BASIC METALLURGICAL CORROSION CONCEPTS AND RECOMMENDATIONS FOR GASKET CORROSION(CREVICE CORROSION) OF FLANGE CONNECTION IN PETRO-CHEMICAL PLANT

By

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FOREWORD

In a petro-chemical plant, material preservation is one of the most important thing during material storage period from manufacturing to equipment erection even after long term period of material stock in site condition. However, sometimes in the severity site condition or long term material storage condition, we easily front material corrosion problems such as gasket setting surface expecially what we called either gasket corrosion or damage in a flange connection for equipment or piping, even if damaged part is in gasket serration area, the criteria is give in related regulation of ASME B16.5,ANSI B461. MSS SP-6, API 605 etc. However, is there gasket corrosion over serration area, this requirement may not be clear against initial status as regulated in reference CODE requirement because this serration is no longer permanent requirement after plant operation considering metallurgy corrosion and flange mechanics. therefore, this paper shows how to decide and recommend solution guide in the event of this kind of corrosion or damage occurs in construction site.

Acknowledgement

The authors writing this paper is for giving guide and recommendation in similar problems on construction site not for manufacturing in fabrication shop particularly because any regulation over this requirement governed by related CODE requirement.

1. INTRODUCTION

Gasket surface corrosion is one of the common fault in a material preservation or during equipment erection in a construction site because this fault depend on metallurgical corrosion and storage period at site as well as the instruction to construction disciplines regarding material preservation from manufacturing vendor or equipment owner which was given in their technical specification from transportation to site erection before plant commissioning operation. Therefore, the author want to give guide line when this kind of corrosion happens at site over after review of corrosion mechanism and metallurgy together.

2. REASON OF GASKET CORROSION AND MECHANISM

Generally, material corrosion in petro-chemical occurs in major of three corrosion manner. The first one is of ionization of Ferrous material (Fe+2 + O3-->Fe2O3, or Fe3O4) for Oxidation Reduction Potential. Secondly, galvanic corrosion will be followed as various

erosion and corrosion condition. Here, the characteristic of galvanic corrosion is generally described as Anode reaction which occurs between two different material, temperature and acidity in its potential difference. Galvanic corrosion take places in lower electric potential as high temperature and low acidity etc. When we place Carbon Steel into a smaller of surface area adjacent to Stainless Steel, Carbon Steel will be of Anode reaction against Cathode reaction of
Stainless Steel, In this case we call this corrosion as galvanic corrosion. Accordingly The surface area of Carbon Steel should be larger than its Stainless Steel otherwise, change Carbon Steel material to same as Stainless Steel.

The third one is we called gasket corrosion as Crevice corrosion between two Carbon Steel such as Flange to Blind flange which gap is keeping gap as much as Gasket thickness, Especially, when we see the mechanism of this crevice corrosion
-Cathode reaction : O2+ 2H2O+ 4e-->4OH-(Gap outside)
-Anode reaction : M--->M+ + e- (Gap inside)
In this case, passivity surface is easily broken and this become a active surface to crevice reaction and finally, this active surface prevent forming scale before surface corrosion. We call this crevice corrosion as well as gasket corrosion between two metal contact. however, this mechanism is closely relationship to Galvanic corrosion in metallurgy corrosion.

3. METALLURGICAL RELATION BETWEEN CORROSION AND SCALE
Generally, when we expose Carbon Steel in ambient condition, this metal will changed to ionization of Ferrous material (Fe+2 + O3-->Fe2O3, or Fe3O4), so most of plant equipment shall be designed in a life time of 30 years or 40 years, and thus corrosion allowance will be given to 3mm or 4mm considering 0.1 mm corroded per year of life time. However, corrosion rate never be constant because scale(passivity) prevent metal corrosion from initial corrosion status. When we give simple example in metal of Aluminum, this surface easily covered with Oxide Aluminum after exposed in air with O2. Finally, this prevent metal corrosion more.
that is why we have to apply TIG negative pole welding for its cleaning action of Ar anode ion.
Here, we have to understand one important thing between scale(passivity) and corrosion because scale(passivity) is completely

different one from metal corrosion considering this corrosion mechanism. And also, if this metal is of Stainless Steel, we have to do passivity in order to avoid metal corrosion because Stainless Steel also corroded metal even though corrosion is less than Carbon Steel, so we called this metal as Stain-less Steel.

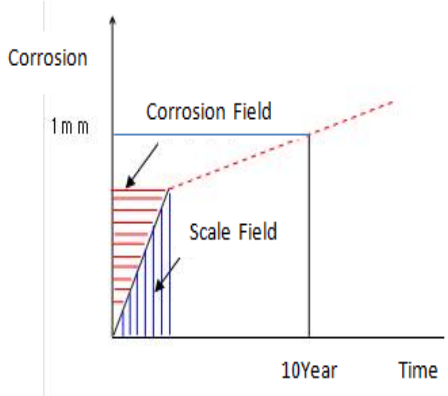
4. KNOWLEDGE OF CORROSION IN FLANGE CONNECTION

As I mentioned previous chart, Metal scale tale place before metal corrosion and this scale prevent corrosion progress an initial stage. In other word, Scale and corrosion may be able to happen at same time in a some case, however, normally Scale is at first than corrosion when this metal is not expose to condition of ionization of Ferrous material.

