Review

Something about a Railbound Forging Manipulator

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Abstract: Heavy payload forging manipulators are mainly characterized by large load output and large capacitive load input. The relationships between outputs and inputs have greatly influenced the control and reliability. Forging manipulators have become more prevalent in the industry today. They are used to manipulate objects to be forged. The most common forging manipulators are moving on a railway to have greater precision and stability. They have been called the rail-bound forging manipulators. In this paper, one presents the general aspects of a rail-bound forging manipulator, like geometry, structure, general kinematics and forces of the main mechanism from such manipulator. The kinematic scheme shows a typical forging manipulator, with the basic motions in operation process: Walking, the motion of the tong and buffering. The lifting mechanism consists of several parts including linkages, hydraulic drives and motion pairs. An idea of establishing the incidence relationship between output characteristics and actuator inputs is proposed. Self-forging systems have the ability to achieve an open, fast, direct forging of products that are often heavy and bulky. Open forging productivity is generally very high, it is determined not only by the capacity of forging press but obviously dynamic handling by forging manipulator. The most prominent and qualitative forging machines are the DANGO and DIENENTHAL series, equipped with high dynamic devices and specially designed to operate on heavy forging presses. They ensure the reliability and repeatability of all forging cycles. Even a modernization of existing forging machines with D&D machines will improve the capacity and quality of these facilities. D&D handlers allow to forge nearly clean shapes and guarantee superior surface qualities, thus saving energy, improving production and saving costs during the machining of parts. Savings due to shorter process times and reduction of reheating cycles result in shorter recovery time.

Keywords: Robots, Mechatronic Systems, Structure, Machines, Kinematics, Forging Manipulator, Heavy Payload, Lifting Mechanism, Rail-Bound Manipulator

Introduction

Such large gauge systems are currently used for hot forging materials in order to prepare them so that all intrinsic qualities grow. In order to have better stability, these monsters generally fit their own train, which also provides them with an extra balance. However, they can also be constructively found as independent forging manipulators, not just as rail bound forging manipulators.

Self-forging systems have the ability to achieve an open, fast, direct forging of products that are often heavy and heavy but also bulky. Open forging productivity is generally very high, it is determined not only by the capacity of forging press but obviously dynamic handling by forging manipulator.

The most prominent and qualitative forging machines are the DANGO and DIENENTHAL series, equipped with high dynamic devices and specially designed to operate on heavy forging presses. They ensure the reliability and repeatability of all forging cycles. Even a modernization of existing forging machines with D&D machines will improve the capacity and quality of these facilities.
D&D handlers allow to forge nearly clean shapes and guarantee superior surface qualities, thus saving energy, improving production and saving costs during the machining of parts. Savings due to shorter process times and reduction of reheating cycles result in shorter recovery time.

A 500kN shelf handle is designed to support the pliers with a variety of actions that keep pace with precision speeds and pressures such as forging in the forging area of the presses.

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For special alloy materials, they require a rapid forging process, to be completed in a narrow temperature range and it is recommended to use the two-handed handle with the press. The solution is used in the high-speed rail system.

Pressing and handling measures are integrated and controlled by an operator in a central impulse. Integrated with the press, the forged positioning by the horizontal forward and backward movement, which rotates in the forging area, synchronizes with the press parts.

Transport capacity: \(30 \text{kN}/60 \text{kN} \cdot \text{m} - 1000 \text{kN}/2500 \text{kN} \cdot \text{m}\)

Movement and commands to these mammoths are slow and difficult, which requires much automation to help the manipulator in conducting various operations, especially to achieve the necessary precision.

Orders can be made from the vehicle giant or from a central panel installed in the hall of the enterprise where the manipulator is used. A railbound forging manipulator is presented in the Fig. 1.

The kinematic chain plan (the kinematic diagram) of the main mechanism, which fall within a single plane or in one or more of the other plane parallel to each other, is presented in the Fig. 2 (Gao et al., 2010; Ge and Gao, 2012; Li and Liu, 2010; Yan et al., 2009; Zhao et al., 2010; Petrescu and Petrescu, 2015a,b,d; Aversa et al., 2017b).

![Fig. 1: Photo of a railbound forging manipulator](https://ssrn.com/abstract=3417321)
The mechanisms of this kind have spread rapidly in all areas of the grove, being extremely precious for metalworking where large materials of considerable size are used, which must be handled, gripped, transported, raised, rotated, pressed, forged, including when incandescent, so these machines are perfectly adapted to these difficult and otherwise dangerous operations for humans.

It can be talked about here by manipulating robots or self-employed robots with a large gauge (Rulkov et al., 2016; Santos and Bedon, 2016; Minghini et al., 2016; Bedon, 2016; Jafari et al., 2016; Chiozzi et al., 2016; Orlando and Benvenuti, 2016; Wang and Yagi, 2016; Obaiys et al., 2016; Ahmed et al., 2016; Jauhari et al., 2016; Syahrullah and Sinaga, 2016; Shanmugam, 2016; Jaber and Bicker, 2016; Wang et al., 2016; Moubarek and Gharsallah, 2016; Amani, 2016; Shruti, 2016; Pérez-De León et al., 2016; Mohseni and Tsavdaridis, 2016; Abu-Lebdeh et al., 2016; Serebrennikov et al., 2016; Budak et al., 2016; Augustine et al., 2016; Jarahi and Seifilaleh, 2016; Nabiou, 2016a; You et al., 2016; Al Qadi et al., 2016a; Rama et al., 2016; Sallami et al., 2016; Huang et al., 2016; Ali et al., 2016; Kamble and Kumar, 2016; Saikia and Karak, 2016; Zeferino et al., 2016; Pravettoni et al., 2016; Bedon and Amadio, 2016; Chen and Xu, 2016; Mavukkandy et al., 2016; Gruener, 2006; Yeargin et al., 2016; Madani and Dabubneh, 2016; Alhasanat et al., 2016; Elliott et al., 2016; Suarez et al., 2016; Kuli et al., 2016; Waters et al., 2016; Montgomery et al., 2016; Lamarre et al., 2016; Daud et al., 2008; Taher et al., 2008; Zulkifli et al., 2008; Pourmahmoud, 2008; Pannirselvam et al., 2008; Ng et al., 2008; El-Tous, 2008; Akhesmeh et al., 2008; Nachiengtai et al., 2008; Mozei et al., 2008; Boucetta, 2008; Darabi et al., 2008; Semin and Bakar, 2008; Al-Abbas, 2009; Abdullah et al., 2009; Abu-Ein, 2009; Opafunso et al., 2009; Semin et al., 2009a-c; Zulkifli et al., 2009; Marzuki et al., 2015; Bier and Mostafavi, 2015; Momta et al., 2015; Farokhi and Gordini, 2015; Khalifa et al., 2015; Yang and Lin, 2015; Chang et al., 2015; Demetriou et al., 2015; Rajupillai et al., 2015; Sylvester et al., 2015; Abrahman et al., 2009; Abdullah and Halim, 2009; Zotos and Costopoulos, 2009; Feraga et al., 2009; Bakar et al., 2016).

