2014 DIE CASTING CONGRESS &TABLETOP
NADCA
NORTH AMERICAN DIE CASTING ASSOCIATION

A simplified approach towards fixing an acceptance criteria for the exposed porosity

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ABSTRACT

Porosity is inherent in the die cast parts and has various effects on the part quality. This also causes the acceptance criteria for each part to vary. There are several methods of defining the acceptance criteria and customers follow varied approaches.

Some of the acceptance standards are either customer specific or individual part specific and they are several pages long. Also these are often cumbersome and subject to several interpretations and understandings. There is no universal standard. Sometimes the drawing even calls for "No Porosity Allowed" in order to cut short the effort, leading to hardships during development and mass production stages.

This paper describes a simplified approach to define the acceptance criteria for the exposed porosity using flags. Porosity depends on the part geometry, process parameters, process capabilities, etc., and fixation of appropriate flags at appropriate locations in relevant sections and views of the engineering drawings makes it very simple to define and easy to follow.

These flags can be added at the time of development in order to alleviate any ambiguity at time of mass production and thereby help reducing the overall time from design to manufacturing. It can also be applicable for fixing the criteria for existing parts that undergo changes during the manufacturing process. In either case it will help to mitigate the cost.

INTRODUCTION

CRP (India) Private Limited is a leading manufacturer of High Pressure Die Casting Products in India. It was founded in the year 1975 by Mr.N.Kunchithapatham, one of the pioneers in the country, in the field of Die-Casting in terms of Design and Manufacturing of HPDC Dies as well as Production of Castings.

CRP is a one stop solution provider for the HPDC Products, having expertise in Product Design, Die Design, Die Manufacturing, Die-casting, Machining, Surface Finishing, Powder Coating, Assembly and Testing.

CRP has joined hands with Twin City Die Castings Company, USA in September 2009 to promote a Joint Venture in India called "CRP-TCDC Die Castings India Private Limited (CTI)", to cater to the growing needs of technical and engineered die castings.

The adaptation/implementation and effective use of newer technologies in the field of die casting has made CRP a cost effective and preferred source for customers. The biggest challenge endured during the development of the technical and engineered die castings is the acceptance criteria for the porosity and related leaks.

The development gets stalled due the issues pertaining to the locations and sizes of the exposed porosity as defined in the print. Mostly these are fixed arbitrarily by the product design and engineering teams at the design tables. Often the acceptance criteria are referred to a common standard either international (e.g ASTM E505) or an internal. Still there are numerous ambiguities and interpretations at the time of application in the field. Imagine the absence of these practices completely and the customer demanding a "NO POROSITY" on his part, the resolution is very difficult, which is often the case.

The extensive use of the flow and solidification simulations helped in finding acceptance of the customer, but it takes a long time and several rounds of discussions and iterations, to establish the acceptance criteria.

Each die cast part is unique in terms of shape, size, wall thickness, section thickness, etc., and requires a specific standard to define the locations, sizes, distance between pores, etc.

There are cases where the customer standard with part specific acceptance criteria defined in details, running into a number of pages, with sketches, pictures and explanations. This is cumbersome to implement and maintain.

Hence we at CRP decided to compile a standard based on several customer standards that we came across over the years. Adding our own experiences and challenges, we have finally stitched them together and implemented last year. Already three of our customers have accepted them and we have successfully started using them in the existing and new products. The simulation results coupled with the developed parts are used as a reference to arrive at the acceptance levels.

The implemented standard is depicted as such in this paper and it is elaborate and self-explanatory.

THIS PAPER IS DEDICATED TO MY COLLEAGUE AND FRIEND LATE MR. THOMAS HEIDER,
Then Chairman, of the NADCA STANDARDS Committee, for the encouragement and support of this work. Hope this leads to further interactions by the Committee and adopted into NADCA Standards for the benefit of the entire die cast fraternity, as he wished.

STANDARD FOR EXPOSED SURFACE POROSITY

1.0 SCOPE:

The purpose of this standard is to establish acceptance criteria of porosity on the surface areas of castings.\

2.0 EXCLUSIONS:

2.1 This standard does not apply to porosity depth.

2.2 This standard does not apply to “internal” part porosity that is exposed via sectioning.

2.3 This standard does not apply to non-porosity surface imperfections such as tool marks, die check marks, heat checks, die gate or vent marks, ejector marks, machining marks, nicks, etc.

