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Chapter XI

High-Pressure Die-Casting Process Modeling Using Neural Networks

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Abstract

This chapter presents the application of a neural network to the industrial process modeling of high-pressure die casting (HPDC). The large number of inter- and intradependent process parameters makes it difficult to obtain an accurate physical model of the HPDC process that is paramount to understanding the effects of process parameters on casting defects such as porosity. The first stage of the work was to obtain an accurate model of the die-casting process using a feed-forward multilayer perceptron (MLP) from the process condition monitoring data. The second stage of the work was to find out the effect of different process parameters on the level of porosity in castings by performing sensitivity analysis. The results obtained are in agreement with the current knowledge of the effects of different process parameters on porosity defects, demonstrating the ability of the MLP to model the die-casting process accurately.

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HPDC is a process used to produce various structural elements for the automotive industry, such as transmission cases, engine sump, rocker covers, and so on. The process begins with pouring melted aluminum in the shot sleeve cylinder through a ladle. After the die is closed, the metal is pushed inside the die cavity by moving a plunger. The plunger starts initially with a low velocity, then the velocity increases during the piston's motion, and the velocity is decreased at the end when nearly all the liquid metal is injected into the die. The metal is injected through gate and runner system at a high velocity and pressure. The die is then opened and a robotic arm extracts the solidified part. The die is lubricated to facilitate the extraction of casting and to avoid soldering of the metal with the die surface. The extracted casting with a biscuit is then cooled down with water and is placed on a conveyor belt for further treatment or otherwise stored on a rack for quality-control tests.

The HPDC process is a complex process, consisting of over 150 inter- and intradependent process parameters. For example, there is a dependency between the gate velocity, the fill time, and the die temperature (Davis, 1978). If the fill time and the gate velocity are optimized, the die temperature becomes less critical. The interaction between the fill time and the metal pressure is also well-known (Walkington, 1990). The complexity of the process results in many problems like blistering and porosity. While the complexity of HPDC makes it difficult to obtain an accurate physical model of the process, having an accurate model of the die-casting process is paramount in order to understand the effects of process parameters on casting defects such as porosity.

Porosity is a defect in which the HPDC machine produces castings with pores in them as a result of either gas entrapment or vacuum due to poor metal flow at the location of pore occurrence. Porosity is by far the most highly occurring defect in automotive engine castings, resulting in the largest percentage of scrap of engine-component castings (Andresen & Guthrie, 1989). At the same time, porosity is one of the most difficult defects to eliminate in die casting. It is in the best interest of the industry (e.g., car manufacturers) and the consumer of die castings that porosity is eliminated completely from the castings, but this is not always possible to do with the current level of process understanding. The industry generally has to settle to move porosity to different noncritical locations in a casting rather than to remove it completely. In addition, attempts to eliminate porosity defects can affect other process settings and result in other casting defects.

Understanding of how HPDC process parameters influence casting defects such as porosity can eventually lead to determining the optimal process parameters to reduce the chance of defects occurring in the castings. The variety and often conflicting nature of the states of process parameters makes it hard in practice to achieve a globally optimized process with no defects in castings. Thus, the industry is generally opting for defect reduction on the basis of intended use of the casting; for example, a casting that has to be attached to other parts using bolts should not have weakness close to the bolt hole. It is crucial that there is either low or no porosity in the area close to the hole, while defects that lie in other parts of the same casting that does not affect structural integrity of the casting can be tolerated.
Background

The porosity defect can be divided into three major types, which are gas porosity, shrinkage porosity, and flow porosity. In HPDC, the first two types of porosity are mostly encountered. The gas porosity is the porosity in casting due to the presence of gas. This type can arise from gas produced during process, entrapped air, and melt composition. The shrinkage porosity is due to shrinkage of metal, so that the metal loses volume and hence more metal is required to fill the voids produced. In HPDC, it is hoped that this problem can be minimized with the application of high pressure to fill the voids when metal is in the solidification state. Formation of porosity in aluminium castings is a combination of die-casting process parameters, such as melt composition and solidification properties, under high pressure. Main process-related porosity formation mechanisms include solidification and entrapped-gas-related formation. Melt related porosity formation is of minor importance, primarily because hydrogen entrapment in HPDC is not a big problem (Walkington, 1997). Hydrogen entrapment can be a serious problem if there is a significant amount of scrap being remelted. The specific reasons for porosity formation are undesirable states of shot sleeve, cavity, runners, vent and gates, solidification pressure, lubricant quantity, and steam formation from water during the process.