Fig. 2: Cinematic schema of a forging manipulator main mechanism.

Electronic copy available at: https://ssrn.com/abstract=3417321
Materials and Methods

Mechanism Structure

Then can be determined easily and the structural schema (Fig. 3).

The structural formula can be determined from the structural diagram (relationship 1) (Gao et al., 2010; Ge and Gao, 2012; Li and Liu, 2010; Yan et al., 2009; Zhao et al., 2010; Petrescu and Petrescu, 2015a,b,d; Aversa et al., 2017b):

\[
EF(0) + DM1(1,2,7) + DM0(3,4) + DM1(5,8,9) + DM1(6,10,11)
\]

(1)

It is obtained: three motor dyads, one classic dyad and a fundamental item 0 [1-5].

![Fig. 3: Structural schema of a forging manipulator main mechanism](https://ssrn.com/abstract=3417321)
The mobility of the mechanism is determined with the formula (2) (Gao et al., 2010; Ge and Gao, 2012; Li and Liu, 2010; Yan et al., 2009; Zhao et al., 2010; Petrescu and Petrescu, 2015a; 2015b; 2015d; Aversa et al., 2017b):

\[
M_1 = 3m - 2C_3 - C_4 = 3 \cdot 11 - 2 \cdot 15 - 0 = 33 - 30 = 3
\]  

(2)

It follows three degrees of freedom corresponding to the three actuators (motors) linear.

The wiring diagram can be determined now using the structural formula (Fig. 4).

**Mechanism Kinematics**

Permanently one knows the constant lengths (a-g) and the coordinates \((x_b, y_b, x_f, y_f, x_K, y_K, x_B, y_B)\) and the \(\phi\) angle who must to be maintained constant [1-5].

In direct kinematics one knows \(l_1, l_2\) and must be determined: Intermediary (with systems I, II, III) \(l_1, \phi_1, \phi_2, \phi_3, \phi_{10}\) and finally (with system IV) \(x_M, y_M\) [1-5].

In inverse kinematics one knows \(x_M, y_M\) and must be determined \(\phi_1, \phi_2, \phi_3, \phi_{10}, l_1, l_2, l_3\) with systems I, II, III, IV.

It takes four independent vector contours (KLKF, KIGEDB, AHIK, AHGM) and one can write the below systems (I, II, III, IV):

\[
\begin{align*}
(x_K - x_F) + g \cdot \cos(\phi_1 + \beta) &= l_1 \cdot \cos \phi_1 \\
(y_K - y_F) + g \cdot \sin(\phi_1 + \beta) &= l_1 \cdot \sin \phi_1 \\
(x_K + b \cdot \cos \phi + l_1 \cdot \cos \phi_1) &= 2a \cdot \cos \phi_1 \\
(y_K + b \cdot \sin \phi + l_1 \cdot \sin \phi_1) &= 2a \cdot \sin \phi_1
\end{align*}
\]  

(I)

\[
\begin{align*}
(x_A - x_K) + l_2 \cdot \cos \phi_2 + a \cdot \cos \phi_3 &= e \cdot \cos \phi_3 \\
(y_A - y_K) + l_2 \cdot \sin \phi_2 + a \cdot \sin \phi_3 &= e \cdot \sin \phi_3
\end{align*}
\]  

(III)

\[
\begin{align*}
(x_A - x_M) + l_1 \cdot \cos \phi_0 + f \cdot \cos(\phi + \theta) &= a \cdot \cos \phi_0 \\
(y_A - y_M) + l_1 \cdot \sin \phi_0 + f \cdot \sin(\phi + \theta) &= a \cdot \sin \phi_0
\end{align*}
\]  

(IV)

**Inverse Kinematics Relationships Computing**

Then can be determined easily the parameters \(\phi_1, \phi_2, \phi_3, \phi_{10}, l_1, l_2, l_3\) solving the four systems I, II, III, IV. Following relationships are obtained (systems 3 and 4) (Gao et al., 2010; Ge and Gao, 2012; Li and Liu, 2010; Yan et al., 2009; Zhao et al., 2010; Petrescu and Petrescu, 2015a; 2015b; 2015d; Aversa et al., 2017b).

\[
\begin{align*}
\cos \phi_1 &= \frac{A_1 \cdot A_2 + A_3 \sqrt{A_1^2 + A_4^2}}{A_1^2 + A_4^2} \\
\Rightarrow \phi_1 &= \arccos(\cos \phi_1) \quad l_2 = -A_1 \sqrt{A_1^2 + e^2} \\
A_0 &= 4a^2 + (x_K + b \cdot \cos \phi)^2 + (y_K + b \cdot \sin \phi)^2 \\
-4a^2 [(x_K + b \cdot \cos \phi) \cos \phi_0 + (y_K + b \cdot \sin \phi) \sin \phi_0] &= \\
\begin{cases}
\cos \phi_0 = \frac{2a \cdot \cos \phi_0 - x_K - b \cdot \cos \phi}{l_1} \\
\sin \phi_0 = \frac{2a \cdot \sin \phi_0 - y_K - b \cdot \sin \phi}{l_1}
\end{cases}
\]

(3)

\[
\begin{align*}
\phi_1 &= \text{sign}(\sin \phi_0) \cdot \arccos(\cos \phi_1) \\
\cos \phi_0 &= \frac{a \cdot \cos \phi_0 - f \cdot \cos(\phi + \theta) + x_M - x_A}{l_1} \\
\sin \phi_0 &= \frac{a \cdot \sin \phi_0 - f \cdot \sin(\phi + \theta) + y_M - y_A}{l_1}
\end{align*}
\]

\[
\begin{align*}
\phi_0 &= \text{sign}(\sin \phi_0) \cdot \arccos(\cos \phi_0)
\end{align*}
\]
Results

