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Tribology in manufacturing processes

IMPROVING AUTOMATIC DETECTION OF DEFECTS IN CASTINGS BY APPLYING DAMAGE ESTIMATION TECHNIQUE FOR DIE CASTING ANALYSIS

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ABSTRACT

In die casting form, the defects such as macroporosity are difficult to control and eliminate by the manufacturer. It is still an on-going test. The preset casting cycle and die structure outline area is the main focusing part as far as the current procedures are concerned. To change and relieve the negative impact and to make the process consistent some procedures for controlling the process should be utilized to progressively change the operational parameters of the procedure. In this work, a limited heat exchange display component has been produced to identify and to predict the development of temperatures and the fluid region exemplification in this die casting process. The correlation with plant trial information has been established for the model. A virtual procedure has been established for the given model to recreate the persistent activity of the system. In order to give a reliable representation of this virtual procedure, a nonlinear state-space display is provided based on data from the virtual method. Direct unique conduct with nonlinear static gain is shown from the control factors driven segment. The linear function is dependent on the feed forward-driven segment characterized by framework identification on the virtual procedure.

Keywords: die casting, defects, virtual procedure, linear function and operational parameters.

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AIMS AND BACKGROUND

Die casting is one of the operations, connected with assembling practice in the die the casting throwing process the liquid metal is infused with strain into the solidified steel dies. It has been lately developed to enable the production of castings that are flawless, having very thin sections, and register an yield approaching even in metals such as aluminum and magnesium. The mould, which is made of the metal, is filled by upward displacement of molten metal from a sealed melting pot or bath. This displacement is effected by applying relatively low pressure of dry air on the surface of molten metal in the bath. The pressure causes the metal to rise through a central ceramic riser tube into the die cavity. The dies are provided with ample venting to allow escape of air the pressure is maintained till the metal is solidified, when it is released enabling the excess liquid metal to drain down the connecting tube back into the bath. Since this system of upward filling requires no runners and risers, there is rarely any wastage of metal due to so many technological improvements in the metal casting industry have taken place nowadays. In recent years, the foundry industry faces increasing demands to achieve higher productivity at minimal cost, even while producing high- quality cast parts of unpredictable shapes. By legitimate determination of a casting strategy with a cautious foundry and metallurgical controls, castings of high caliber are monetarily produced. Among countless methods, one is low and high pressure die-casting. It has been developed and industrially employed to produce castings of near-net-shape components. The close net shape cast parts are celebrated for their fine points of interest, great surface conditions, complex shapes, and the economy. Under the present situation of mechanical improvement, metal casting has moved from a workmanship and specialty industry to the business inspired science and innovation. The structure of pressure die casting may be measured and quality may be assured due to the systematic development of the pressure die casting manufacturing processes. The foundryman can do the speediest methods for creating castings by the die casting method with a substantially much higher level of exactness than that ordinarily acquired by a sand casting method. Indeed, this strategy is excelled for large-scale manufacturing function as various castings can be created quickly with less effort. The die casting apparatus is shown in Figure 1.

The castings can be made to close tolerances and surface finish. Pressure die casting in aluminium alloy offers means for very rapid production of engineering and other related components even or intricate design. This technique has obvious advantages, when a component is required in large quantities. However, for engineering components, such as those required for aeronautic space, the defense also, car applications, mechanical properties, and sturdiness are of essential significance. It is in this way basic that the best highlights of configuration ought