Porosity formation is a subject of active research that can be divided into discussions of porosity types, whether gas or shrinkage (Garber & Draper, 1979) or the specific issues regarding porosity formation like entrapped air in shot sleeve or cavity (Garber, 1981, 1982; Thome & Brevick, 1995), gate and runner systems (Andresen & Guthrie, 1989), pressure (Kay, Wollenburg, Brevick, & Wronowicz, 1987; Murray, Chadwick & Ghomashchi, 1990), and melt composition (Kaghatil, 1987; LaVelle, 1962).

Shot-Related Porosity Formation

Shot-sleeve-related parameters are perhaps the most sensitive ones when it comes to entrapped-air porosity. The parameters like acceleration, stage velocities, diameter, or even deceleration are all shot-related parameters determining the formation of metal-wave patterns, which can be crucial factors in deciding whether air becomes entrapped. Other important parameters are shot-delay time and the percentage fill of the shot sleeve.

As soon as the metal is ladled, the goal of HPDC is to begin injection as soon as possible but still at the right time in the case of a cold-chamber die-casting machine. Metal injection should begin soon because the metal starts to solidify in the shot sleeve; and, if metal with solid particles is injected into the die, the high velocities can cause die wear and may contribute to die erosion and towards a deterioration of the quality of the castings. It is not recommended to inject immediately because it can destroy the wave pattern and can entrap air in different forms. Hence, shot-command delay is the first process parameter to be selected carefully. Then it is the first stage velocity. If it is too low and too high, it can contribute to wrong wave formation. The wave is formed if shot velocity (first-stage velocity) is too slow. The wave gets on top of the air, and the air is injected into the cavity (Thompson, 1996; Garber, 1982).
The other sleeve-related process parameters are acceleration to attain different stages of velocity and fill percentage. The acceleration can also be a deciding factor in porosity formation. Shot-sleeve percentage fill can also affect the wave formation. If the sleeve is full of metal, the air quantity is less when compared to a lesser extent of fill, and hence higher velocities can be applied safely to fill the cavity without forming deteriorated wave patterns. Plauchniak and Millage (1993) has described a four-stage shot system that adds a deceleration phase between stages in the hope to minimize impact pressure.

The process parameters affecting the entrapped air in the shot sleeve are the velocities of the plunger, shot-sleeve fill percentage and the acceleration to reach the first stage of desired velocity (Thompson, 1996). A too low first-stage velocity can form an inward wave of air entrainment in the sleeve (Figure 1). A too high velocity can form different flow in the metal towards the die cavity within shot sleeve that can result in entrainment of the air in a forward direction (Figure 2). It helps if the shot sleeve is filled more than 50% (Thompson, 1996; Walkington, 1997). It is possible to instantaneously accelerate the plunger from zero to first-stage velocity without producing porosity in 50% fill. The pressure requirements, fill time, and gate velocity very often make the 50% fill impossible (Walkington, 1997).

Garber (1982) has developed a mathematical model of the effects of plunger-related process parameters. It is noticeable that his model does not include the shot-sleeve parameter—the acceleration of plunger. In fact, in his previous work, Garber (1981)

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**Figure 1. Air is entrapped when shot velocity is too low in the backward reflected wave**

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**Figure 2. Air is entrapped if the shot velocity is too high; the three small arrowheads show the problematic flow responsible for entrainment**
vehemently denies the importance of acceleration at all. The view that a smooth acceleration can minimize air entrapment in castings from shot sleeve, while doubtful for Garber, is considered very important by other authors (Thome and Brevick, 1995; Thompson, 1996). Thome and Brevick (1995), similar to Thompson (1996), discuss optimal acceleration to reach different stages of velocities. The authors advocate control of acceleration to reduce turbulence in shot sleeve and to minimize air entrapment for less than 50% fills. Backer and Sant (1997) found a direct effect of acceleration during a slow shot of velocity. The authors have found that high accelerations break the waves at the ends of the plunger that has the potential to entrap air while the metal is being injected in the die cavity. Slow accelerations, on the other hand, were found to be optimal in the sense that they do not break the wave and there is a low probability of air entrapment in this case. A study conducted by Brevick, Duran, and Karni (1991) addresses the issue of acceleration with respect to Garber's optimal velocities (Garber, 1982) to minimize air entrapment. It was found that an acceleration of 2 in/sec/in further minimizes air entrapment at Garber's critical velocity. If acceleration is considered important, the concept of critical velocity can be applied to further low percentages of shot sleeve fills. Brevick, Duran, and Karni (1991) report achievement of nonbreaking waves up to as low a percent initial fill as 20%.