Determining Driving forces of the Main Mechanism

In step 1 (starting from system 5) it calculated the all external forces from the mechanism (The inertia forces, gravitational forces and the force of the weight of the cast part):

\[
\begin{align*}
\cos \phi_i &= \frac{x_i - x_a + l_i \cdot \cos \phi_0 + a \cdot \cos \phi_h}{l_i} \\
\sin \phi_i &= \frac{y_i - y_a + l_i \cdot \sin \phi_0 + a \cdot \sin \phi_h}{l_i} \\
\Rightarrow \phi_i &= \arctan(\sin \phi_i) \cdot \arccos(\cos \phi_i)
\end{align*}
\]

\[
l_i = \sqrt{\left(x_a - x_i - g \cos(\phi_i + \beta)\right)^2 + \left(y_a - y_i - g \sin(\phi_i + \beta)\right)^2}
\]

\[
\cos \phi_h = \frac{x_h - x_i + g \cos(\phi_i + \beta)}{l_i} \\
\sin \phi_h = \frac{y_h - y_i + g \sin(\phi_i + \beta)}{l_i} \\
\Rightarrow \phi_h &= \arctan(\sin \phi_h) \cdot \arccos(\cos \phi_h)
\]

\[
A = 3a + \left(x_c + b \cdot \cos \phi \right)^2 + \left(y_c + b \cdot \sin \phi \right)^2 - \left(x_h - x_i - f \cdot \cos(\phi + \theta)\right)^2 - \left(y_h - y_i + f \cdot \sin(\phi + \theta)\right)^2
\]

\[
A = 4a \left(x_c + b \cdot \cos \phi \right) + 2a \left(x_h - x_i - f \cdot \cos(\phi + \theta)\right)
\]

\[
A = \cos \phi_h \cdot (a \cdot \cos \phi_h + x_h - x_i) + \sin \phi_h \cdot (a \cdot \sin \phi_h + y_h - y_i)
\]

\[
F_G = \begin{cases} 
-m_{h,2} \cdot \ddot{x}_{i_1} & F_G = \begin{cases} 
-m_{h,2} \cdot \ddot{x}_{i_1} \\
-m_{h,3} \cdot \ddot{y}_{i_1} - m_{h,3} \cdot g \\
-M_i \cdot \ddot{\phi}_h \\
-m_{h,6} \cdot \ddot{x}_{i_1} \\
-m_{h,6} \cdot \ddot{y}_{i_1} - m_{h,6} \cdot g \\
-M_{i,h} \cdot \ddot{\phi} \\
-m_{h,10,11} \cdot \ddot{x}_{i_1} \\
-m_{h,10,11} \cdot \ddot{y}_{i_1} - m_{h,10,11} \cdot g \\
-M_{i,10} \cdot \ddot{\phi}_{h} 
\end{cases} 
\end{cases}
\]

Is then calculated all the forces from couplers. In the end we can determine and (three) driving forces [1-5]. In Fig. 5 can be monitored engine element c1 composed of kinematic elements 8-9.

Fig. 5: Kinematics schema of the motor mechanism c1

189
Determine motive power $F_m$ with relations of the system 7 (Gao et al., 2010; Ge and Gao, 2012; Li and Liu, 2010; Yan et al., 2009; Zhao et al., 2010; Petrescu and Petrescu, 2015a,b,d; Aversa et al., 2017b):

$$\begin{aligned}
\sum F^{(10)}_x &= 0 \Rightarrow F_{m_1} \cdot \cos \phi_h + F^\omega_{G_{10}} + R^\omega_H = 0 \Rightarrow F_{m_1} = \frac{F^\omega_{G_{10}} - R^\omega_H}{\cos \phi_h} \\
\sum F^{(10)}_y &= 0 \Rightarrow F_{m_1} \cdot \sin \phi_h + F^\nu_{G_{10}} + R^\nu_H = 0 \Rightarrow F_{m_1} = \frac{F^\nu_{G_{10}} - R^\nu_H}{\sin \phi_h}
\end{aligned}$$

(6)

In Fig. 6 can be monitored engine element $c_2$ composed of kinematic elements 10-11 and determine motive power $F_{m_2}$ with relations of the system 7:

$$\begin{aligned}
\sum F^{(10)}_x &= 0 \Rightarrow F_{m_2} \cdot \cos \phi_h + F^\omega_{G_{11}} + R^\omega_H = 0 \Rightarrow F_{m_2} = \frac{F^\omega_{G_{11}} - R^\omega_H}{\cos \phi_h} \\
\sum F^{(10)}_y &= 0 \Rightarrow F_{m_2} \cdot \sin \phi_h + F^\nu_{G_{11}} + R^\nu_H = 0 \Rightarrow F_{m_2} = \frac{F^\nu_{G_{11}} - R^\nu_H}{\sin \phi_h}
\end{aligned}$$

(7)

In Fig. 7 can be monitored engine element $c_3$ composed of kinematic elements 1-2 and determine motive power $F_{m_3}$ with relations of the system 8:

$$\begin{aligned}
\sum F^{(1)}_x &= 0 \Rightarrow F_{m_1} \cdot \cos \phi_h + F^\omega_{G_{11}} + R^\omega_E = 0 \Rightarrow F_{m_1} = \frac{F^\omega_{G_{11}} + R^\omega_E}{\cos \phi_h} \\
\sum F^{(1)}_y &= 0 \Rightarrow F_{m_1} \cdot \sin \phi_h + F^\nu_{G_{11}} + R^\nu_E = 0 \Rightarrow F_{m_1} = \frac{F^\nu_{G_{11}} + R^\nu_E}{\sin \phi_h}
\end{aligned}$$

(8)

Discussion

A 500kN shelf handle is designed to support the pliers with a variety of actions that keep pace with precision speeds and pressures such as forging in the forging area of the presses.

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Pressing and handling measures are integrated and controlled by an operator in a central impulse. Integrated with the press, the forged positioning by the horizontal forward and backward movement, which rotates in the forging area, synchronizes with the press parts.

Transport capacity: 30kN/60kN · m - 1000kN/2500kN · m.

Servicing of hydraulic presses during forging operations by forging manipulators can lead to doubling the productivity of the forging machine (hydraulic press or hydraulic hammer).

This, especially when a certain degree of inter-conditioning of their movements with the basic equipment is achieved and even more so when their functional integration is achieved.

This integration is usually based on a programmable machine or a process calculator and modern instrumentation that is appropriate to automatic systems that can monitor, control and emit the command signals imposed by the system and close the loop reaction needed to adjust the functional parameters.

