Development of a novel rapid prototyping system for the production of fuel lines

J. Ganzwind, S. Dill, M. Müller-Roosen

Darmstadt Institute of Plastics Engineering ikd

PolyMerTec 2018

Preface

One way to save unnecessary weight in automotive engineering is to replace metal components with lightweight materials. In comparison to metallic media lines, the replacement by plastic pipes implies a previously very time-consuming, energy-intensive and cost-intensive moulding process. In addition to a high personnel expenditure, it is also apparent that current methods are very inflexible due to the use of specific forms and cannot be used for changed contours.

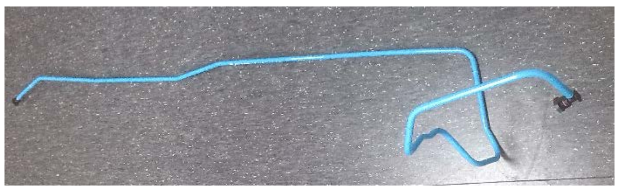

Figure 1: Plastic fuel line

In the automotive industry it is common to plan pipelines and cable harnesses last. As can be seen in Figure 1 this has the consequence that these are laid around the essential aggregates with elaborate contours. Furthermore, the required sample cables are only required shortly before the completion of the development work and must be made available at short notice. The suppliers (TIER-1) who apply for a new pipe supply order thus produce them with immense effort, since an independent bending form is required for each of these sample parts.

Aim of the project

Inspired by the tool-free forming of metal pipes with cycle times of a few seconds, a comparable process is also to be implemented for plastic pipes.

The tube is inserted into a bending machine and clamped between the clamping jaws. Then it is pulled around the bending head, whereby the counterholder holds the still unbent pipe piece so that it cannot move to the side. Metal pipes are slightly bent over and then have the desired bend. In the case of plastic pipes, however, pure deformation is not sufficient and elastic reshaping would take place in a high double-digit percentage range. In order to permanently deform plastic pipes, the stresses that occur must be reduced in the deformed state. In view of the cycle time, heat-induced relaxation, which is to be achieved by means of dielectric heating, is the preferred method.

The Department of Mechanical Engineering and Plastics Technology at Darmstadt University of Applied Sciences (h_da) deals with the development of the bending head. Particular attention is paid to the suitability of the material for use in the high-frequency field, the mechanical and thermal design, the construction of the bending head and the optimization of the process.

Mobitec - Kottmann und Berger GmbH develops, designs and implements the bending system. This includes, among other things, the design of the bending mechanism, the heating and cooling device as well as the bending machine electrics, control technology and operating software for the bending head.

Novel bending machine

It should be possible to bend up to 2.5 m long plastic pipes on the system. The deflection of the pipes due to gravity should be prevented or compensated as best as possible. As shown in Figure 2, a vertical arrangement was determined as the ideal machine concept, as gravity can be used to stabilise the pipes. Due to the spatial expansion of the pipe to be bent, the entire bending unit is designed to swivel in order to make the best possible use of gravity to stabilize the pipe. For smallest series production, the pipe data to be bent should be supplied digitally to the plant in order to derive a bending program from it. In principle, the individual bends are carried out in the following steps:

1. Automatic positioning of the bending head
2. Bending of the tube along the bending head
3. Dielectric heating of the bend up to the set relaxation temperature
4. Cooling of the heated area until the reloading temperature

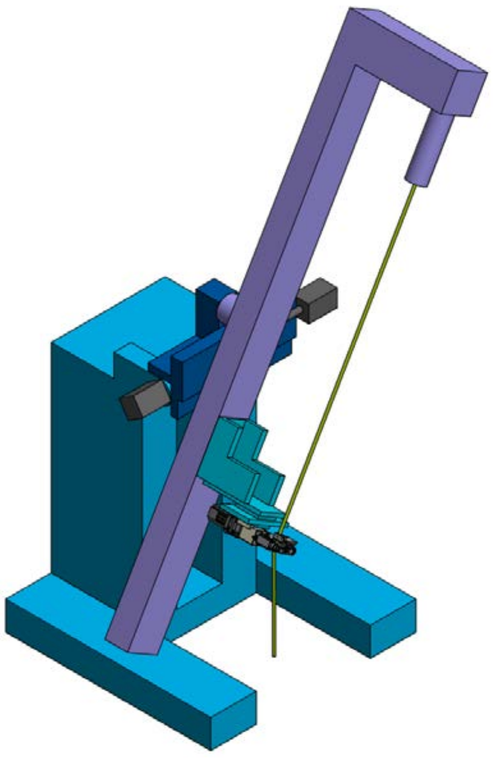

Figure 2: Principle sketch of a vertical CNC bending machine

This computer-controlled process makes it possible to change geometry directly in the CAD file and make adjustments in the shortest possible time.

Design of the bending head

A universal bending head is required to implement a fast tool shape-free contouring process. This ensures flexible forming, relaxation of the bending stresses and cooling of the bending in three process steps. The bending head must have the following core properties:

1. Lowest dielectric heating in the high-frequency field
2. Sufficient mechanical suitability for rotational draw bending of plastic pipes
3. Fast and uniform cooling of the pipe
4. Flexible adaptation to different bending radii

As a result, the bending disc shown in Figure 3 was designed. This has an integrated pair of suitable electrodes for dielectric heating of the pipe and near-contour cooling for rapid reloading of the bend.

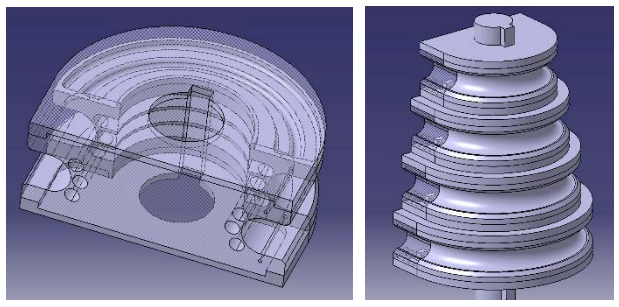

Figure 3: Detailed view of the bending disc (left) and combined bending tower (right)

For the production of various bending contours, up to four of these bending discs are combined in one bending tower.

Next steps

The bending head was developed using mechanical and thermal simulations.

The next steps will therefore be to produce the first prototype, which will be used for the first bending, heating and cooling tests. In further iteration steps, the bending head is optimized before it is integrated into the bending system. In the long term, a suitable process will also be developed, starting with the automatic insertion of the pipe into the plant, which enables a completely computer-controlled shaping of a pipe.

Acknowledgement

The project "CNC Plastic Pipe Bending" (funding code ZF4104905P07) is funded by the German Federal Ministry of Economics and Energy (BMWi) as part of the "Central Innovation Program for Medium-Sized Businesses (ZIM)".

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

ZIM Zentrales Innovationsprogramm Mittelstand

aufgrund eines Beschlusses des Deutschen Bundestages

Literature

[1] Scherer, J., Kaempf, R., Gesche, R.: Energy efficient bending of polymer tubes by dielectric heating. auto.mobilFORUM, Gelnhausen, 08.11.2013

h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
ikd
INSTITUT FÜR
KUNSTSTOFFTECHNIK DARMSTADT

Contact

Prof. Dr. Martin Müller-Roosen
Darmstadt Institute of Plastics Engineering ikd
University of Applied Sciences h_da
Haardtring 100, 64295 Darmstadt
mail: Martin.Mueller-Roosen@h-da.de

Partner

mobitec
Kottmann und Berger GmbH
Lorcher Straße 36, 73102 Birenbach
mail: info@kottmann-berger.de

mobitec
Rohrbiege- und Rohrumformtechnik