A series of work dealing with the application of control engineering to die casting emphasizes acceleration and provides the mechanism to measure and control the acceleration of the plunger for successful die casting with minimum scrap (Hadenhag, 1989; Shu & Kazuki, 1997; Vann, 1993). Vann and Shen (1989) claimed that controlled acceleration during the whole shot press (shot cycle) minimizes air entrapment and hence porosity. Hadenhag (1989) made similar claims that using controlled acceleration and deceleration gets rapid paybacks with fewer rejects, metal savings, and higher machine utilization. Similar results and conclusions have been drawn about acceleration in older die-casting literature (Kruger and Bosch, 1966; Pomplas, 1972). It seems that only Garber (1982) has disagreed with the importance of acceleration.

The velocities of first and second stages of plunger movement are other process parameters that affect the formation of porosity for pretty much the same reasons as acceleration. Both are related to the formation of “wrong” motion of liquid aluminum (waves) inside the plunger. Figures 1 and 2 show the cases with too high and a too low initial (first-stage) shot velocity (Thompson, 1996). The change over position naturally becomes important when the velocity has to be changed from first to second stage. According to Garber (1981, 1982), Thome and Brevick (1995), and Thompson (1996), porosity arises out of the suboptimal settings of parameters — namely settling time after pouring; first-stage velocity; inappropriate changeover position; and, to some extent, second-stage velocity.

Garber’s pioneering paper (1982), supported with a mathematical model of porosity formation, remained the center of discussion for a decade and a half. Garber identified further two shot-sleeve-related parameters that affect air entrapment in a cold-chamber machine. They are initial fill percentage and diameter of the plunger itself.

Hairy, Hemon, and Marmier (1991) designed an expert system to diagnose and suggest solutions to the die-casting problems. According to the authors, most defects result from poor settings of machine parameters like first- and second-stage velocities and overpressure.
Asquith (1997) studies the effect of first- and second-stage plunger velocities, changeover position, intensification pressure, and biscuit length. The author observes an increase in porosity with increasing first-stage velocity with no significant effect on surface or X-ray quality test results. Second-stage velocity should be low to achieve low porosity but a higher second-stage velocity is required to minimize surface defects. It is suggested to have a 3.5 m/s second-stage velocity considering other factors like die wear and flashing that can occur with higher velocities.

Asquith (1997) and others (Andresen & Guthrie, 1989; Backer & Sant, 1997; Brevick, Duran, & Karm, 1991; Garber, 1982; Garber & Draper, 1979a, 1979b; Hadenhag, 1989; Kruger and Bosch, 1966; Plauchniak & Millage, 1993; Shu & Kazuki, 1997; Vann & Shen, 1989) have unanimous agreement that shot velocities are crucial to the quality including occurrence of porosity in high-pressure die casting. Aforementioned authors describe all their systems under two stages of velocities in sharp contrast to Plauchniak and Millage, who argue that third-, even fourth-stage velocity systems are better. The first two stages are essentially the same for elimination of gases through forming a wave that eliminates them before entering gate and runner systems. Second stage is to fill the cavity by matching the resistance offered to the flow-by runner. The third stage is to enhance solidification (intensification) pressure. The fourth-stage system described by the authors actually adds a deceleration stage between the first two stages. The authors argue that this stage breaks any spike in pressure developed when the cavity is filled and can increase die life.

The effect of the changeover position is very interesting. The porosity decreases with an increase in the changeover position. Increasing it to 600 mm produced the least porosity, and all castings passed the visual tests. Asquith (1997) does not point out the effect of a high second-stage velocity and a high changeover position. It is worth studying if it is possible to have a high second-stage velocity with a high changeover position to minimize porosity, as well as surface defects. The effects of combination of this configuration on die wear and die flashing can also be investigated.

**Vents, Pressure, and Gas-Related Porosity**

The air in a cavity can be entrapped due to the problems in runners or ventilation. The vents should be big enough to let the air escape and be located near the last spot to solidify. The runner should not have sharp corners in general. If the vents are working properly, the air entrapped can escape to a sufficient extent (Walkington, 1997).