Of course, in order to operate in such working regimes, it is necessary for the forging manipulators, as well as the hydraulic press or forging hammer, to be able to achieve the corresponding dynamic responses, so that when lifting the ram on a race and then returning it to the level of the forgings, the manipulator executing the feed strokes, pivoting the pliers and lifting the necessary pliers required by the plastic deformation process by pressing, especially when working with a press, or with a forging hammer, with increasing work cadences. This required forging manipulators to have all the working mechanisms capable of performing. Therefore, in order to know in detail the dynamic responses of the working mechanisms of forging manipulators, it is necessary to investigate their dynamic behavior.

One of these mechanisms is the lifting/lowering mechanism of the clamp.

The hoisting and lowering mechanisms of the deflector manipulator clamp have specific design and action solutions based on electro-mechanical elements. They are generated by the large masses they have to raise during the forging operation, in accordance with the movements of the press or the hammer with which they work in tandem. In order to know the dynamic behavior of this mechanism, theoretical research was carried out. This research was based on the modern method of analysis and synthesis of components and systems by modeling and computer simulation of dynamic behavior. Modeling of the elements and systems of the displacement mechanism was carried out in several stages, as follows: Physical modeling; system modeling, mathematical modeling and computer modeling. Analysis and synthesis involve describing the dynamic behavior of the components of hydro-mechanical elements by mathematical modeling, in the form of systems of differential equations that best express the characteristics of the equivalent physical model, after which, on the basis of the inter conditions existing between the component elements, their synthesis is made.

Dynamic phenomena that take place in the work schedules of the actions hydro-mechanical, is a result of the interaction between the mechanical-hydraulic subsystem and the working process. That is why the theory of systems was approached as the theoretical basis of research development.

Fig. 8: Heavy forging manipulator
It is known that, in the systemic sense, hydro-mechanical drive systems are comprised from bipolar, quadrupolar or six polar elements, characterized by inbound margins and specific outputs that bind and interact with each other. The system model, based on the physical model, was the basis for the mathematical model and it created the possibility of conceiving the simulation model. The computer simulation model of the dynamic behavior of the lifting/lowering mechanism allowed knowledge of the graphical evolution of the parameters of interest: Races, speeds, accelerations, moments, pressures, power, energy, etc. The article presents the results of the theoretical research on the dynamic behavior of the lifting and lowering mechanism from the recently designed forging manipulator.

The very large loads of the forging manipulator led to the use lifting and lowering electro-hydro-mechanical clamp mechanisms based on linear hydraulic motors which, by means of an articulated bar mechanism, perform the force and the required lifting/lowering of the hot semi-finished products.

Elaborate the physical model of the lifting mechanism lowering pliers (Fig. 9).

In order to elaborate the physical model of the claw-lowering mechanism, the hydromechanical actuation scheme, which mentions the physical dimensions involved in carrying out the lifting-lowering process of the semi-fabric caught in the manipulator clamps, was started.

The main physical elements involved in the lift-down movement clergy and the physical dimensions involved in the process are the following:

- The electric drive motor M, characterized by a moment factor K_ME, a supply voltage U, an absorbed current I, a moment of inertia J_ME and an angular synchronous velocity s
- The GH hydraulic generator, characterized by a Qp cylinder, an angular velocity p, a Qa aspiration flow rate, a Qp effluent flow rate, a suction pressure p_a and a discharge pressure p_p
- The RU oil tank with a surface A_RU, at the pressure p_01 where the oil level h varies accordingly
- The SLP pressure limitation pump, characterized by the opening pressures p_11 and p_12
- The lift-down mechanism, consisting of a parallelogram (ABCD), with uneven sides b and c, with the variable diagonal materialized by the MHL linear hydraulic motor with the minimum length L_min and the current length L_x

The parallelogram is suspended by means of some tensioners, the body of the weight clamp Gc, which requests the parallelogram (Dg + b) from the fixed joint A. The distance Dc is the proper clamp, where the hot semi-finished part of the length L_s which has the center of gravity at the distance L_s/2.

The current angle made by the horizontal bar with AC is the current angle between the side AB and MHL is. With respect to the horizontal position of the AC side, the clamps rise and fall by half of the h_c stroke on the current stroke x_c with the V_c speed and the accelerator. The weight of the moving parts of the casing and of the semi-product is thrown by the FR lifting force generated by the MHL.

Conclusion

Self-forging systems have the ability to achieve an open, fast, direct forging of products that are often heavy and heavy but also bulky. Open forging productivity is generally very high, it is determined not only by the capacity of forging press but obviously dynamic handling by forging manipulator.

The most prominent and qualitative forging machines are the DANGO and DIENENTHAL series, equipped with high dynamic devices and specially designed to operate on heavy forging presses. They ensure the reliability and repeatability of all forging cycles. Even a modernization of existing forging machines with D&D machines will improve the capacity and quality of these facilities.

D&D handlers allows to forge nearly clean shapes and guarantee superior surface qualities, thus saving energy, improving production and saving costs during the machining of parts. Savings due to shorter process times and reduction of reheating cycles result in shorter recovery time.

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3-Contract research. GR 69/10.05.2007: NURC in 2762; theme 8: Dynamic analysis of mechanisms and manipulators with bars and gears.

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**Ethics**

This article is original and contains unpublished material. Authors declare that are not ethical issues and no conflict of interest that may arise after the publication of this manuscript.

**References**

Ab-Rahman, M.S., H. Guna, MH. Harun, SD. Zan and K. Jumari, 2009. Cost-effective fabrication of self-made 1×12 polymer optical fiber-based optical splitters for automotive application. Am. J. Eng. Applied Sci., 2: 252-259. DOI: 10.3844/ajeassp.2009.252.259

Abam, F.I., I.U. Ugot and D.I. Igbong, 2012. Performance analysis and components irreversibilities of a (25 MW) gas turbine power plant modeled with a spray cooler. Am. J. Eng. Applied Sci., 5: 35-41. DOI: 10.3844/ajeassp.2012.35.41

Abdelkrim, H., S.B. Othman, A.K.B. Salem and S.B. Saoud, 2012. Dynamic partial reconfiguration contribution on system on programmable chip architecture for motor drive implementation. Am. J. Eng. Applied Sci., 5: 15-24. DOI: 10.3844/ajeassp.2012.15.24