Therefore, if metal is well in material preservation, scale will be formed before corrosion.

Generally, we may see that almost of corrosion happens due to Galvanic corrosion when metal is placed with same metal or different metal, even though in case of same metal to metal contact, Galvanic corrosion will not be able to avoid because of different metal surface area. For example, we can find some place of Bolt tighten surface is may be corroded against nearest bolt location. this area have been well sealing prevent to contact with air during bolt tightening period. so we can believe that scale only occurs in this location before metal corrosion unless otherwise Galvanic corrosion was prevented.

-Crevice & Galvanic corrosion



- Scale & Corrosion progress

5. METALLURGICAL CORROSION IN FLANGE SERRATION

The machine requirement of Flange Serration is regulated in ASME B16.5, ANSI B461. MSS SP-6, API 605 for details of Serration surface, as height of thread is of 0.4mm and width of 0.8mm over

14" nominal diameter of flange. As I mentioned in previous chart, the major corrosion factor is the Galvanic corrosion and Crevice corrosion because of different metal to metal contact surface with Gasket material. Especially Stainless of Steel Hoop material used in Spire Wound which contact to Carbon Steel of flange. Consequently this different material contact will be cause of Galvanic corrosion due to different electric potential. One of the character in Galvanic corrosion occurs in partial surface and break the scale(passivity) over metal surface, and then corroded in same area. This is the reason why am I saying that we can not find scale over the corroded surface. When we take look at closely in Serration surface where corroded condition, we may find that there is more accumulation of scale in bottom side of thread serration, this may occurs Galvanic corrosion comparing with mount side of thread serration. This is the evidence of that Serration surface is more easily corroded than grain surface.

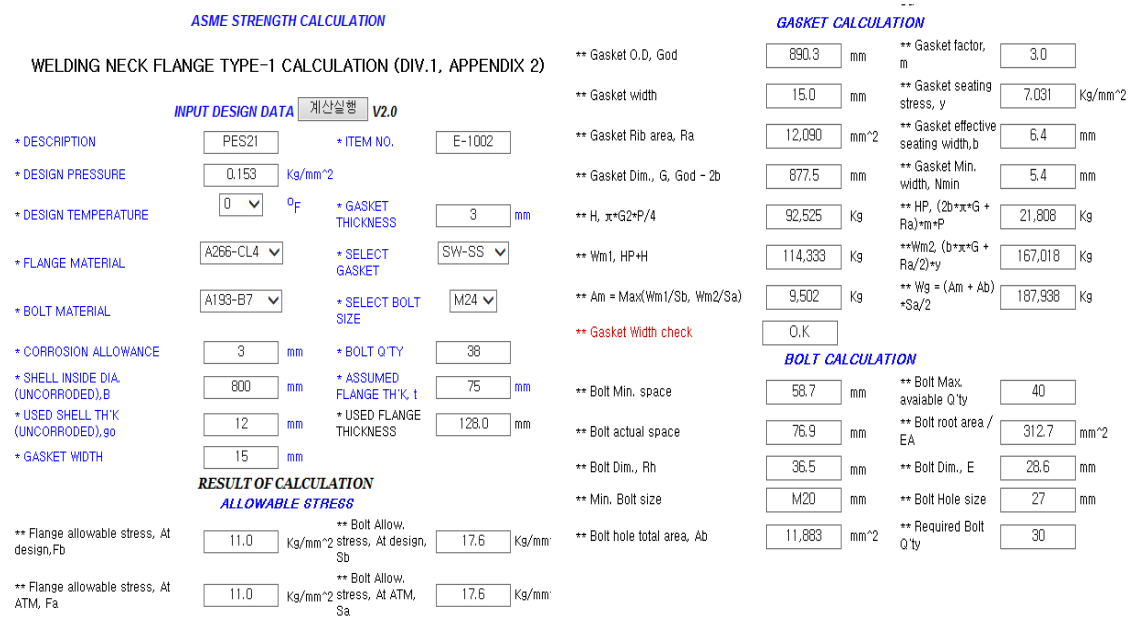
6. STRUCTURAL DESIGN OF FLANGE SERRATION

The purpose of gasket surface Serration is the only prevention of fluid leakage using function of reducing the outlet of internal pressure with change of fluid direction over thread mount to bottom. However, actually this serration is not applied for structural design of flange as shown on sample Flange calculation sheet. For more details, we use two gasket factor called "m" factor and "y" factor in strength calculation. The first of "m" factor is called simply Gasket factor and "y" factor is called Gasket Setting Stress. the function of "m" factor is the pressure ratio between before and after of flange tightening pressure. And "y" factor is the pressure ratio of remaining pressure versus internal pressure after flange tightening. Consequently, this serration is never mentioned related code regulation except serration configuration in code requirement.

