AUTOMATED UNIT FOR NAIL AND THIN-WALLED WASHER ASSEMBLING

Zautomatyzowane stanowisko do montażu gwoździa w cienkościennej podkładce

Роботизированное выполнение отверстий под сварку в цилиндрических крупногабаритных заготовках

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Abstract: In the paper, the automated unit for nail-washer assembling has been presented. The nails with the same diameter and different lengths are inserted to the thin metal washer.
Keywords: automated machine design, assembly process, joining elements, washer, weldable nail

Streszczenie: W artykule przedstawiono w sposób syntetyczny zautomatyzowane stanowisko do montażu wybranego typoszeregu metalowych gwoździ (o tej samej średnicy i różnych długościach) w metalowej, okrągłej i cienkościennej podkładce
Słowa kluczowe: stanowisko montażowe, proces montażu, łączenie elementów, podkładka, gwóźdź zgrzewalny

Introduction

The contemporary times have charged the humanity with a special duty of taking care of the environmental protection. We segregate the rubbish; we leave the waste electronic and electric equipment at the special points, or we run organic cultivations in our household gardens.

Also, in the field of industry, we try to reduce the energy losses, when applying different types of thermal insulation. We limit the emission of vibrations and noise to the environment by insulation of their sources, as well. The most popular insulating materials, as employed in a form of mats, rollers and coatings (Fig.1) must be fixed to the protected objects.

Assembling with the application of nails (Fig.2 and 4), struds (Fig.3), and mandrels from weldable wire are a relatively new and more and more popular method for fixing the insulating layers in the case of metal casing of the objects.

Demand on such assembly elements is constantly increasing; hence, there is a need of their mass production. Responding to the request of NEWIR Company with the seat in Warsaw, which supplies the assembling, and constructional accessories and pre-fabricated products for construction of ventilation, heating and air-conditions equipment, Institute of Mechanized Construction and Rock Mining undertook the work on development and performance of automated unit for assembly of weldable nail and thin-walled washer.

Additionally, there was designed and started up the unit for punching of metal sheet in a form of tape. The punching unit consists of the following elements:

Rys. 1. Maty, rolki i otuliny izolacyjne (źródło: materiały firmy NEWIR [1])
Fig. 1. Mats, rollers and insulating coatings (source: NEWIR [1])

Rys. 2. Mata izolacyjna zamocowana do kanału wentylacyjnego przez zgrzewalny gwóźdź, wyposażony w dodatkową podkładkę izolacyjną (źródło: materiały firmy NEWIR [1])
Fig. 2. Insulation mat attached to the ventilation duct by a weldable nail equipped with an additional insulating pad (source: NEWIR [1])

- Eccentric press with pneumatic conveyor of tape, the task of which is to shift the tape under the stamp, with the constant stroke of the tape (Fig. 5),
- Mechanism, allowing to unwind the tape of steel sheet (Fig.6),
- System of buffer of the unwound tape (Fig.7) together with the sensors of the tape situation

Rys. 3 . Szpilki służące do mocowania poprzez zgrzewanie lub spawanie izolacji termicznych i akustycznych na powierzchniach stalowych - głównie kotłów, zbiorników (źródło: materiały firmy NEWIR [1])
Fig. 3. Struds for fixing by welding thermal and acoustic insulation on steel surfaces - mainly boilers, tanks (source: NEWIR [1])

Rys. 4. Gwóźdź zgrzewalny z klipsem samozaciskowym wykorzystywany w instalacjach wentylacyjnych, grzewczych i klimatyzacyjnych do mocowania na gładkich powierzchniach (źródło: materiały firmy NEWIR [1]).
Fig. 4. Weldable nail with self-locking clip used in ventilation installations, heating and air conditioning for fixing on smooth surfaces (source: NEWIR [1])

The punching unit supplies the washers to production of ready connector in the automated unit.

Analysis of the existing solutions of the automated machine for assembly of weldable nails

The weldable nails have been known in the industry for many years and in spite of this fact, in general literature concerning production automation as well as in publications of nail producers, any information on automated assembly units serving for production of such type of product has not been found. From available information, it is followed that manufacture of weldable nails takes place most frequently in the manual work sites or in semi-automated units. It is connected with many problems relating to the automation of the discussed process.