The purpose of the application of high pressure in die casting is to minimize shrinkage apart from rapid production, low costs, and to achieve a lower cycle time. In HPDC, no extra metal is generally provided to reduce shrinkage porosity that is a result of volumetric contraction. Many die casters still find shrinkage-related porosity despite applying enough pressure, because the applied pressure can be different than the actual pressure developed inside cavity. This happens because of insufficient biscuit size or too big a size and unexpected solidification. If the biscuit is too small, it can solidify first or even metal in the shot sleeve can solidify which can take pressure off the cavity.

Asquith (1997) observed double porosity when he applied "no intensification pressure" (which means that a base pressure of 25.8MPa was applied). Here, the author was able
to test the plunger movement with high pressure and concluded that high intensification
pressure has a more significant effect on porosity than the plunger-speed configuration.
It is worthwhile here to point out that the porosities that result from velocity profiles and
intensification are two entirely different kinds of porosities: gas and shrinkage porosities.

The quantity or type of lubricants used to grease the die and plunger can be a significant
contributor to porosity if they get burnt and result in the formation of gas. The purpose
of die lubricant is easy extraction of the part after solidification, while plunger lubricant
is used to facilitate motion of the heavy plunger through the cylinder.

Due to the extreme temperatures in the die-casting environment, some of the lubricant
gets burnt and produces gases. An optimal amount of lubricant that is dispersed evenly
is used to reduce lubricant porosity. Water is an integral part of die lubricants, and it can
occur as steam porosity due to high temperatures. Water can accumulate on a die from
a sprayer and leaking water-cooling lines.

Porosity Models

Gordon, Meszaros, Naizer, and Mobley (1993) have developed a model to calculate
porosity in terms like the volume of liquid in the casting cavity, which does not require
extra metal supply to compensate for shrinkage, volume of cavity, temperature of the gas
in the casting cavity, pressure applied to the gas during solidification, liquid alloy density
at the melting temperature, solid alloy density at the melting temperature, quantity of gas
contained in the casting at standard temperature and pressure (STP), solubility limit of
gas in the solid at the melting point, or solidus temperature at STP. It is noticeable that
some of these are not die-casting machine parameters. The authors correlate the results
of other researchers in terms of die-casting process parameters like volume of die
lubricant per casting, plunger lubricant (amount), state of shot sleeve, cavity fill time,
fast-shot velocity, die-temperature gradient, metal temperature in the furnace, and die
open time.

This work is of particular interest to the authors of this chapter because the model
proposed by Gordon et al. (1993) is helpful in calculating porosity but does not provide
any direct recommendations on how to reduce it, as it does not address the formation of
porosity in terms of die-casting process parameters. This warrants further work to verify
the model given by Gordon et al. (1993). The authors do not have a framework to fit in
the die-casting process parameters in their mathematical model; however, die-casting
process is essentially controlled by its process parameters. One of the observations
going against the model of Gordon et al. 1993), as reported by Garber and Draper (1979a),
is the decrease in porosity with the decrease in holding temperature. It is assumed that
the decrease in temperature may affect the volume of liquid in the casting cavity that is
not supplied with extra liquid metal (because it is not required to) to compensate for
solidification shrinkage and the gas that is entrapped in the casting cavity. This is further
needed to be investigated and can result in a change in the model of Gordon et al. (1993).

Significant work has been done in Australia recently with novel approaches and
applications to the porosity-modeling problem (Rogers, Yang, Gershenzon, & Vandertouw,
2003). The authors put emphasis on the data-acquisition (shot-monitoring) kit. They
have developed revolutionary technology that has the ability to "look into a casting" and signal the red/green light to indicate rejects. Our work (Khan, Frayman, & Nahavandi, 2003) uses an artificial neural network (ANN) to predict porosity reliably in aluminium HPDC. The work by Huang, Callau, and Conley (1998) is a similar attempt, but it is not related to HPDC. Yarlagadda and Chiang (1999) have used neural networks to find out the intradependence of process parameters in the die-casting process. Our work is different from the work noted previously since it is an attempt to model HPDC process defects given the process parameters, which represent the state of the machine at a given instant of time.

