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Review

Robots in the shipbuilding industry

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ABSTRACT

In this paper, details of the uses of various robots in the shipbuilding process are provided, with an emphasis on newer developments and applications. The current state of robot applications will be discussed according to the priority of the shipbuilding process. First, various robots for open structures, such as several types of welding carriages and 6-axis articulated robot manipulators, will be reviewed in terms of their mechanisms and applications. Second, several attempts to design autonomous mobile robotic systems for closed blocks of the double-hulled structure of a ship will be discussed in terms of the performance characteristics of their proposed self-traveling mechanisms. Lastly, all corresponding technologies for overcoming structural complexities in closed blocks as well as future directions of robot automation in the shipbuilding industry are also discussed.

Contents

1. Introduction

Over the past few decades, research on robotics has made considerable impact on many industrial fields [38,39]. Briefly, these successful achievements of robotics research in industrial applications can be attributed to rising labor costs, aging skilled workers, and the inclination to avoid 3D (dirty, dangerous, and difficult) jobs in many industries. The shipbuilding industry, which is the major concern of this paper, is still one of the labor-intensive industries that demand numerous skilled workers. Owing to the nature of the shipbuilding industry, shortening the shipbuilding process should directly lead to additional financial rewards from ship owners and their increased loyalty to a business. Thus, shipbuilding companies have naturally concentrated on improving their production efficiencies within their quality assurance requirements through intensive investments in robot automation as well as developments in shipbuilding processes [40–42]. In this section, the necessity of robot automation technologies in the shipbuilding industry will be discussed in terms of industrial accident prevention and employment of workers, as well as production efficiency and quality.

Recently, the amount of received orders in the shipbuilding dockyards of both Korea and China has fallen sharply. Oversupply of vessel tonnage had a strong impact on the fall of new orders. The aggressive promotion of the marine plant business by shipbuilders has not led to any remarkable achievements. Moreover, the

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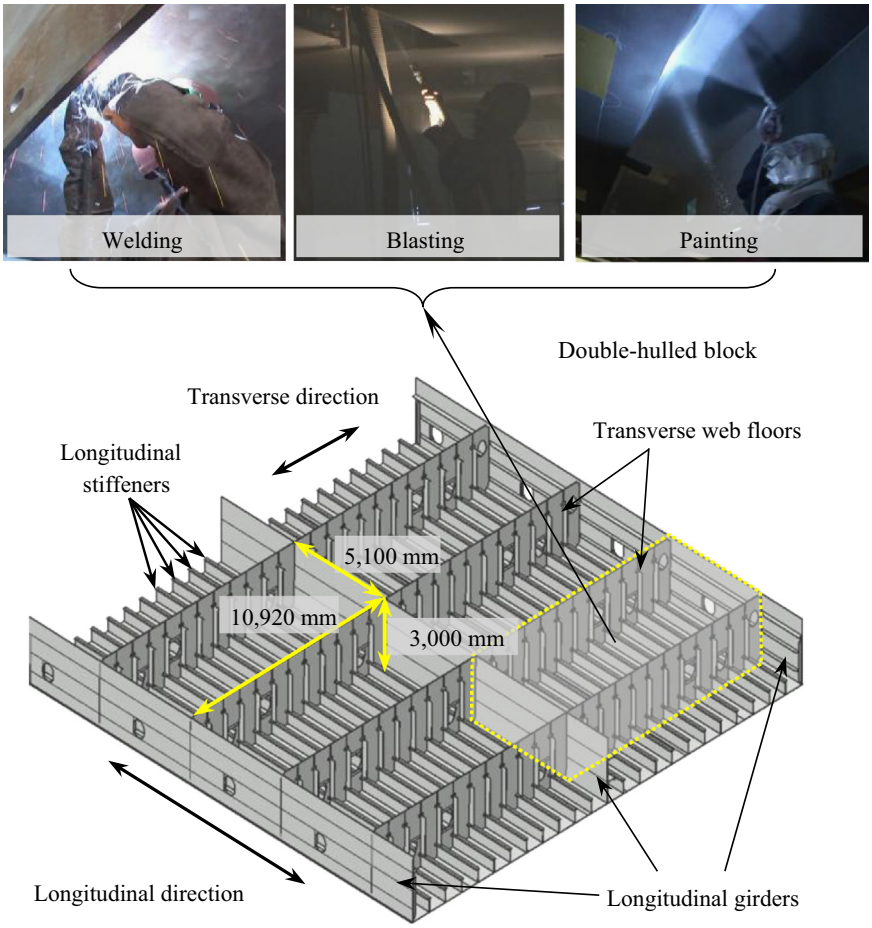

Fig. 1. Overall view of double-hulled structure with some overhead operations needed during the shipbuilding process.

Table 1
Industrial accident rate in the Korean shipbuilding industry [1].

Year	'06	'07	'08	'09	'10
Shipbuilding industry					
Accident rate (%)	1.89	1.55	1.76	1.41	1.20
Industrial accident victims (person)	2240	2065	2375	2413	2122
Death toll (person)	48	46	45	53	47
Average accident rate for all industries (%)	0.77	0.72	0.71	0.70	0.69

rate of industrial accidents in the shipbuilding industry is quite a high compared with other industries because remarkable progress has been made on transitions to ships with double-hulled structures (Fig. 1). Such structures were incorporated into ship hull design because they could prevent the outflow of cargo when a sudden impact occurred on the outer hull. However, this has definitely led to an increase in the rate of working processes inside enclosed structures, which represent quite difficult and hazardous environments to workers. In fact, most major shipbuilding companies have readily adopted robot automation in various shipbuilding processes such as welding, one of the core working process in the field. As shown in statistics from the 'Korea Occupational Safety and Health Agency' in Table 1, applications of robot automation and improvement of shipbuilding processes have played major roles in reducing industrial accident rates by preventing the exposure of workers to injurious worksites. However, the industrial accident rate remains higher than the average for all industries. The working process in a double-hulled structure is likely to be one of the main causes of this phenomenon.

A further issue that needs to be addressed in applying robot automation to the shipbuilding industry is that there are tacit voices of concern for long-term decline in employment and additional responsibilities of maintenance tasks due to the increasing role of robot automation. Such prejudices definitely lead robot designers to difficult situations in successful field applications of developed robots. Statistics in the 'Inter-industry relation table 2010' from the Bank of Korea suggest that improvement in production quality through robot automation should directly lead to improved credibility of a business, and that a 10% increase in order quantity through improved credibility should enhance production with 6040 additional jobs in associated industries (Table 2). For instance, successful application of a robotic painting

Table 2
Effect of increased production in the Korean shipbuilding industry on employment [1].

Amount of increase of production (billion)	Coefficient of employment induction (person/thousand million)	Employment induction effect (person)
1006.7	6.0	6040