The problem itself concerning combination of the object of roller type and another object, possessing the roller-like opening is widely met in the industry [2}. For example, there are automatic devices for assembling the

Rys. 5 . Prasa mimośrodowa z pneumatycznym podajnikiem, przesuwającym taśmę w przyrządzie narzędzia wykrawającego podkładki, z lokalnym pulpitem sterującym (źródło: własne)
Fig. 5. Eccentric press with pneumatic conveyor, for moving the tape in the instrument of a washer punching tool, with a local control panel (source: own)

Rys. 6. Odwijak taśmy blachy stalowej z lokalnym pulpitem sterującym (źródło: własne)
Fig. 6. Belt sheet unwinder with a local control panel (source: own)

Rys. 7 . Bufor z czujnikami minimum-maksimum kontrolującymi ilość odwijanej taśmy stalowej (źródło: własne)
Fig. 7. Buffer with minimum-maximum sensors for controlling the amount of unwound steel tape (source: own)

nails and washer, for molder's sprigs, for applicators with caps or for expansion bolts. The dimensional specificity of the defined detailed parts causes that the discussed processes may run with a different speed; the methods for solving the basic assembly problems are similar.

In spite of the fact that the presented below automated assembly units produce the detailed parts with a somewhat different shape and dimensions as compared to those required ones, their constructors had to solve many similar problems, beginning from supply and addressing the details, ensuring the appropriate quality of joining, separation of the correctly joined details from the defective ones and receipt of the finished details.

The assembly of the nails with the washer may be investigated in the device, presented in Fig.8 and in the materials of the producers [4], [5]. It is a special machine, destined for production of paper nails, the so-called umbrella nails. The nails are made of a wire which is wounded by the system of rollers. Flat washers with opening, placed in vibrating conveyor are then stacked in a pile from where a single washer falls down to matrix. The washer is nailed on a cut piece of wire and then a part of head of the nail is formed. Next, the wire conveyor pulls out the wire with washer in appropriate distance which is a set length of the nail and after it, there is a movement of two lateral scissors which shape the edge of the nail and, also, cut off the shaped nail which falls down to a storage bin. Subsequently, the washer is driven on the cut part of a wire and the process is cyclically repeated. The performance of automates of the discussed type is 50 ÷70 [pcs/min.] [2], depending on the length of the nail. The presented process is easy in respect of automation because the details have an uncomplicated shape – a drawn wire and relatively high washer and with a small external diameter. Owing to such solution, the detailed parts are quickly and perfectly oriented and by this, all units of the machine may be driven from one engine, using a set of gears and cams. Control consists only in change of rotary speed of the engine. The washer is driven in the end of the nail having a length of several millimeters and is formed in the shape of umbrella, with the simultaneous forming of the end of the nail. It is probably connected with a smaller force necessary for joining than in the case of pushing out the whole length of the nail throughout the washer because the processes of friction and punching of the washer's material do not occur in such length. Generally, the force required for such type of joint is dependent on mutual relation of diameter of the nail and diameter of a hole in the washer and on the materials from which these elements are produced.

Another example of automate which implements similar tasks is machine for assembling paper nails (Fig.2) described in publication [1]. The mentioned automat joins

Rys. 8. Automat do produkcji gwoździ papowych tzw. "parasolek". Po lewej stronie: widok ogólny automatu, w środku: widok na strefę kształtowania gwoździa, po prawej: uzyskany kształt gwoździa (źródło: po lewej i po prawej: materiały firmy MANEK [4] ,w środku: materiały firmy ABM Tools [5])
Fig. 8. Assembly automat for the production of paper nails "umbrellas". On the left: general view of the machine, in the middle: view of the nail shaping zone, on the right: the obtained shape of the nail

Rys. 9. Automat do montażu gwoździ papowych z podkładką. Po lewej: widok z przodu, po prawej: widok na strefę montażu (źródło: własne) Automatic machine for tar paper nail and washer assembly.
Fig. 9. On the left: front view, on the right: view of the assembly zone (Source: own)

the nails of the length up to 36 [mm] and the washers of diameter of 30 [mm].