Biscuit Size

Very low and very high biscuit sizes generally result in higher porosities. An increase from 13 mm to 15 mm lengths dramatically decreased porosity (Asquith, 1997). It is recommended to use a minimum 25 mm biscuit length with maximum intensification for sake of passing the X-ray test for the casting, with ladle consistency being taken into account to maintain the size. It is noticeable that in Gordon et al. (1993) the authors do not attempt to relate the size of the biscuit to their equations. Further research can be conducted to relate biscuit size to equations or a new term added to the equations to take the biscuit size into account. The exploitation of a neural network can be a good idea, because it offers the utility of adding the biscuit size to the inputs of the network.

Methodology

Computational intelligence techniques that include ANNs, genetic algorithms, simulated annealing, and fuzzy logic have shown promise in many areas including industrial engineering where the use of neural networks, genetic algorithms, and fuzzy logic is quite prominent. The capability of ANNs to learn complex relationships well has made them a popular methodology for modeling the behavior of complex systems. Computationally, ANNs in their most common form of a multilayer perceptron (MLP) are distributed parallel-processing systems capable of a fault tolerant and efficient learning and are resistant to noise and disturbances. They are connectionist structures composed of nodes called neurons and arcs connecting the neurons with weights associated with the arcs. Weights are adaptable and are the main learning parameters of the network. The network learns typically by using a backpropagation learning algorithm (Rumelhart, Hinton, & Williams, 1986) that updates the weights. The network has generally three types of layers called input, output, and hidden layers. The information is presented in a preprocessed or raw format into the input layer of the network and the predictions are obtained at the output layer of the network.

MLPs are quite useful in developing an inductive model of the problem at hand with a fair accuracy when there is no mathematical/physical model available and have been used in the die-casting industry (Huang, Callau, & Conley, 1998; Yarlagadda & Chiang, 1999; Khan, Frayman, & Nahavandi, 2003).
A MLP can be represented symbolically as:

$$y_{r,n}^p = \sum_{r=1}^{\eta=n} \sum_{j=1}^{i=n} \Phi(\sum_{l=1}^{x_{ij}} \theta_{ij})$$

Here:
- $y_{r,n}^p$ is a noisy output especially in the case of real-world data,
- $p$ is a pattern number,
- $r$ represents noise (random distribution),
- $n$ is the number of output components (neurons),
- $\theta_{ij}$ is the adjustable parameter of the model (weight),
- $\Phi$ is the transfer function, and
- $i$ and $j$ are the neuron numbers.

An MLP was selected for this work, and the aim of the work is the understanding and modeling of the casting defects in terms of machine parameters.

**Experimental Setup**

An MLP with one hidden layer has been used in this work to model location and quantity of porosity in a casting. The data used to train the network consisted of process parameters related to porosity and location and quantity measures of porosity in the castings. The process parameters (the inputs to the ANN) to use were chosen on the basis of existing knowledge of the porosity-related parameters from the die-casting domain. These parameters are: first-stage velocity, second-stage velocity, changeover position, intensity of tip pressure, cavity pressure, squeeze-tip pressure, squeeze-cavity pressure, and biscuit thickness. A dataset consisting of 306 data points and obtained from data logging the operation of a multicavity HPDC machine in a die-casting manufacturing environment has been used. The first 204 data points in a dataset were used for training, and the remaining 102 points were used for testing.

The level of porosity was quantified using X-ray grades at two different locations labeled as A and E. These X-ray grades are quality measures ranging from 1 to 4, with 1 representing minimum level of porosity at the designated location and 4 representing the worst porosity level. Occurrence of porosity level of 4 in any of the locations on the casting results in the casting being rejected. The outputs of MLP are the levels of porosity (quality) measures at location A and E in the casting.
D = a + Δ

and then for the rest of iteration by

D = D + Δ

The iteration was stopped when D had reached h. During the variation of Xs, the output is logged and plotted to visualize the change in ΔO. The general equation through which this is generated and averaged data is passed was:

\[ O = net_{ho} f(D, \bar{X}, net_{ih}) \]

Here net_{ho} are the weights associated with hidden and output layers and net_{ih} are the weights between hidden and input layers. \( \bar{X} \) is the average of all inputs other than \( X_s \), since D is the representative of \( X_s \) and f is the function performed by the hidden layer of the MLP model.