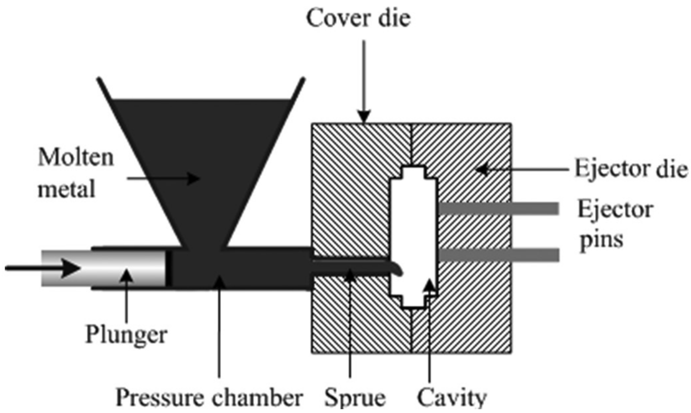


Fig. 1. Die Casting

to be utilized, and ideal casting method with least cost to be received. Pressure die-cast items are utilized as a part of the type of segments of different electrical, electronic, mechanical instruments and apparatuses utilized as a part of residential and also industrial fields. The main role of tribology in energy - sparing here is high most of the time. It is notable that by lessening the coefficient of contact materials generous measures of energy can be spared because of decreasing the creation of squandered warmth energy. The energy aspects of the tribological conduct of materials are dictated by estimating the coefficient of the grating in the contact between components of the tribo-mechanical system. Tribological conduct of two sorts of nodular solid metal, EN-GJS-500-7, and EN-GJS-700-2, depends to a vast degree on the conditions under which its warmth treatment is performed, specifically by the microstructure that forms by heat treatment. When looking at the tribological conduct of nodular solid metal it is important to consider the sliding speed and sort of other material that the contact combines in tribo-mechanical system. The experimental investigations of the enhanced tribological conduct of nodular solid metal can be utilized amid the determination of materials and warmth treatment with the end goal to decrease the grating and wear of the chosen contact materials in the particular mechanical conditions[1]. The aim is to develop a modeling die-casting machine for fault detection to improve fault forecasting model accuracy of Back Propagation Neural Network (BPNN), an improved prediction method of optimized back propagation neural network based on damage estimation algorithm was proposed as design, to solve back propagation neural network problems with constraints. MATLAB should be utilized to code the calculation.

The textured surfaces can be easily produced by the die casting process without requiring any additional processing. Zinc alloys have many merits, such as its low melting point, and the high resistance to oxidation during melting. Furthermore, the service life of the metal mold can be ensured. Moreover, zinc alloy has good casting properties and cannot adhere to the mold easily. Meanwhile, zinc alloy has good deformation resistivity, high strength, and abrasion resistance[2]. In the process of high-pressure die casting, the liquid metal fills the chamber very quickly and solidifies under pressure, so the production efficiency of high-pressure die casting is high and the product dimensional precision is good[3,4,5]. Improvement of die-casting die combination uses laser process, for low-pressure die-cast process parameters optimization[6] The most common defect in die casting is gas entrapment, which loosens the metal structure, and reduces the electric conductivity and strength. Therefore, predicting the sizes of gas entrapment defects accurately is highly significant for production to predict the gas entrapment defects accurately. High-pressure die casting process has the characteristics of high filling speed and the great interaction effect between gas and liquid metal. The gradual improvement of numerical techniques, international and domestic scholars have done many types of research profoundly in the field of numerical recreation by high-pressure die casting[7-11]. The influence of the gas phase during the filling process was not considered, such as the hindering effect of the isolated gas to the liquid metal. Adopted direct finite difference method to portray the shape and area of free surfaces in casting mold filling forms, and the investigation shows that last porosities in high-pressure die castings are dependent on both gas entrapment through the mold filling process and pressure transfer within solidification period[12-14]. The operations of cool runner method and hot runner system simulated high-pressure die casting process based on smoothed particle hydrodynamics algorithm, which belongs to Lagrangian simulation techniques, and the results demonstrate that simulations can be done so many times in order to get large-scale automotive castings and it provides a high degree of accuracy[15-16]. Al-Si-Mg die-casting aluminium alloy[17], a nucleation model that correlated the cooling rate with the nucleation density of magnesium alloys during solidification of the process, Magnesium Die-Casting Alloys for Elevated Temperature[18] what's more, the model can likewise uncover the dendrite morphology with highlights of optional and ternary dendrite branches. As it is observed from the important references, single-stage stream display is regularly connected to the recreation of high-weight die casting filling process at the exhibit. With regards to the immense impact of the gas stage to the high-pressure die casting filling process, gas-liquid multiphase flow model is of great value for simulating the high-pressure die casting filling process[19-21]. An overview of the actual status of technology is described in the current work, where both critical aspects and potential advantages are evidenced. Specific attention is paid to the quality requirements from the end users, as well as to the achievable production rate, the process monitoring and control, and the European and worldwide scenario. So it is very crucial to have control and learning of the stream of the liquid and warmth exchange at the metal-die interface. Estimations of the temperature in the sprinter divider amid high-weight die casting of two aluminium material combinations, AlSi4 and AlSi9, were recorded. During the examination, it was found out that the scone measure, the solidification behavior of the metal, alloy and pressure are highly influenced the measured temperature profiles[22,23]. As far as the die casting industries are concerned, many company manufacturers have Company-specific methods of modularization in their construction departments. The design engineers have the capability of making the dies to be so strong. A holistic methodology of making the design is not yet established. In order to improve this current situation, the layout of modular die methodology has been developed. Die to cast is a widely used well high- technology method of the manufacturing process, which is both energy intensive and capital. Even though there are several environmental and economic advantages to die casting; the energy consumption is very high required to cast products warrants attention. Within a die casting process, design and operational decisions can have a significant impact on the total energy use and emission of equivalent carbon dioxide. The model support decision-makers evaluate the most possible design, investment, and operational decisions, such as the purchasing of new machinery etc. Data elements are very necessary to implement the model, which is specified and they are the necessary reference data for analyzing computing the emissions related to energy fuel consumption. Figure 2 shows the Casting Defect Analysis and Detection.