Abdullah, M.Z., A. Saat and Z. Hamzah, 2011. Optimization of energy dispersive x-ray fluorescence spectrometer to analyze heavy metals in moss samples. Am. J. Eng. Applied Sci., 4: 355-362. DOI: 10.3844/ajeassp.2011.355.362

Abdullah, M., A. F.M. Zain, Y. H. Ho and S. Abdullah, 2009. TEC and scintillation study of equatorial ionosphere: A month campaign over sipitang and parit raja stations, Malaysia. Am. J. Eng. Applied Sci., 2: 44-49. DOI: 10.3844/ajeassp.2009.44.49

Abdullah, H. and S.A. Halim, 2009. Electrical and magnetoresistive studies Nd doped on La-Ba-Mn-O manganese for low-field sensor application. Am. J. Eng. Applied Sci., 2: 297-303. DOI: 10.3844/ajeassp.2009.297.303

Abouobaida, H., 2016. Robust and efficient controller to design a standalone source supplied DC and AC load powered by photovoltaic generator. Am. J. Eng. Applied Sci., 9: 894-901. DOI: 10.3844/ajeassp.2016.894.901

Ahmed, M., 2009. Numerical and analytical study of exhaust gases flow in porous media with applications to diesel particulate filters. Am. J. Eng. Applied Sci., 2: 70-75. DOI: 10.3844/ajeassp.2009.70.75

Abu-Lebdeh, M., G. Pérez-de León, S.A. Hamoush, R.D. Seals and V.E. Lamberti, 2016. Gas atomization of molten metal: Part II. Applications. Am. J. Eng. Applied Sci., 9: 334-349. DOI: 10.3844/ajeassp.2016.334.349

Agarwala, S., 2016. A perspective on 3D bioprinting technology: Present and future. Am. J. Eng. Applied Sci., 9: 985-990. DOI: 10.3844/ajeassp.2016.985.990

Ahmed, M., R. Khan, M. Billah and S. Farhana, 2010. A novel navigation algorithm for hexagonal hexapod robot. Am. J. Eng. Applied Sci., 3: 320-327. DOI: 10.3844/ajeassp.2010.320.327

Ahmed, M.K., H. Haque and H. Rahman, 2016. An approach to develop a dynamic job shop scheduling by fuzzy rule-based system and comparative study with the traditional priority rules. Am. J. Eng. Applied Sci., 9: 202-212. DOI: 10.3844/ajeassp.2016.202.212

Akhesmeh, S., N. Pourmahmoud and H. Sedgi, 2008. Numerical study of the temperature separation in the ranque-hilsch vortex tube. Am. J. Eng. Applied Sci., 1: 181-187. DOI: 10.3844/ajeassp.2008.181.187

Akubue, A., 2011. Appropriate technology for socioeconomic development in third world countries. J. Technol. Stud., 26: 33-43. DOI: 10.21061/jots.v26i1.a.6

Al-Abbas, I.K., 2009. Reduced order models of a current source inverter induction motor drive. Am. J. Eng. Applied Sci., 2: 39-43. DOI: 10.3844/ajeassp.2009.39.43

Al-Hasan and A.S. Al-Ghamdi, 2016. Energy balance for a diesel engine operates on a pure biodiesel, diesel fuel and biodiesel-diesel blends. Am. J. Eng. Applied Sci., 9: 458-465. DOI: 10.3844/ajeassp.2016.458.465
Al Smadi, T.A., 2011. Low cost smart sensor design. Am. J. Eng. Applied Sci., 4: 162-168. DOI: 10.3844/ajeassp.2011.162.168

Al Qadi, A.N.S., M.B.A. Alhasanat, A. Al Dahamsh and S. Al Zaiydeen, 2016a. Using of box-benken method to predict the compressive strength of self-compacting concrete containing Wadi Musa bentonite. Jordan. Am. J. Eng. Applied Sci., 9: 406-411. DOI: 10.3844/ajeassp.2016.406.411

Al Qadi, A.N.S., M.B.A. Alhasanat and M. Haddad, 2016b. Effect of crumb rubber as coarse and fine aggregates on the properties of asphalt concrete. Am. J. Eng. Applied Sci., 9: 558-564. DOI: 10.3844/ajeassp.2016.558.564

Aleksic, S. and A. Lovric, 2011. Energy consumption and environmental implications of wired access networks. Am. J. Eng. Applied Sci., 4: 531-539. DOI: 10.3844/ajeassp.2011.531.539

Alhasanat, M.B., A.N. Al Qadi, O.A. Al Khashman and A. Dahamsh, 2016. Scanning electron microscopic evaluation of self-compacting concrete spalling at elevated temperatures. Am. J. Eng. Applied Sci., 9: 119-127. DOI: 10.3844/ajeassp.2016.119.127

Ali, K.S. and J.L. Shumaker, 2013. Hardware in the loop simulator for multi-agent unmanned aerial vehicles environment. Am. J. Eng. Applied Sci., 6: 172-177. DOI: 10.3844/ajeassp.2013.172.177

Ali, G.A.M., O. Fouad and S.A. Makhlouf, 2016. Electrical properties of cobalt oxide/silica nanocomposites obtained by sol-gel technique. Am. J. Eng. Applied Sci., 9: 12-16. DOI: 10.3844/ajeassp.2016.12.16

Al-Nasra, M. Daoudb and T.M. Abu-Lebdeh, 2015. The use of the super absorbent polymer as water blocker in concrete structures. Am. J. Eng. Applied Sci., 8: 659-665. DOI: 10.3844/ajeassp.2015.659.665

Alwetaishi, M.S., 2016. Impact of building function on thermal comfort: A review paper. Am. J. Eng. Applied Sci., 9: 928-945. DOI: 10.3844/ajeassp.2016.928.945

Aly, W.M. and M.S. Abuelsarsr, 2010. Electronic design automation using object oriented electronics. Am. J. Eng. Applied Sci., 3: 121-127. DOI: 10.3844/ajeassp.2010.121.127

Amani, N., 2016. Design and implementation of optimum management system using cost evaluation and financial analysis for prevention of building failure. Am. J. Eng. Applied Sci., 9: 281-296. DOI: 10.3844/ajeassp.2016.281.296

Amer, S., S. Hamoush and T.M. Abu-Lebdeh, 2015. Experimental evaluation of the raking energy in damping system of steel stud partition walls. Am. J. Eng. Applied Sci., 8: 666-677. DOI: 10.3844/ajeassp.2015.666.677

Anizan, S., K. Yusri, C.S. Leong, N. Amin and S. Zaidi et al., 2011. Effects of the contact resistivity variations of the screen-printed silicon solar cell. Am. J. Eng. Applied Sci., 4: 328-331. DOI: 10.3844/ajeassp.2011.328.331

Angeles, J. and C. Lopez-Cajun, 1988. Optimal synthesis of cam mechanisms with oscillating flat-face followers. Mechanism Mach. Theory, 23: 1-6. DOI: 10.1016/0094-114X(88)90002-X

Antonescu, P., 2000. Mechanisms and Handlers. 1st Edn., Printech Publishing House, Bucharest.

