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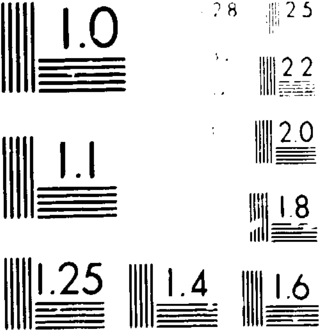
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PERIODICAL INSPECTION AND TREATMENT OF DEFECTS ON AMMONIA CONVERTERS *

by

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Abstract

This article analyzes the causes and treatment of the frequently found defects on converters and illustrates the merits of regular periodical inspection which would guarantee satisfactory performance and economical results in ammonia converter operation.

I. Preface

Ammonia converter is a major equipment in nitrogen fertilizer production. For its successful operation, not doubt, we need rational design, suitable material of construction, good manufacturing technology, high quality installation, adequate operation and precise control. Besides, it's important to have regular periodical inspection, so as to find out the existence of development of defects, upon which we can analyze their nature. After correct evaluation, proper treatment can be given in time. During operation, the defects may develop until a critical point or dimension is reached, thus causing severe damage. This procedure will discover them early enough for treatment so as to guarantee safety and economy in ammonia converter operation.

We have established regulations for periodical inspection and examination of ammonia converters and other pressure vessels, which have been successfully for many years.

II. Requirement and Procedure of Periodical Inspection of Ammonia Converters

01. Requirement:

Judging by our experience in operation and from the accidents occured on ammonia converters in many countries, the importance of regular periodical inspection of ammonia converters and pressure vessels is obviously attached to. Many countries including China have established code or regulation for regular periodical inspection for all pressure vessels in service. China has also made the code to suit the historical background, fabrication and operation technique, maintenance and existing condition of the converters in service.

As the periodical inspection of the converters is to be carried out during operation, its time schedule, procedure and items to be investigated have to be well chosen and arranged so as to avoid un-economical interruption of operation and to be able to find any existing defects timely and effectively. According to our regulation the periodical inspection includes external, internal and overall inspection at a specified inspection interval and with itemized details. Besides, there are special inspections for special cases such as resuming operation of converters after out of two-year service, installation at a new site, resuming service after modification of vessel construction, etc. Furthermore, the details and requirement are also specified for nonperiodic inspection.

02. Procedure of Periodical Inspection

Inspection and examination are to be carried out on site "where is, as is", with restricted space and limited conditions, such as: (1) The converter can be turned or moved around as desired. (2) The conditions on site prevent the usage of instrument of high precision or of large scale, like electronic scanner, X ray stress analyzer, laser stress analyzer, photoelasticity instrument, etc. (3) The sensitivity of the instrument may be impaired by the stain or rust accumulated on the surface of the converter which has been in operation for some time. (4) In order to safeguard the converter in serviceable condition, only non-destructive detecting methods are suitable. Measures which could weak the strength of the converter should not be taken. The most commonly used non-destructive detecting methods are: magnetic pigmentation, super-sonic and radioactive detections, field metallographic or coating film metallographic examination, chemical composition anlysis, depth of fracture or crack detecting, hydraulic test and resistance strain measurement.

According to our experience gained in the periodic inspections of pressure vessels like ammonia converters and with the above mentioned apparatus a group of well trained technecians capable of selecting and manipulating the correct instrument and proper methods for any specific job, can, no doubt, detect the defects in time. Judging by the scope, size and nature of defects found, effective measures can be taken for treatment.

For many years, we have detected a lot of defects of ammonia converters in time, including those inherited during fabrication stage and those started or developed during operation. By correct anlysis and proper treatment, we have successfully safeguarded the proper and economical operation of so many varieties of converters.

However, new methods of degect detection are now being developed and under trials, which will, no doubt, improve our technic along this line.