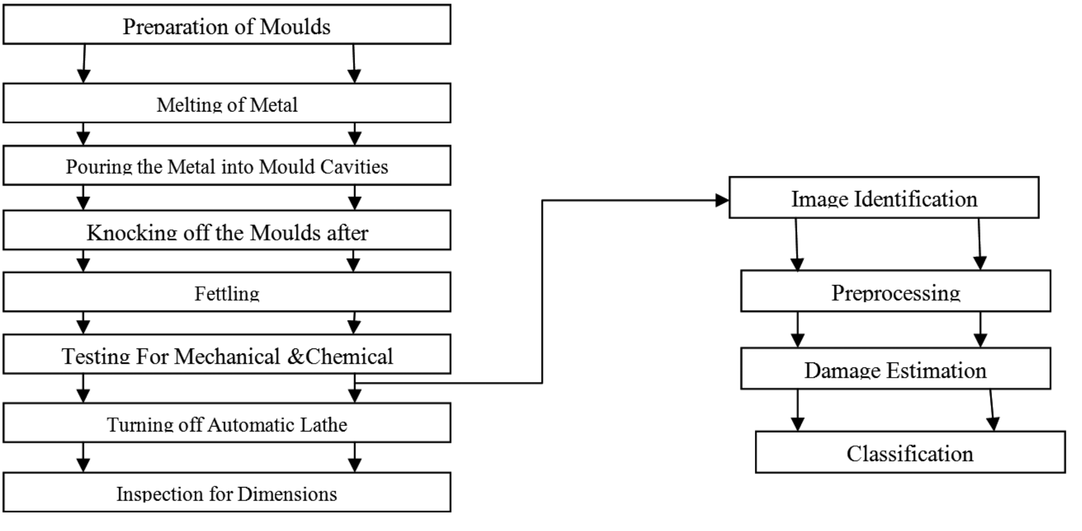


Fig. 2. Casting Defect Analyses and Detection

MATERIALS AND METHODS

The proposed work adopts a new Damage Estimation Algorithm for the multi-view image registration and classification. In the included image analysis step there is defect detection, defect segmentation, feature extraction, defect classification. The first task is to capture an image from the plant. After capturing an image, the first step is detection to find out the defects on the metal surface, if the difference between the reference and target image is over the given threshold. Noise is present in an image, which is to be reduced using the filter. Then the particular features like area features, color functions that could be used for creating the classification model are extracted.