Antonescu, P. and F.I.T. Petrescu, 1985. An analytical method of synthesis of cam mechanism and flat stick. Proceedings of the 4th International Symposium on Theory and Practice of Mechanisms, (TPM’ 85), Bucharest.

Antonescu, P. and F.I.T. Petrescu, 1989. Contributions to cineoelastodynamic analysis of distribution mechanisms. Bucharest.

Antonescu, P., M. Oprean and F.I.T. Petrescu, 1985a. Contributions to the synthesis of oscillating cam mechanism and oscillating flat stick. Proceedings of the 4th International Symposium on Theory and Practice of Mechanisms, (TPM’ 85), Bucharest.

Antonescu, P., M. Oprean and F.I.T. Petrescu, 1985b. At the projection of the oscillating cams, there are mechanisms and distribution variables. Proceedings of the 5th Conference of Engines, Automobiles, Tractors and Agricultural Machines, (AMA’ 58), I-Motors and Cars, Brasov.

Antonescu, P., M. Oprean and F.I.T. Petrescu, 1986. Projection of the profile of the rotating camshaft acting on the oscillating plate with disengagement. Proceedings of the 3rd National Computer-aided Design Symposium in the field of Mechanisms and Machine Parts, (MMP’ 86), Brasov.

Antonescu, P., M. Oprean and F.I.T. Petrescu, 1987. Dynamic analysis of the cam distribution mechanisms. Proceedings of the 7th National Symposium on Industrial Robots and Space Mechanisms, (RSM’ 87), Bucharest.

Antonescu, P., M. Oprean and F.I.T. Petrescu, 1988. Analytical synthesis of Kurz profile, rotating the flat cam. Mach. Build. Rev.

Antonescu, P., F.I.T. Petrescu and O. Antonescu, 1994. Contributions to the synthesis of the rotating cam mechanism and the tip of the balancing tip. Brasov.

Antonescu, P., F.I.T. Petrescu and D. Antonescu, 1997. Geometrical synthesis of the rotary cam and balance tappet mechanism. Bucharest, 3: 23-23.

Antonescu, P., F.I.T. Petrescu and O. Antonescu, 2000a. Contributions to the synthesis of the rotary disc-cam profile. Proceedings of the 8th International Conference on the Theory of Machines and Mechanisms, (TMM’ 00), Liberec, Czech Republic, pp: 51-56.
Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016n. The basic elements of life's. Am. J. Eng. Applied Sci., 9: 1189-1197.
DOI: 10.3844/ajeassp.2016.1189.1197

Aversa, R., F.I.T. Petrescu, R.V. Petrescu and A. Apicella, 2016o. Flexible stem trabecular prostheses. Am. J. Eng. Applied Sci., 9: 1213-1221.
DOI: 10.3844/ajeassp.2016.1213.122

Bahayemi, A.K., 2016. Thermodynamics, non-linear isotherms, statistical modeling and optimization of phosphorus adsorption from wastewater. Am. J. Eng. Applied Sci., 9: 1019-1026.
DOI: 10.3844/ajeassp.2016.1019.1026

Bakar, R.A., M.K. Mohammed and M.M. Rahman, 2009. Numerical study on the performance characteristics of hydrogen fueled port injection internal combustion engine. Am. J. Eng. Applied Sci., 2: 407-415.
DOI: 10.3844/ajeassp.2009.407.415

Barone, G., A. Buonomano, C. Forzano and A. Palombo, 2016. WLHP systems in commercial buildings: A case study analysis based on a dynamic simulation approach. Am. J. Eng. Applied Sci., 9: 659-668.
DOI: 10.3844/ajeassp.2016.659.668

Bedon, C., 2016. Review on the use of FRP composites for facades and building skins. Am. J. Eng. Applied Sci., 9: 713-723.
DOI: 10.3844/ajeassp.2016.713.723

Bedon, C. and C. Amadio, 2016. A unified approach for the shear buckling design of structural glass walls with non-ideal restraints. Am. J. Eng. Applied Sci., 9: 64-78. DOI: 10.3844/ajeassp.2016.64.78

Bedon, C. and C. Louter, 2016. Finite-element numerical simulation of the bending performance of post-tensioned structural glass beams with adhesively bonded CFRP tendons. Am. J. Eng. Applied Sci., 9: 680-691.
DOI: 10.3844/ajeassp.2016.680.691

Bier, H. and S. Mostafavi, 2015. Structural optimization for materially informed design to robotic production processes. Am. J. Eng. Applied Sci., 8: 549-555.
DOI: 10.3844/ajeassp.2015.549.555

Bolonkin, A., 2009a. Femtotechnology: Nuclear matter with fantastic properties. Am. J. Eng. Applied Sci., 2: 501-514. DOI: 10.3844/ajeassp.2009.501.514

Bolonkin, A., 2009b. Converting of matter to nuclear energy by ab-generator. Am. J. Eng. Applied Sci., 2: 683-693. DOI: 10.3844/ajeassp.2009.683.693

Boucetta, A., 2008. Vector control of a variable reluctance machine stator and rotor discs imbricates. Am. J. Eng. Applied Sci., 1: 260-265.
DOI: 10.3844/ajeassp.2008.260.265

Bourahla, N. and A. Blakeborough, 2015. Similitude distortion compensation for a small scale model of a knee braced steel frame. Am. J. Eng. Applied Sci., 8: 481-488. DOI: 10.3844/ajeassp.2015.481.488

Bucinell, R.B., 2016. Stochastic model for variable amplitude fatigue induced delamination growth in graphite/epoxy laminates. Am. J. Eng. Applied Sci., 9: 635-646. DOI: 10.3844/ajeassp.2016.635.646

Budak, S., Z. Xiao, B. Johnson, J. Cole and M. Drabo et al., 2016. Highly-efficient advanced thermoelectric devices from different multilayer thin films. Am. J. Eng. Applied Sci., 9: 356-363.
DOI: 10.3844/ajeassp.2016.356.363

