thattherightportionof thelenswallisalmostnegligible.

Crackinitiationandruptureoccursinmostcasesthepointatthe base andthe tip ofthe lens.Ifruptureoccursinotherareas, itis due tohiddendefectsinthe material, whichcanfacilitatethe productionof cracks (pores, inclusions, improperstructure).

2.2.2. The influence oftechnologyon thereliability ofmanufacturing andassemblyof compensators

The mostadvancedmanufacturingprocess(implementation andcontrol)isthe elastic elementsof the semi-mechanical deformationofaustenitic stainless steelsheet, followedbyspecialrollsproducthavingrequiredgeometry. Weldingismadebyweldingthe longitudinalends bytheprocessmanualorelectricatmosphereofprotective gases non-fusibleelectrode(WIG, **W**olfram **I**nert **G**as).

To increase the compensators reliability isimportantthat the montage ofelements to be made ofweldedjointpipe, whichcanbebutt weldor corner weld(Fig. 8).

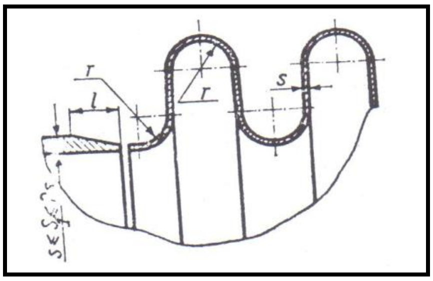

Fig. 8*. a) butt weld*

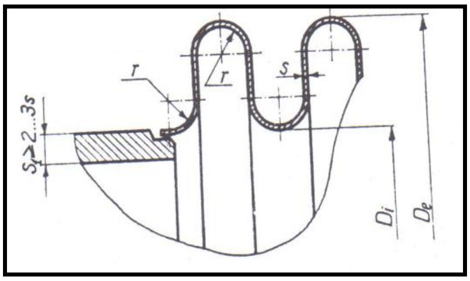

Fig. 8. *b) cornerweld*

For the connectionbywelding,buttweldingispreferable(Fig. 8. a) toweldthe corner(Fig. 8. b). Weld seamforbuttweldqualityisequaltothemechanical strengthofbase materialandatight seal.Thistype ofcompensators does notrequirespecial supervision, andtheirmaintenanceisminor.

InFig. 9. a, bandcarelistedconstructivemeasuresto be takenin order tomakeminormaintenance: protectionpipeinsidethe elastic element(Fig. 9. a), capsappliedtothebottomofthe lenstoeliminatecondensation(Fig. 9.b) protectivesleeveon the outside ofthe elastic element(Fig. 9. c).

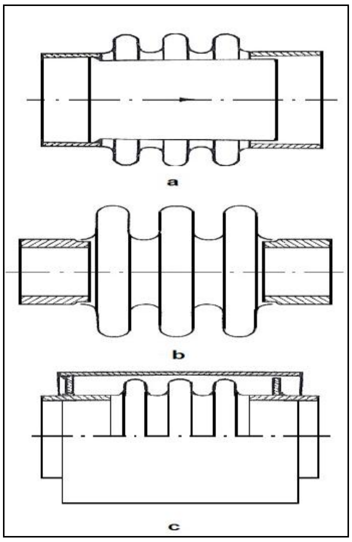

Fig. 9.

2.2.3. Influenceof thereliability of maintenancecompensators

Remedybygouging(removingdefectsbylocalmeltingof the materialanditsremovalwithajet ofcompressedair) ofcracksinthe wallsof thelensorcords, welding andgrindingadditionofmaterial. Repairscarried out in suchpermitto extend thelifeofthelenticularcompensatorsaveragevalueof the numberofcyclesthatoccurredbeforethe emergenceof the firstfailure, i.e.untilthe firstoccurrence ofcracks.

Arrival of the firstcracksinelasticelements(lenses) are notautomaticallydeterminethe disposal ofcompensators.

References

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