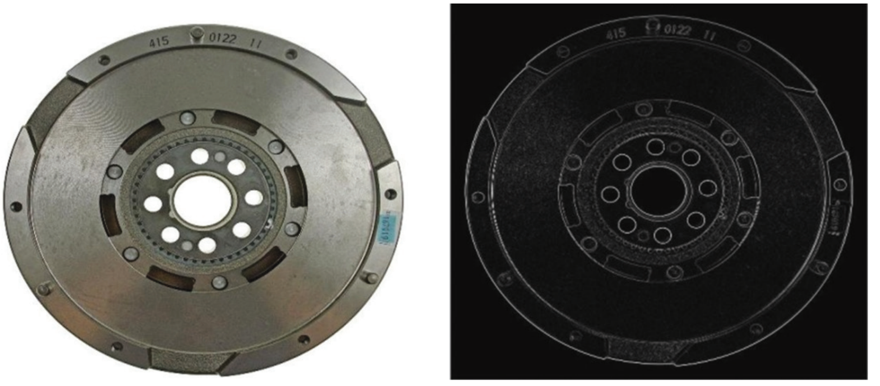
CONSTRUCTION AND VERIFICATION OF PRACTICABLE DAMAGE ESTIMATION ALGORITHM

In this study, we construct the damage estimation algorithm, which estimates the damage caused by the repetitive use of a product. To satisfy the following requirements for practicality, the proposed damage estimation algorithm is constructed. Estimation of damage can be analyzed. It is corresponding to the product that is configured with a plurality of materials. The linear cumulative damage law enables us to estimate the fatigue life of a structure that receives a service load, to which the stress amplitude changes with time. Thus, it becomes possible to estimate the damage for each node or element in a finite element model and estimating of the area composed of a different material becomes possible.

i) *Damage Evaluation Using Linear Cumulative Damage Law*

The linear cumulative damage law considers a state, in which the stresses of various amplitudes occur at random as those sums, from which stress of different amplitude as in $S_1, S_2, .., S_i$ is individually repeated, allowing the fatigue life to be estimated. As a concrete procedure, first it is assumed that a stress amplitude, such as $S_1, S_2, \ldots,$ or S_i occurs in the structure. Next, the number of repetitions until the tip ruptures is referred to from the *S-N* curve for an individual stress amplitude and it is assumed $N_1, N_2, \ldots, N_i$. Then, the damage values that occur, when these stress amplitudes are repeated respectively in times of $n_1, n_2, \ldots, n_i$ is $n_1=N_1, n_2=N_2, \ldots, n_i=N_i$. The damage value is obtained by calculating the damage sum of two values. Finally, the damage value is given by Eq. (1):

$$D = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \ldots + \frac{n_i}{N_i} = \sum_{i=1}^{k} \frac{n_i}{N_i} \quad (1)$$



a) Input Image b) Preprocessing Image

Fig. 3.1.1.

Where k is the number of stress amplitudes.
ii) *Damage Estimation Algorithm*

The linear cumulative damage law is applied to the finite element model used in the structure analysis. At this time, when we refer to stress, we must choose either element stress or node stress. In this study, we adopt node stress, which does not receive change in element size easily. The Eq. (1) is defined as follows to explain the flow of this algorithm.

$$D_1 = \frac{n_1}{N_1} \tag{2}$$

Eq. (2) is a damage value D_1, when the stress occurs under a certain loading condition. First, the node stress s node is calculated by the analysis and the repeated time until the rupture N node corresponding to this s node is obtained from the S-N curve. Next, the repeated time of the stress amplitude, that is, the damage value, is calculated using the repeated time under the targeted loading condition.

Therefore, Eq. (2) can be rewritten as follows.

$$D_1(j) = \frac{n_1}{N_1(\sigma j)}(j = 1, 2, ..., T) \tag{3}$$

Where T is the total number of nodes on the finite element model. The loading condition is then changed, and the damage value of each term is calculated:

$$(j) = D_1(j) + D_2(j) + ...D_i(j)$$
$$= \frac{n_1}{N_1(\sigma j)} + \frac{n_2}{N_2(\sigma j)} + ...\frac{n_i}{N_i(\sigma j)}$$

$$\sum_{i=1}^{k} \frac{n_i}{N(\sigma j)} (j = 1, 2, ..., T) \tag{4}$$

The damage value of each node on the finite element model can be calculated by using Eq. (4). It only has to obtain the repeated time until the rupture N_i using the *S-N* curve corresponding to material in the node, because the product is usually composed of plural materials.