III. The Most Frequently Found Defects during Periodical Inspection of ammonia Converters

01. The most frequently found defects

By periodical inspection of ammonia converters, the most frequently found defects are: corrosion, decabonization, cracks inherited from fabrication, cracks of welding and development of hair cracks during operation. The defects detected during periodical inspection on 24 converters are listed in the following table. These defects can be divided into two categories: those inherited before servicing, such as cracks inherited from fabrication and welding delay cracks: those developed after servicing due to operation conditions, (such as pressure, temperature, working medium and duration of service, etc.) like defects

Table: The most frequently found defects

Defects	Ammonia Converters &		Causes
	No.	Percentage	
Corrosion	3	12.5	Prolonged service
De-carbonization	2	8,3	Operating technology and adequacy of intervals assembling process
Cracks inherited from fabrication	10	41.7	Quality of fabrication
Welding delay cracks	9	37.5	Welding technic
Development of hair cracks after servicing	4	16.7	Prolonged service
Cracks from patched welds	3	12.5	Welding technic

of corrosion, de-cabonization, development of hair cracks or cracking from patched welds, etc. Sometimes, the latter is developed from the former category. However, it's obvious that most of the defects are formed or developed after servicing, except those inherited from fabrication. As the converters designed becomes bigger and bigger in size and low alloy high strength steel is extensively used, the occurance of delayed cracking caused by welding exists, Most of defects are detected after several hundred hours to several hundred days after operation. Thereby, it emphasizes the importance of the first round of periodical inspection after operation for detecting this kind of defect.

Development of corrosive defects and hair cracks can only be detected after a number of periodical inspections. For example: a crack 3mm. deep, extending half of its circumference is found inside of a 20g steel 800 multilayer ammonia converter after 9 years in service; a 900 unit is in service for 30 years, no defect is found through regular periodical inspections for all those years, until lately a detrimental defect is detected. We have, therefore, to keep on practising regular periodical inspections to detect defects in time so as to provent any possible disastrous caused by the development of minor defect.

02. The nature of the defects deteдted in regular periodical inspection of ammonia converters.

In order to evaluate the seriousness of the defect and to find out the proper treatment, we have to analyze its nature and cause of formation or development if any. It's influenced by and closely related with the following factors construction of the equipment, material of construction, fabrication process, operation conditions, duration of service; classification, size and location of defect. Co-ordination of diversified technical knowledge is essential foe the evaluation of defects. The items to be studied are as follows:

(1) Investigation of the general conditions of the equipment, including its specification, construction, operating conditions, records of fabrication, installation, operation, maintenance and repair, and especially the records of previous regular periodical inspections.

(2) Loading analysis: to make sure of the loading condition and working parameters at the locality of the defect and its vicinity such as wall working temperature and pressure, frequency of stoppage and loading, temperature changes, nature and magnitude of loading, etc.

(3) Material of construction: chemical analysis, metallic construction and metallographic structure.

(4) Stress analysis: the nature and magnitude of the stress on the shell and the determination of the stress at the locality of the defect which can be analyzed by calculation and resistance strain measurement.

(5) Macroscopic and microscopic analysis: The size and profile of the defect and the changes of its metallographic structure can be verified by non-destructive detection and field metallographic checks. Thereby, the characteristic and causes of formation of the defects discovered during regular periodical inspection can be determined. For example, we have a 900 converter with a forged shell. For 30 years in service no defect was found. In March 1980 a concentrated cracking area was discovered by magnetic check, 630mm from its top opening. There were more than

40 lateral cracks. It was unsafe for further service. We m made the following analyses:

(1) By analyzing aarefully the existing conditions of the vessel, the case history of the operation and records of regular periodical inspections in the past, it was clear that conditions were normal; the defects occured and developed not long ago.

(2) By magnetic and supersonic checks, we found that the cracks covered an area of 5cm, started from the inner surface to a depth of 22-24mm. The individual crack had a length of 3-10mm. We thought that this was the only cracking stopspot we found on the shell.

(3) We found the material of construction of the vessel was unhomogeneous locally through careful investigation of its chemical analysis, mechanical strength testing and metallographic studies.

(4) The loading and stress data of the specific area were calculated and evaluated.

(5) By making field metalographic check on the inner surface and coating film metallographic checks on the cracking area, slight hydrogen corrosion was found on

the inner surface and around the cracks. Besides, non-metallic foreign material was found in the cracking area. In conclusion: it's the result of gradual development of the hair cracks and the existence of non-metallic foreign materi... under the inluence of high temperature and pressure and working medium in the 30 years of service.