3.0 APPLICATION:

3.1 All new casting drawings (RFQs) and any ongoing revisions to existing casting drawings (Parts presently supplied) should be considered to add porosity allowance criteria. The part drawing must specify the porosity allowance as well as the applicable surface areas for inspection, as described below.

3.2 The engineering department must determine the appropriate values and appropriate regions that are highlighted for porosity allowance.

3.3 The product development engineer and/or marketing department are to inform the casting supplier of the Porosity allowance and provide this porosity specification document.

3.4 The drawing shall have a default callout that refers to this porosity standard document and applies to all as-cast and machined surfaces unless otherwise specified. In some cases all that may be required is the default callout, but only if one blanket size for porosity will suffice for the entire part.

3.5 In addition to the default note, the drawing may have additional “flag” notes that indicate shaded or crosshatched areas which have different porosity allowance. If there are multiple porosity regions, each shall have its own flag note.

4.0 INSPECTION AREA:

4.1 The inspection for surface porosity is based on visual assessment of both as-cast and machined surfaces of the casting. Magnification in the range of 5X to 25X is recommended. For best inspection results, a Measuring Magnifier containing an internal grid overlay is recommended.

4.2 Part surfaces for inspection are to be clean and degreased. Light sanding or polishing of the part inspection area is allowed to better view porosity.

4.3 Inspection shall be done under a suitable lighted environment. If lighting is in question, a minimum of 200 lux intensity is recommended.

4.4 The size and shape of porosity is irregular by nature. For purposes of inspection, the “size” of the porosity pit or pore is determined to be either its maximum length or maximum width along the exposed surface of the part.

4.5 A 10 mm x 10 mm area will be evaluated for number and size of pores. Any area of this size across the noted surfaces of the part is subject to this requirement. The inspection area should be selected over the “worst case” porosity concentrations. The inspection area upon the part surface shall be a continuous planar surface, a curved surface such as an inside bore or an outside diameter, or a radius or fillet of at least R 2.0 mm. For larger curved surfaces greater than R6.4 mm the 10 mm length for the inspection area shall be measured along the actual curved surface. For smaller radii or fillets of R 2.0 mm to R 6.0 mm the area under consideration shall be the curved radius section along a depth or length of 10 mm. The smallest radii or fillets, those below R 2.0 mm, shall be included within either adjacent wall area.

4.6 If the specific area under scrutiny is less than 10 mm in either width or length, for example the floor of a narrow groove, then the area will be reduced to the actual length or width (whichever is shortest) x 10 mm. If the area indicated is less than 10 mm x 10 mm in any direction, then the porosity allowance applies to the actual available area.

4.7 Perpendicular or adjacent angled surfaces, such as the wall or the floor of an O-ring groove, are considered separate surfaces.

5.0 DRAWING NOTATION:

5.1 The porosity default callout and the flag note(s) shall use the following convention for
NUMBER of pores allowed per area (an integer) and SIZE RANGE (numbers with one decimal place for mm size, representing size in mm of the pore). Use the letter “N” followed by a whole number, then a “colon”, then the letter “S” followed by two numbers (the size range) that are separated by a “dash”.
Optionally this can be followed by a “colon” and the letter “D” to denote minimum DISTANCE between two adjacent pores followed by a whole number, representing distance in mm.
Decimal mm numbers shall have leading zeroes in the callout.

5.2 A given flag note should only have one set of values for N ,S and D. Do not combine two criteria into a single flag note.

5.3 In some cases a specific critical area on the casting may have more than one flag note for porosity allowance assigned. This can be used to control density of smaller porosity, for example.

5.4 The Notations N , S and D can be used in any combination to define the levels of porosity. They can be also left blank as follows.

- “N” is absent in the Notation means the Number of pores is not counted
- “S” is absent in the Notation means Size is not a criteria. If the range is ignored and only “S” is followed by a single number with one decimal place indicates a maximum allowable size of a single pore.
- “D’ is absent in the Notation means Distance between pores are not controlled.

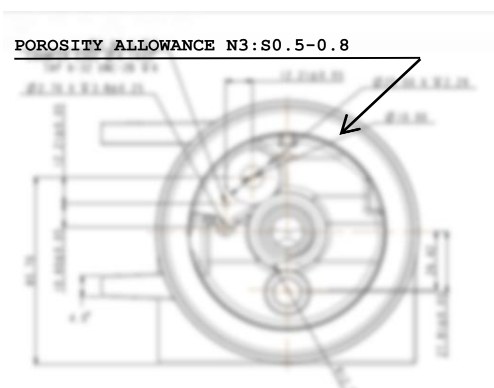
With this it is possible to define every type of porosity on a wide spectrum of parts and applications without any ambiguity.