B) input image

Fig. 3.1.2.

RESULTS AND DISCUSSION

To optimize the die casting process parameters for minimum of casting defects the data were generated randomly by providing a higher limit and lower limit of the process parameters and applying a normalization formula, which was shown earlier.

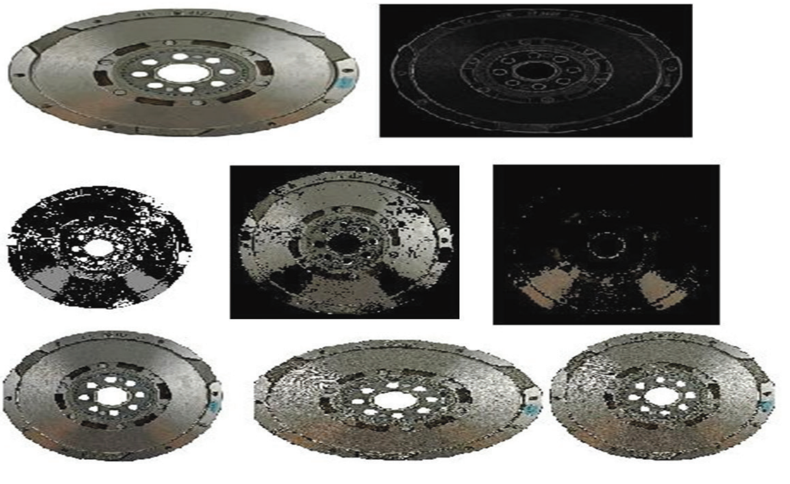


Fig. 4. Die casting simulation results

The results are applicable to some extent for a specific number of data. MATLAB is a specialized registering and creative environment for algorithm advancement. It coordinates algorithm, representation, and programming in a simple to-utilize environment, where issues and arrangements have communicated in the original numerical documentation. One of the upsides of working in MATLAB is that capacities work on whole varieties of information, not simply on single scalar qualities.

PERFORMANCE COMPARISON

Table 1. Comparison of optimal control values

Factor analysis function	Optimal Yield strength			Optimal S/N ratio		
	Taguchi	GA	MOE	Taguchi	GA	MOE
1	151	140	136	45.9181	44.3550	43.2774
2	159	152	147	45.9181	44.3550	43.7108
3	165	157	152	45.9181	44.3550	44.0022
4	161	158	154	46.2181	44.6550	44.2022
5	165	160	158	46.8181	44.7550	44.3022

Abbreviation

GA- Genetic Algorithm, MOE- Multi-Objective Evolutionary (MOE)

At the beginning, the measure of the abatement in rejection rate esteems for given speed is generally the same by each one of the three models. Regardless, in case one watches almost, it is obvious that proposed model can cover the turning instrument much better than anything else of various models. Despite the similarities, each process could better suit a particular application, depending on the property requirements, casting size, production rate and design complexity the proposed controller show worked for controlling information current to proposed controller utilizing various controller methods individually.

CONCLUSION

In this effort an approach is suggested how to monitor and control the quality of parts in die casting industry using a neural network for control. A central element of this approach, the image recognition with neural networks has been presented an approach even on low end embedded process control computers. As future work, the whole scenario has to be realized on a test die casting facility. This includes the image recognition part as well as the control of the heating and cooling areas in the mold. It has to be shown that the image recognition delivers sufficiently reliable results and also that the control via heating and cooling areas will improve product quality and will reduce the scrap percentage. After this approach has shown to be successful in experimental casting facility further studies have to be undertaken, if this approach can be deployed in a series production environment. The feasibility of the transparent part of the mold will have to be considered as well as the costs have to be calculated for the additional technical equipment.

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