The nails and washers are oriented and conveyed to buffer strips using vibratory feeders. The cluster, driven by pneumatic servo-motor contains two sockets which are alternatively positioned under the mechanism of a single dispensing of washers. After taking a correct position, the washer falls down to the socket of the cluster. At the same time, a single nail falls down into the centering head, being situated above the socket. After positioning of these two details, there is a movement of stamp, causing joining of nail and washer together. Then, the cluster is shifted into another extreme position and the extractor situated under the socket throws the linked detail from the socket away. At the same time, in the neighboring socket, the simultaneous process of assembly is carried out, owing to which the capacity of the machine is equal to 2 pieces per second.

In the both presented above automates, the nail-washer joint is assured by flanging of the sheet on the nail. For the plate of 1÷2 [mm] thickness, the discussed type of joint is durable. In the case of weldable nails, the washers are very thin, they have 0.5 [mm] thickness; due to this fact such type of joint cannot be performed. The joining is obtained, therefore, by appropriate formation of the bottom of the nail which is tightened on the both sides on the opening of the washer.

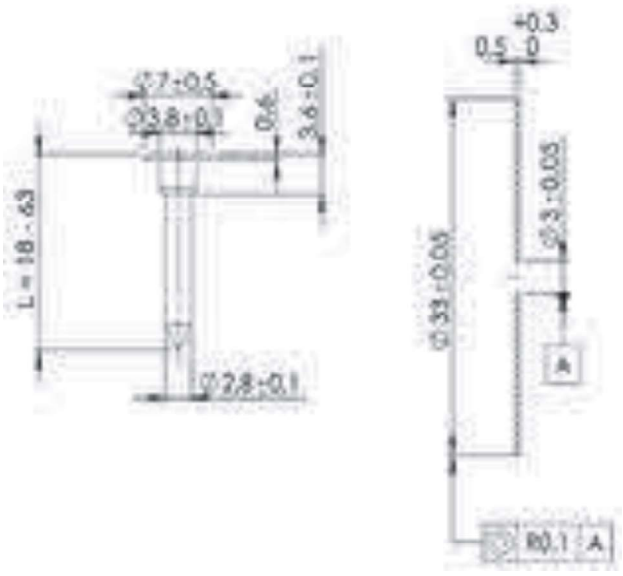
A thin washer causes also many other problems. A small thickness of the metal plate excludes a series feeding of the washers, one next to another. A small weight causes that the process of inserting the washer to the socket must run slower and more precisely; it is not enough to base upon the gravitation forces or compressed air.

The assumptions to development and performance of the automated assembly unit

The assumptions concerning details intended for assembly

A view of the nail and washer and their basic dimensions are given below in Fig. 10.

The joint between the nail and washer should be durable and aesthetic. The nails should not lose a permanent contact with the nail during their packaging into cartoons and during transportation. The nail should be positioned rectangular to the surface of the washer with tolerance of ±5 [o] in relation to the axis of the washer. The embossed head of the nail should be faced with the front surface of the washer. It is allowed to flange the edge of the washer during the assembly.



Rys. 10. Widok gwoździa i podkładki (źródło: własne)
Fig. 10. View of the nail and washer (source: own)
The nails differ in length which is found within the interval of 18 – 63 [mm]. The washers are flat, not moulded.

The assumptions of the construction of automated work stand for assembly of the nail and washer

Construction of the automating device has been based upon the multi-position, indexing-rotary table on which the sockets will be fixed in a constant distance each other. The table will perform, each time, the rotation by one position, carrying the detailed parts for further operations. By this, the time for performance of one complete detail piece will be a sum of performing the longest operation and the change of the table position into the successive one. The operations to be performed in the successive working positions include:

- Delivery of washers to the sockets of the table – the washers will be manually placed in the vibrating feeder, from where they will be stacked in a tube of buffer; the buffer will be equipped with two tubes: the empty tube will be filled from the vibrating feeder and from the full tube, the single washers will be selected and inserted with the manipulator to the socket in the indexing-rotary table,
- Preliminary association of the washer and nail (putting the nail in the washer) – the nails will be manually fed to the vibrating feeder of nails where they will oriented and directed to the buffer strip of the nails; the guiding part of the feeder may be utilized for the nails in the total range of their length, without the necessity of rearming or additional regulation; at the end of buffer strip, there will be a mechanism of single release of a nail the task of which will be to pick up a single nail from the strip and put it in the opening in the washer; to simplify the service, it was assumed that the association of all types of the nails with the opening in the washer will be performed with the use of the same servo-motor with the constant stroke,
- Formation of joint of the nail and washer – the stamp of the pneumatic-hydraulic actuator will perform the tightening of the nail and the washer,
- Release (pushing out) of the ready assembled detail from the socket matrix – the pneumatic actuator will perform the release of the detail from the socket by breaking the friction forces of the detail in relation to the socket matrix,
- Removal of the detail from the socket - the manipulator will take a final detail from the socket and throw it to the container of good products.

The additional assumptions

Between the particular working positions of the table, a series of sensors, supervising the correct functioning of the machine in the particular positions will be installed.

In the case of discovering the irregularities, the operation will be informed about the existing problem by a light and sound signal.

All mobile elements of the machine will be protected in accordance with the obligatory rules and good engineering practice, with assurance of a free access to subunits of the equipment.

All actuators, being present in the equipment, as well as manipulators will possess pneumatic or electric drive.

The automated assembly station for assembly of the weldable nail and thin-wall washer and the selected problems occurring during its performance

After approval of the assumptions of the project of the working unit by the Orderer, i.e. NEWIR Company, the implementation of the project was commenced.

At the beginning, the time was dedicated to designing of the model of assembly sockets with matrixes and after a series of the trials, the appropriate type and shape of the matrix was selected. In the situation of thin-wall washer and the set shape of the nail head, the construction of such matrix that would ensure – after assembly – the stable inseparable joint of the nail and washer was a big problem. It is very important for the later process of welding the nail to the metal surface e.g. of the insulated reservoir or ventilation system. The mentioned joint must ensure as small as possible resistance for the current during the welding process. It became successful.

The shape of matrix was so selected that after performance of the joint, the detailed part may be removed from the matrix without the necessity of its opening and, at the same time, not causing any damages of the detail itself.

It allows time saving and decreases the costs of constructing the machine.

The successive challenge included transport of the separated washers between the cylindrical vibrating feeder and the tube of their buffer. Due to zinc coating of the washers, their flow on the transporting gutter was difficult. The problem was however solved owing to the passage of the details of the air cushion.