7. FLANGE SERRATION EFFECTIVENESS

When we review the effectiveness of Flange serration in the representative of Carbon Steel Flange material as per (ASTM A105). The first thing is Serration of flange will affect Galvanic corrosion due to different electric potential. Moreover, in case of Carbon Steel, The corrosion will not be avoided physically during the plant operation as much as 0.1mm per each year, thus 0.4mm of thread

mount will be eliminated after 4 years. thus corrosion allowance of 40 years of life time of plant operation this serration is no more expecting the function of gasket sealing in flange connection. Particularly, the bearing ratio is high at threaded area. Therefore, wearing ratio also will be high comparing sound surface area. For this reason, the effectiveness of Serration have to be reviewed in a future again.



ASME STRENGTH CALCULATION

WELDING NECK FLANGE TYPE-1 CALCULATION (DIV.1, APPENDIX 2)

INPUT DESIGN DATA 계산실행 V2.0

* DESCRIPTION	PES21	* ITEM NO.	E-1002
* DESIGN PRESSURE	0.153 Kg/mm^2		
* DESIGN TEMPERATURE	0 °F	* GASKET THICKNESS	3 mm
* FLANGE MATERIAL	A266-CL4	* SELECT GASKET	SW-SS
* BOLT MATERIAL	A193-B7	* SELECT BOLT SIZE	M24
* CORROSION ALLOWANCE	3 mm	* BOLT Q'TY	38
* SHELL INSIDE DIA. (UNCORRODED),B	800 mm	* ASSUMED FLANGE TH'K, t	75 mm
* USED SHELL TH'K (UNCORRODED),go	12 mm	* USED FLANGE THICKNESS	128.0 mm
* GASKET WIDTH	15 mm		

RESULT OF CALCULATION

ALLOWABLE STRESS

** Flange allowable stress, At design,Fb	11.0 Kg/mm^2	** Bolt Allow. stress, At design, Sb	17.6 Kg/mm^
** Flange allowable stress, At ATM, Fa	11.0 Kg/mm^2	** Bolt Allow. stress, At ATM, Sa	17.6 Kg/mm^

GASKET CALCULATION

** Gasket O.D, God	890.3 mm	** Gasket factor, m	3.0
** Gasket width	15.0 mm	** Gasket seating stress, y	7,031 Kg/mm^2
** Gasket Rib area, Ra	12,090 mm^2	** Gasket effective seating width,b	6.4 mm
** Gasket Dim., G, God - 2b	877.5 mm	** Gasket Min. width, Nmin	5.4 mm
** H, π*G2*P/4	92,525 Kg	** HP, (2b*π*G + Ra)*m*P	21,808 Kg
** Wm1, HP+H	114,333 Kg	**Wm2, (b*π*G + Ra/2)*y	167,018 Kg
** Am = Max(Wm1/Sb, Wm2/Sa)	9,502 Kg	** Wg = (Am + Ab) *Sa/2	187,938 Kg
** Gasket Width check	O.K		

BOLT CALCULATION

** Bolt Min. space	58.7 mm	** Bolt Max. avaiable Q'ty	40
** Bolt actual space	76.9 mm	** Bolt root area / EA	312.7 mm^2
** Bolt Dim., Rh	36.5 mm	** Bolt Dim., E	28.6 mm
** Min. Bolt size	M20 mm	** Bolt Hole size	27 mm
** Bolt hole total area, Ab	11,883 mm^2	** Required Bolt Q'ty	30

8. RECOMMENDATIONS OF PROTECTION METHOD OF GASKET CORROSION

Considering the scale and corrosion, I want to recommend that following two metallurgy method.

1) Prevent Galvanic corrosion

We may see this method in piping line or equipment installation in plant, there is two kind of method, the one is connect flange with electric wire in direct current(D.C), Second one is to connect with Sacrifice physical metal like as lead(Pb)

it's electric potential is lower than that of carbon steel of flange metal. and this Sacrifice metal will be corroded instead of Flange surface.

2) Prevent Crevice corrosion(Gasket corrosion)

My personal opinion, sealing gap is the best way to prevent Crevice corrosion between Flange bolt tightening with bolt, so, sealant material may be available to sealing the metal gap.

9. CONCLUDE

It seems to me that so many time of this kind of flange-refacing have to do during plant construction because of this metallurgy

corrosion. Moreover, construction sub-contractor may not be able to prevent this corrosion during site storage period as well as equipment erection period ahead of plant operation without reasonable technical requirement for material preservation. Even if either Crevice corrosion or Scale is not allowed on gasket serration area especially, the equipment have to be N2 charge until plant commissioning start. However, this sequence is not possible considering the plant construction schedule. Consequently, When we put that who have to take responsibility for metallurgy corrosion, As far as I know, the manufacturing contractor have to prevent Galvanic corrosion and Prevent Crevice corrosion(Gasket corrosion) before transportation to construction site as I referring above recommendations unless noted in technical requirement otherwise.

10. EPILOGUE

During writing regarding corrosion of flange surface, I feel that, As far as I'm concerned The flange surface have to be designed considering gasket character as well as design condition and internal pressure or fluid, For example, when we design the flange and select applied gasket. Mechanical engineer have to decide this flange serration application because I believe that this effectiveness of flange serration is not only depend on metallurgical corrosion closely but design condition mechanically. --THE END--