Buonomano, A., F. Calise and M. Vicidomini, 2016a. A novel prototype of a small-scale solar power plant: Dynamic simulation and thermo-economic analysis. Am. J. Eng. Applied Sci., 9: 770-788.
DOI: 10.3844/ajeassp.2016.770.788

Buonomano, A., F. Calise, M.D. d’Accadia, R. Vanoli and M. Vicidomini, 2016b. Simulation and experimental analysis of a demonstrative solar heating and cooling plant installed in Naples (Italy). Am. J. Eng. Applied Sci., 9: 798-813.
DOI: 10.3844/ajeassp.2016.798.813

Cao, W., H. Ding, Z. Bin and C. Ziming, 2013. New structural representation and digital-analysis platform for symmetrical parallel mechanisms. Int. J. Adv. Robotic Sys. DOI: 10.5772/56380

Calise, F., M.D. d’Accadia, L. Libertini, E. Quiriti and M. Vicidomini, 2016b. Dynamic simulation and optimum operation strategy of a trigeneration system serving a hospital. Am. J. Eng. Applied Sci., 9: 854-867. DOI: 10.3844/ajeassp.2016.854.867

Campo, T., M. Cotto, F. Marquez, E. Elizalde and C. Morant, 2016. Graphene synthesis by plasma-enhanced CVD growth with ethanol. Am. J. Eng. Applied Sci., 9: 574-583.
DOI: 10.3844/ajeassp.2016.574.583

Cardu, M., P. Oreste and T. Cicala, 2009. Analysis of the tunnel boring machine advancement on the Bologna-Florence railway link. Am. J. Eng. Applied Sci., 2: 416-420.
DOI: 10.3844/ajeassp.2009.416.420

Casadei, D., 2015. Bayesian statistical inference for number counting experiments. Am. J. Eng. Applied Sci., 8: 730-735.
DOI: 10.3844/ajeassp.2015.730.735

Cataldo, R., 2006. Overview of planetary power system options for education. ITEA Human Exploration Project Authors, Glenn Research Center. Brooke Park, OH.

Chang, S.P., M.C. Chen and J.D. Lin, 2015. Study of heat-treated steel and related applications. Am. J. Eng. Applied Sci., 8: 611-619.
DOI: 10.3844/ajeassp.2015.611.619

Chen, G. and L. Xu, 2016. A general strategy to enhance up conversion luminescence in rare-earth-ion-doped oxide nanocrystals. Am. J. Eng. Applied Sci., 9: 79-83.
DOI: 10.3844/ajeassp.2016.79.83

Electronic copy available at: https://ssrn.com/abstract=3417321
Chiozzi, A., G. Milani, N. Grillanda and A. Tralli, 2016. An adaptive procedure for the limit analysis of FRP reinforced masonry vaults and applications. Am. J. Eng. Applied Sci., 9: 735-745. DOI: 10.3844/ajeassp.2016.735.745

Chisari, C. and C. Bedon, 2016. Multi-objective optimization of FRP jackets for improving the seismic response of reinforced concrete frames. Am. J. Eng. Applied Sci., 9: 669-679. DOI: 10.3844/ajeassp.2016.669.679

Comanescu, A., 2010. Bazele Modelarii Mecanismelor. 1st Edn., E. Politeh, Press, București, pp: 274.

Darabi, A., S.A. Soleamani and A. Hassannia, 2008. Fuzzy based digital automatic voltage regulator of a synchronous generator with unbalanced loads. Am. J. Eng. Applied Sci., 1: 280-286. DOI: 10.3844/ajeassp.2008.280.286

Daud, H., N. Yahya, A.A. Aziz and M.F. Jusoh, 2008. Development of wireless electric concept powering electrical appliances. Am. J. Eng. Applied Sci., 1: 12-15. DOI: 10.3844/ajeassp.2008.12.15

Demetriou, D., N. Nikitas and K.D. Tsavdaridis, 2013. New composite electrode for sodium chloride separation. Am. J. Eng. Applied Sci., 8: 620-632. DOI: 10.3844/ajeassp.2015.620.632

Dixit, S. and S. Pal, 2015. Synthesis and characterization of ink (Carbon)-perovskite/polyaniline ternary composite electrode for sodium chloride separation. Am. J. Eng. Applied Sci., 8: 527-537. DOI: 10.3844/ajeassp.2015.527.537

Djalel, D., M. Mourad and H. Labar, 2013. New approach of electromagnetic fields of the lightning discharge. Am. J. Eng. Applied Sci., 6: 369-383. DOI: 10.3844/ajeassp.2013.369.383

Dong, H., N. Giakoumidis, N. Figueroa and N. Mavridis, 2013. Approaching behaviour monitor and vibration indication in developing a General Moving Object Alarm System (GMOAS). Int. J. Adv. Robotic Sys. DOI: 10.5772/56586

Ebrehim, N.A., S. Ahmed, S.H.A. Rashid and Z. Taha, 2012. Technology use in the virtual R&D teams. Am. J. Eng. Applied Sci., 5: 9-14. DOI: 10.3844/ajeassp.2012.9.14

El-Labban, H.F., M. Abdelaziz and E.R.I. Mahmoud, 2013. Modification of carbon steel by laser surface melting: Part I: Effect of laser beam travelling speed on microstructural features and surface hardness. Am. J. Eng. Applied Sci., 6: 352-359. DOI: 10.3844/ajeassp.2013.352.359

Elliott, A., S. AlSalihi, A.L. Merriman and M.M. Basti, 2016. Infiltration of nanoparticles into porous binder jet printed parts. Am. J. Eng. Applied Sci., 9: 128-133. DOI: 10.3844/ajeassp.2016.128.133

Elmeddahi, Y., H. Mahmoudi, A. Issaadi, M.F.A. Goosen and R. Ragab, 2016b. Evaluating the effects of climate change and variability on water resources: A case study of the cheliff Basin in Algeria. Am. J. Eng. Applied Sci., 9: 835-845. DOI: 10.3844/ajeassp.2016.835.845

El-Tous, Y., 2008. Pitch angle control of variable speed wind turbine. Am. J. Eng. Applied Sci., 1: 118-120. DOI: 10.3844/ajeassp.2008.118.120

Faizal, A., S. Mulyono, R. Yendra and A. Fudholi, 2016. Design Maximum Power Point Tracking (MPPT) on photovoltaic panels using fuzzy logic method. Am. J. Eng. Applied Sci., 9: 789-797. DOI: 10.3844/ajeassp.2016.789.797

