Development of high-performance take-out robots for injection molding machines using a structural optimization method

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1. Overview

Take-out robots are robots that remove injection-molded parts from injection molding machines. Injection molding is a fundamental technology for mass production of plastic parts for PCs, cellular phones, automobiles, medical devices, the food industry, and a myriad of other goods. Take-out robots are expected to move quickly, since higher productivity requires mold open times that are as short as possible. In our development, we aimed to construct a structural optimization method for take-out robots that achieves dramatically faster robot speed.

2. Technical Features

Making robots faster has been one of our main concerns for decades. Recent designs include heavier robots, with reinforced structures that can withstand more rapid movement. Using conventional development methods, we eventually reached a limit to improvements in speed and stiffness. In our current development, we constructed a structural optimization method for take-out robots that takes advantage of a topology optimization method that provides great flexibility in structural optimization, to achieve designs that are significantly lighter and faster.

A take-out robot is a linear type of robot that has three main arms, mounted on the injection molding machine (Fig.1). The third arm and the gripping device at its end enter the space between the mold halves from the top or side, to take out molded products immediately after they are formed. Part of our approach was to replace the dynamic problem with a static problem.

Our optimization method consists of (1) prioritization of weight reduction, (2) derivation of load conditions using a simplified model, (3) separate topology optimization for each part, (4) verification of stress and displacement distribution by structural analysis of the entire robot, and (5) verification of operability, ease of maintenance, and manufacturability, and an endurance test. We constructed a coherent method that performs optimization directly from a CAD model and generates CAD data from optimized configurations, to streamline the process from the conceptual design stage to the detailed design stage. An example of an optimized structure and robot arm which adopts an optimized design is shown in Fig.2.

The total weight of the robot was reduced by 13% compared to our conventional robot, due to the developed structural optimization method. The take-out time was decreased by 11%, due to the advantage of lighter parts, and the improved robot is now increasing productivity in plastic molding factories around the world.

The development of our optimization method was achieved with technical cooperation from the Nishiwaki Laboratory, Department of Mechanical Engineering and Science, Graduate School of Engineering, Kyoto University, Japan. For the topology optimization process, we used the method proposed by Yamada et al. in their paper, "A Structural Optimization Method Incorporating Level Set Boundary Expressions Based on the Concept of the Phase Field Method" (Transactions of the Japan Society of Mechanical Engineers. A, Vol.75, No.753, 2009, pp.550-558, JSME Medal for Outstanding Paper 2009).

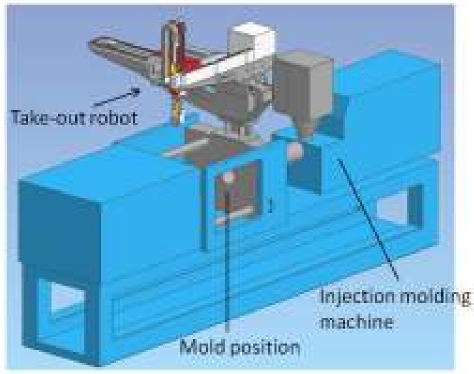
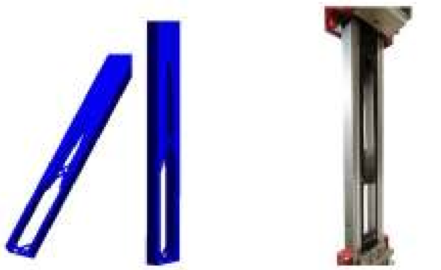


Fig. 1 Take-out robot installation environment



(a) Optimized results (b) Optimized-design arm

Fig. 2 Structural optimization of robot arm

Fig. 3 Optimized-design, robot "HSA"

3. Summary

The optimized-design robot was exhibited at the world's largest international plastic show, "K2010," held in Germany in October of 2010. We achieved a take-out time of 0.32 seconds and the robot was publicized as the "fastest robot." We released our robots, "HSA", to the market in December 2010 (Fig.3).

In addition, using the same structural optimization method, we have developed "YC" robots whose energy consumption was cut by 26% compared to conventional robots, by making the robot lighter.

We are planning to use this structural optimization method in the development of other products and hope to continue producing Yushin products that offer higher performances.