

Research on Biomechanical Stress Factors of Workplaces with Collaborating Robots

Hans Jürgen Ottersbach and Matthias Umbreit *)

Safe human – robot cooperation

Collaborative industrial robots are complex machines that work hand in hand with people. In a joint working process, robots support and take the load off workers when for example, a robot lifts and positions a heavy workpiece while a person welds lightweight iron hooks. During this work activity, the person is very close to several robotic elements – for example, robot arm or tool – so robot and person may touch one another. A similar situation takes place with mobile

the robot’s working range could be safely protected against the mechanical effects of fast-moving robot parts. When the industrial robot standards were revised and updated, the new application field of collaborative robots was added as a supplement.

Background

When collaborative robots are used, guards are no longer installed in certain working or collaboration rooms, so a robot-human collision risk cannot be

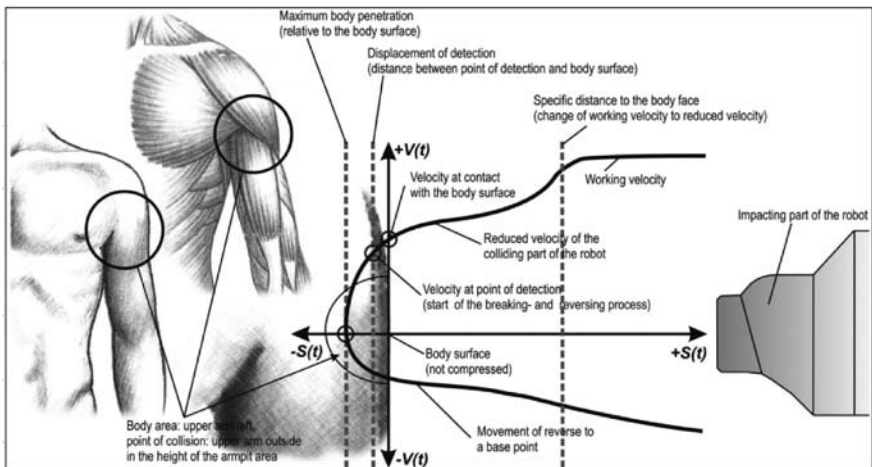


Fig. 1: Schematic diagram of the collision process between upper arm and impacting robot part. Source: BGIA

service surroundings in close proximity to people. Until now, guards were needed when using robots so the persons that were within

entirely ruled out. Thus, technical protective measures other than guards must be taken to continuously determine the collision risk and minimize it as part of the

robot control system – but an element of risk remains.

When a workplace that includes a collaborative robot is planned, the user must carry out a risk assessment based on a legal framework such as the machinery directive and industrial robot standards that should also include an evaluation of injury risks caused by robot-human collisions. In the standards that apply to industrial robots, however, there are not enough occupational safety requirements for evaluating these injury risks. Acting on an initiative of the Expert Committee for Machine Construction, Production Systems and Steel Construction, the Institute for Occupational Safety and Health (BGIA) compiled in a development project the technological, medical/biomechanical, ergonomic and work schedule requirements made to such

workplaces. They supplement and specify the requirements of the standards and were summarized in BG/BGIA recommendations.

Since a collaborative work process during intended use carries a collision risk between a robot and a person, the task consisted in limiting the straining effects caused by collisions so only small and tolerable injury severity or injury risk could occur. According to this, tolerable severe injuries are only skin and underlying tissue strains that do not penetrate the skin and tissue deeply and do not cause bleeding wounds. Fractures or other injuries of the musculoskeletal system must be ruled out (see fig. 1).

Injury severity can be depicted by limit values of related injury criteria. Limit values for the injury criteria of “impact force”, “clamping/squeezing force” and



Fig. 2: Dashboard assembly, Source: Daimler AG

“pressure/surface pressing” for all regions of a simple body model were established, based on injury data from external mechanical strains that the BGIA compiled from bibliographical references and databases. Guiding limit values were obtained on that basis for the maximum permissible injury severities according to body model and selectively verified by various laboratory control tests.

The results of the project were summarized in BG/BGIA recommendations for arranging workplaces with collaborative robots. It contains extensive aids for applying occupational safety measures in practice, as part of risk assessments. A team of experts with robot manufacturers and users collaborated in the development of the content.

Thanks to the BG/BGIA recommendations, workplaces with collaborative robots can be set up so that the potential mechanical effects on persons as a result of a collision do not exceed a tolerable level. These workplaces can be designed in a way to ensure the required occupational safety for the person in question. The BG/BGIA recommendations can be downloaded at: http://www.dguv.de/bgia/en/prakollaborierende_roboter/index.jsp.

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Hans Jürgen Ottersbach¹ and Matthias Umbreit²

¹ Institute for Occupational Safety and Health of the German Social Accident Insurance (DGUV), Germany

² Expert Committee for Mechanical Engineering, Manufacturing Systems, Steel Construction of BG Metall Nord Süd, Germany