IV. Treatment of Defects Detected in Periodical Inspection of Ammonia Converters

Through periodical inspection, some detrimental defects are found which are beyond repair and make the unit unsafe to operate any longer. For example: we have a 20g steel multi-layer ammonia converter 700 in size. When in service, the vessel has a local hot spot which happens quite often, causing local decarbonization. The carbon content drops from 0.18% to 0.05-0.17%. In Mei's impact test, K=0.03-0.04kg-m/cm^2 From metallographic study, it's apparent that pearlite was completely decarbonized into ferrite. The vessel has to be discarded. However, according to our statistics, most of the converters' defects detected can be repaired by proper treatment and we put the unit back to service conforming to safety code, and make the best out of it. In the process of regular periodical inspection, the defects detected are evaluated quantitatively and qualitatively to guarantee the safety operation of converters, upon which proper conclusion can be drawn for chosing the correct treatment according to the concrete conditions as discussed in the following paragraphs.

For minor cracks on the surface, conventional filing, polishing or grinding may suffice. Of course, the strength of the vessel should not be impaired; otherwise additional measures should be taken. In case of deep cracks or severe corrosion, which may weaken the vessel, welding under restricted regulations is recommended. The internal stress subjected by the vessel in service, which can be determined by resistance strain measurement, will serve as a guide to guarantee its operation in safety.

If the defect is beyond repair on site, it has to be returned to the shop for overhauling. For example: we have a 1190 converter with a single layer welded shell of 14Mn MoV steel. After one year service, 90 cracks were detected, which were welding delay cracks scattering on the inside and outside surfaces. After repairing in the shop. it was put back to service and operated normally ever since.

Moreover, according to our statistics and analysis, cracking is the most common defect detected through periodical inspections. Refering to the theory of conventional mechanics, no cracking is permissible in high pressure vessel. To its contrary, in the modern theory of fractural mechanics rapidly developed in the 1960s, it's believed that this kind of ideal case never exists. There bound to be defect and non-homogeneity. Judging by the position and size of the defect or crack, the remaining life of the vessel can be calculated to ensure continuation of safe operation. In recent years, the theory of fractural mechanics has been applied to evaluate cracks or defects of ammonia converters as a reference for defect treatment. For example, on six 1010mm 14MnMoVB steel multi-layer ammonia converters, the following steps are taken to analyze the longitudinal and transverse welding delay cracks: determination of fractural mechanics parameters; imitation failure and fatigue tests of pressure vessel with defects subjected to internal pressure; low circulation fatigue test on the vessel section with cracks. In conclusion:

The portion with minor circumferential cracks is not the weakest point of the vessel, its axial factor of safety remains adequate, the cracks are not enlarged, and the residue life of the vessel remains over 24×10^4 times, even though the portion without crack fails tangentially. It's estimated that thede six converters with circumferential cracks of 42mm (max.) in length will remain in service for another 20 years or more under the designed operation parameters.

The acoustic emission technic developed recently has been used during hydraulic test of pressure vessels for detecting the occurance of any development of crack and the starting point of cracks for determining the parameters of fractural mechanics. We have few occasions using accoustic emission technic for detection of pressure vessels in the field.

However, according to our experience in the last few years, acoustic emission technis is proved to be effective in the field detection for disclosing the progressive activities of the sub-critical cracks during operation. The acoustic emission technic will open a new phase in field detection of defects and the trend of treatment.

V. Conclusion

From the foregoing discussions, It's obvious that a pressure vessel as ammonia converter bounds to have some minor defects or cracks, because its fabrication is rather complicated, it subjects to high temperature and pressure and is in contact with corrosive mediums for long time continuous operation. Even though it's well designed, constructed with carefully chosen material, skillfully fabricated and strictly tested defects found during fabrication or developed in the course of operation are un-avoidable. We have to rely on periodical inspection to detect the defects in time and to repair them by properly chosen treatment. That's the way to keep the equipment in good working conditions for long term operation in safety and good economy. Our regulation concerning periodical inspection of pressure vessel such as ammonia converters and the like is practical. It's an effective means to safeguard the equipment achieved an economical operation. By practising periodical inspection in the field, we may encounter some restrictions, difficultied or inconvenience

However, by utilizing proper chosen treatment, no doubt, we can detect the existing defects in time and treat them effectively to achieve the goal of safe and economical operation of ammonia converters.