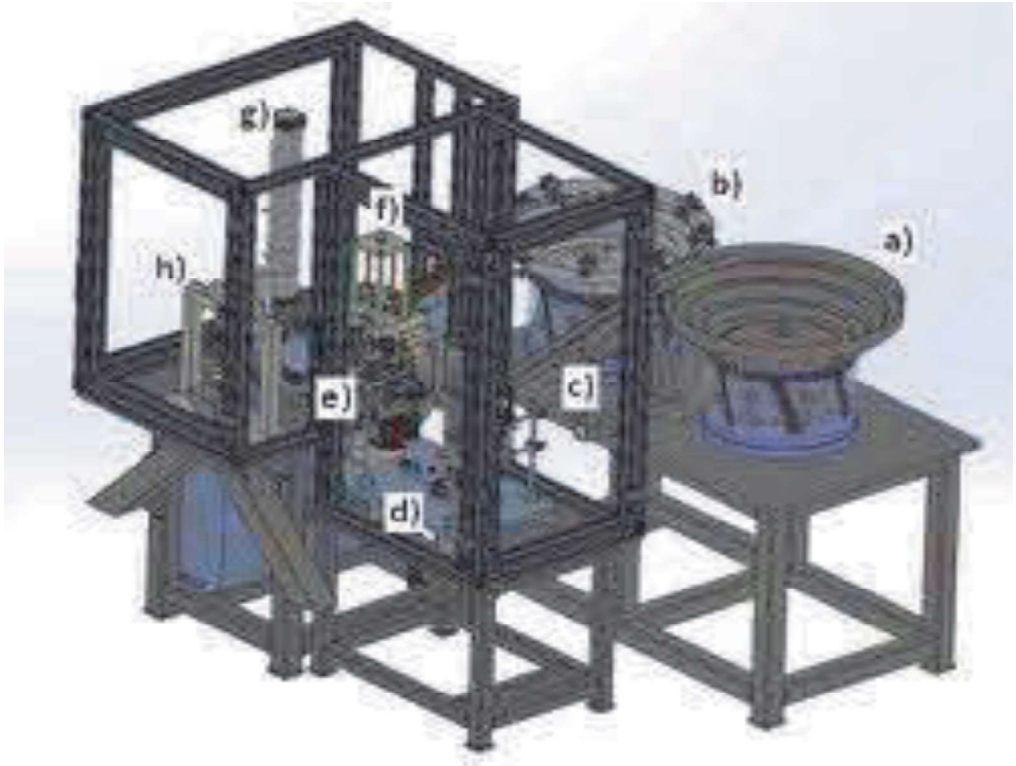
A lot of time was also dedicated to the appropriate modelling of mechanism of a single release of the nail. Selection of its shape and geometric parameters requires especially much work. A capture of a single dispatched mail by the magnetized prism and its introduction to centring jaw head occurred to be a helpful operation. The mentioned head facilitates placement of the nail in the central hole of the washer – the preliminary association of the nail and the washer.

Owing to, inter alia, the mentioned above operations it was possible to give a final shape to the device (Fig.11 and 12).

Conclusions

The described work caused construction of the automated station for assembly of the weldable nail and thin-wall washer for the most frequently sought series of types of the nail lengths i.e. from 188 mm to 63 mm. The capacity of the machine is equal to 1.5 seconds up to 1.6 seconds per one piece. During constructional and implementing stage it was possible to develop such shape of matrixes which guarantees the repeatability.

The unit for cutting the washers as the auxiliary device, supplying the detailed parts to the process of the assembly of the nail and the washer is working with the output not lower than one piece per second. It cuts out the washers from galvanized steel tape of 0.5 mm thickness using fours-socket device from the tape of the 70 mm width and six-socket unit from the tape of 102 mm width. The both devices are adapted to the work with the press stroke equal to 20 mm and stroke of the tape feeder equal to 33 mm.



Rys. 11. Widok zaprojektowanego zautomatyzowanego stanowiska montażowego składającego się z: podajnika podkładek, podajnika gwoździ, rynny transportującej rozseparowane podkładki, bufora podkładek z magazynkami tubowymi, stacji pobierania podkładki z tuby bufora do gniazda stołu obrotowego, stacji wydania pojedynczego gwoździa i umieszczenia go w podkładce, prasy montującej gwóźdź z podkładką, stacji zdejmowania gotowego detalu ze stołu obrotowego (źródło: własne)
Fig. 11. A view of designed automated assembly station - washer feeder, nail feeder, gutter for transporting separated washers, washer buffer with tube magazines, unit for collecting washers from buffer, and placing in rotary table socket, unit for the release of a single nail, and placing it inside the washer, the press for nail and washer assembling, unit for removing finished part from the rotary table (source: authors)

Rys. 12. Widok wykonanego zautomatyzowanego stanowiska montażowego (źródło: własne)
Fig. 12. A view of automated assembly station (source: authors)

Literature

1. Klusek K., M. Fabiszewski, J. Lenczewski. 2014. „Automat do montażu gwoździ papowych z podkładką", Technologia i Automatyzacja Montażu (1): 64-68.
2. Kowalski T., G. Lis, W. Szenajch. 2000. „Technologia i automatyzacja montażu maszyn". Warszawa: OWPW.
3. http://www.newir.pl/, dostęp 31.07.2019.
4. http://www.maneklalexports.com/English/SmallScale/RoofingNail.htm, dostęp 31.07.2019.
5. https://www.youtube.com/watch?v=BJWGsU_k8wo, dostęp 31.07.2019.

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