6.0 DRAWING EXAMPLES:

6.1 Default porosity drawing note with blanket coverage for all surfaces:
POROSITY ALLOWANCE PER CRP ENGINEERING STANDARD CE1301 TO BE N5:S0.8-1.5 FOR ALL AS-CAST AND MACHINED SURFACES UNLESS OTHERWISE NOTED.
This note indicates that up to 5 pores of size 0.8 to 1.5 mm is allowed. Note that the values selected for N and S are at the discretion of design engineering.

6.2 The drawing should indicate the largest permissible size values in the default note and address the smaller or more critical areas per an additional flag note as described below.

6.3 Example flag note, used in addition to the default note above, with appropriate flags pointing to shaded or highlighted areas on the drawing.



[FLAG #] POROSITY ALLOWANCE N3:S0.5-0.8
This note indicates that up to 3 pores of size 0.5 to 0.8 mm is allowed within the flagged (shaded) region of the drawing.

6.4 Some more examples

[FLAG #] POROSITY ALLOWANCE N3:S0.5-0.8:D5
This note indicates that up to 3 pores of size 0.5 to 0.8 mm is allowed within the flagged (shaded) region of the drawing, with a minimum distance between pores is 5mm.

[FLAG #] POROSITY ALLOWANCE S0.5-0.8:D2
This note indicates that any number of pores of size 0.5 to 0.8 mm is allowed within the flagged (shaded) region of the drawing, with a minimum distance between pores is 2mm.

[FLAG #] POROSITY ALLOWANCE N3:D5
This note indicates that up to 3 pores of any size are allowed within the flagged (shaded) region of the drawing, with a minimum distance of 5mm.

[FLAG #] POROSITY ALLOWANCE N3:S0.8:D8
This note indicates that up to 3 pores of size up to 0.8 mm is allowed within the flagged (shaded) region of the drawing, with a minimum distance of 8mm.

[FLAG #] POROSITY ALLOWANCE N3:S0.5-0.8
This note indicates that up to 3 pores of size 0.5 to 0.8 mm is allowed within the flagged (shaded) region of the drawing, with no limit on the minimum distance

[FLAG #] POROSITY ALLOWANCE N5
This note indicates that up to 5 pores of any size is allowed within the flagged (shaded) region of the drawing, with no limit on the minimum distance

[FLAG #] POROSITY ALLOWANCE S2.0
This note indicates that up to any number of pores of maximum size of 2.0 mm is allowed within the flagged (shaded) region of the drawing, with no limit on the minimum distance

[FLAG #] POROSITY ALLOWANCE D10
This note indicates that up to any number of pores of any size are allowed within the flagged (shaded) region of the drawing, with a 10mm limit on the minimum distance.

These examples and values are selected randomly to explain the different possibilities. Though the number of options and examples shown above are many, it will be helpful to define every combination of porosity.

7.0 FUNDAMENTAL RULES:

7.1 Any pores that are smaller than the first number of the SIZE RANGE are totally acceptable, without regard to quantity.

7.2 The second number in the SIZE RANGE indicates the maximum allowable size of porosity. This means that absolutely ZERO porosity pores that are larger than the second size number is allowed on the part or within the area designated.

7.3 There must be a minimum solid distance of 1 mm between any two pores that are within the SIZE RANGE for the specified area of the part. Exceptions to this rule are at the discretion of design engineering and must be noted on the drawing.

7.4 Form, Fit and Function of the part should be the ensured while fixing the flags.

7.5 In case of not meeting the section 7.4, a mutually agreed method of ensuring the form fit and function has to be arrived at, such as ,

- Change in Product design,
- As cast and machining dimensions and the machining stock
- Impregnation

8.0 PURPOSE & CONCLUSION

As porosity depends on the part geometry, process parameters, process capabilities, etc., fixing of appropriate flags at appropriate locations in relevant sections and views at the time of development, will alleviate any ambiguity at time of mass production and help reducing the overall time from design to manufacturing. It can also be helpful for fixing the criteria for existing parts that undergo changes towards manufacturing process. In either case it will help to mitigate the cost.