### Results and Discussion

The criterion that was used to judge the model quality was the agreement of the MLP model with the existing work in porosity modeling. We have found that in most cases, the MLP model of porosity formation was able to represent the underlying process well. Figure 3 shows that the obtained MLP model was able to predict accurately that the increase in first-stage velocity has a decreasing effect on the level of porosity in agreement with Garber (1981, 1982) and Thome and Brevick (1995).

Figure 4 shows that the obtained MLP model was able to predict accurately that an increase in second-stage velocity (high-speed velocity) decreases the amount of porosity in accordance with the concept of critical velocity (Garber, 1982). The porosity decreases sharply with initial increases in the high-speed velocity and then tends to stabilize as it reaches the critical velocity when it matches the resistance offered by the gate and runner system in order to inject the metal immediately as it reaches the end of the shot sleeve.

Figure 5 shows that the obtained MLP model predicts that an increase in changeover position decreases the amount of porosity. This result is in conflict with the existing work on porosity (Asquith, 1997). Further investigation is needed to determine why the MLP model has determined it in such a way.

Figure 6 shows that the increase in tip-intensification pressure is increasing the amount of porosity contrary to what should happen. Part of the problem is the pressure that is transferred inside the cavity. This result has to be seen in tandem with the next result and
Figure 3. Relationship between the level of porosity and the slow-stage velocity (also known as first-stage velocity) measured in meters per second (m/s); the Y-axis represents the quantity of porosity between levels 1 to 4, with one as minimum and four as maximum.

Figure 4. Relationship between the level of porosity and the high-stage velocity (also known as second-stage velocity) measured in meters per second (m/s).

Figure 5. Relationship between the level of porosity and the changeover position (mm).
Figure 6. Relationship between the level of porosity and the intensification of tip pressure (MPa)

Figure 7. Relationship between the level of porosity and the maximum cavity-intensification pressure (MPa)

has shown the capability of the MLP to model the HPDC process well. Figure 7 shows that the increase in cavity-intensification pressure lowers the porosity. It is the pressure that develops inside the cavity and is a result of a tip-intensification pressure. The porosity is supposed to decrease with increasing pressure (Kay et al., 1987; Murray et al., 1990). Figure 6 shows an increase in porosity with increasing tip pressure while Figure 7 shows a decrease with increasing cavity pressure in accordance to Kay et al. (1987) and Murray et al. (1990). That means that the MLP has been able to learn that the cavity pressure has a real decreasing effect on porosity. Applying more pressure normally reduces gas porosity. The pressure helps the gas to escape out of the casting. It is the pressure that reaches the casting rather then the applied pressure that makes the difference and the MLP has been able to predict this accurately.
Figure 8. Relationship between the level of porosity and the biscuit size (mm)

The dataset that we used had larger biscuit sizes (greater than 25 mm). The porosity is increasing with an increase in biscuit size — in accordance with the literature (Asquith, 1997). According to Asquith, a very low biscuit size (i.e., lower than 13 mm) and a biscuit size higher than 25 mm further increases porosity. In our dataset, the biscuit sizes happen to be higher than 25 mm.

Future Work

We have recently developed a novel type of MLP — a Mixed Transfer Function Artificial Neural Network (MTFANN), customized to obtain insights into data domain from the developed MLP model (Khan, Frayman & Nahavandi, 2004). The novel MLP contains more than one type of transfer function that simplifies the process of knowledge extraction from an MLP model. The application of the MTFANN to HPDC process-monitoring data is on our future agenda to provide further insights into the HPDC process.

In this chapter, we have followed the classical approach used by the die-casting industry to vary a process parameter in order to discover its effect on the quality of output (casting). The industry has a limitation of resources that prevents it from further increasing the combinatorial complexity of experiments. We can however change more than one process parameter at the same time using ANNs to study combinatorial effects of the inputs (process parameters) on the output.

Conclusion

The developed neural network model of the presented work is able to model the complex realities of HPDC. Several previous attempts in the field to model porosity using simpler
methods produce contradictory results. We believe that the usage of simpler methods is the main reason that there has not been much consensus in the work on HPDC modeling. If advanced computational intelligence techniques, such as neural networks, are further used and receive favorable response from material scientists, then it is a possibility that some sort of consensus can be obtained.

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References


Thome, M., & Brevick, J. R. Optimal slow shot velocity profiles for cold chamber die casting (Transaction No. I-T95-024). In Transactions of the 18th International Die Casting Congress, NADCA.


Endnote

The acceleration is measured in L/T/L dimensions rather than L/T/T in die casting.