Farahani, A.S., N.M. Adam and M.K.A. Ariffin, 2010. Simulation of airflow and aerodynamic forces acting on a rotating turbine ventilator. Am. J. Eng. Applied Sci., 3: 159-170. DOI: 10.3844/ajeassp.2010.159.170

Farokhi, E. and M. Gordini, 2015. Investigating the parameters influencing the behavior of knee braced steel structures. Am. J. Eng. Applied Sci., 8: 567-574. DOI: 10.3844/ajeassp.2015.567.574

Fathallah, A.Z.M. and R.A. Bakar, 2009. Prediction studies for the performance of a single cylinder high speed spark ignition linier engine with spring mechanism as return cycle. Am. J. Eng. Applied Sci., 2: 713-720. DOI: 10.3844/ajeassp.2009.713.720

Fawcett, G.F. and J.N. Fawcett, 1974. Comparison of Polydyne and Non Polydyne Cams. In: Cams and Cam Mechanisms, Rees Jones, J. (Ed.), MEP, London and Birmingham, Alabama.

Fen, Y.W., W.M.M. Yunus, M.M. Moksin, Z.A. Talib and N.A. Yusof, 2011. Optical properties of crosslinked chitosan thin film with glutaraldehyde using surface plasmon resonance technique. Am. J. Eng. Applied Sci., 4: 61-65. DOI: 10.3844/ajeassp.2011.61.65

Feraga, C.E., A. Moussaoui, A. Bouldjedri and A. Yousfi, 2009. Robust position controller for a permanent magnet synchronous actuator. Am. J. Eng. Applied Sci., 2: 388-392. DOI: 10.3844/ajeassp.2009.388.392

Franklin, D.J., 1930. Ingenious Mechanisms for Designers and Inventors. 1st Edn., Industrial Press Publisher.

Fu, Y.F., J. Gong, H. Huang, Y.J. Liu and D. Zhu et al., 2015. Parameters optimization of adaptive cashew shelling cutter based on BP neural network and genetic algorithm. Am. J. Eng. Applied Sci., 8: 648-658. DOI: 10.3844/ajeassp.2015.648.658

Gao, F., W.Z. Guo, Q.Y. Song and F.S. Du, 2010. Current development of heavy-duty manufacturing equipment. J. Mech. Eng., 46: 92-107.
Jones, J.R. and J.E. Reeve, 1974. Dynamic Response of Cam Curves Based on Sinusoidal Segments. In: Cams and cam Mechanisms, Rees Jones, J. (Ed.), MEP, London and Birmingham, Alabama.

Kawena, S. and S. Wongwises, 2011. Improvement of the runner design of francis turbine using computational fluid dynamics. Am. J. Eng. Applied Sci., 4: 540-547. DOI: 10.3844/ajeassp.2011.540.547

Khalifa, A.H.N., A.H. Jabbar and J.A. Muhsin, 2015. Effect of exhaust gas temperature on the performance of automobile adsorption air-conditioner. Am. J. Eng. Applied Sci., 8: 575-581. DOI: 10.3844/ajeassp.2015.575.581

Khalil, R., 2015. Credibility of 3D volume computation using GIS for pit excavation and roadway constructions. Am. J. Eng. Applied Sci., 8: 434-442. DOI: 10.3844/ajeassp.2015.434.442

Kamble, V.G. and N. Kumar, 2016. Fabrication and tensile property analysis of polymer matrix composites of graphite and silicon carbide as fillers. Am. J. Eng. Applied Sci., 9: 17-30. DOI: 10.3844/ajeassp.2016.17.30

Kazakov, V.V., V.I. Yusupov, V.N. Bagratashvili, A.I. Pavlikov and V.A. Kamensky, 2016. Control of bubble formation at the optical fiber tip by analyzing ultrasound acoustic waves. Am. J. Eng. Applied Sci., 9: 921-927. DOI: 10.3844/ajeassp.2016.921.927

Kechiche, O.B.H.B., H.B.A. Sethom, H. Sammoud and I.S. Belkhodja, 2011. Optimized high-frequency signal injection based permanent magnet synchronous motor rotor position estimation applied to washing machines. Am. J. Eng. Applied Sci., 4: 390-399. DOI: 10.3844/ajeassp.2011.390.399

Koster, M.P., 1974. The Effects of Backlash and Shaft Flexibility on the Dynamic Behavior of a Cam Mechanism. In: Cams and Cam Mechanisms, Rees Jones, J. (Ed.), MEP, London and Birmingham, Alabama.

Kuli, I., T.M. Abu-Lebdhe, E.H. Fini and S.A. Hamoush, 2016. The use of nano-silica for improving mechanical properties of hardened cement paste. Am. J. Eng. Applied Sci., 9: 146-154. DOI: 10.3844/ajeassp.2016.146.154

Kumar, N.D., R.D. Ravali and PR. Srirekha, 2015. Design and realization of pre-amplifier and filters for on-board radar system. Am. J. Eng. Applied Sci., 8: 689-701. DOI: 10.3844/ajeassp.2015.689.701

Kunanoppadon, J., 2010. Thermal efficiency of a combined turbocharger set with gasoline engine. Am. J. Eng. Applied Sci., 3: 342-349. DOI: 10.3844/ajeassp.2010.342.349

Kwon, S., Y. Tani, H. Okubo and T. Shimomura, 2010. Fixed-star tracking attitude control of spacecraft using single-gimbal control moment gyros. Am. J. Eng. Applied Sci., 3: 49-55. DOI: 10.3844/ajeassp.2010.49.55

Lamarre, A.E.H. Fini and T.M. Abu-Lebdhe, 2016. Investigating effects of water conditioning on the adhesion properties of crack sealant. Am. J. Eng. Applied Sci., 9: 178-186. DOI: 10.3844/ajeassp.2016.178.186

Lee, B.J., 2013. Geometrical derivation of differential kinematics to calibrate model parameters of flexible manipulator. Int. J. Adv. Robotic Sys. DOI: 10.5772/55592

Li, G. and D.S. Liu, 2010. Dynamic behavior of the forging manipulator under large amplitude compliance motion. J. Mech. Eng., 46: 21-28.

Li, R., B. Zhang, S. Xiu, H. Wang and L. Wang et al., 2015. Characterization of solid residues obtained from supercritical ethanol liquefaction of swine manure. Am. J. Eng. Applied Sci., 8: 465-470. DOI: 10.3844/ajeassp.2015.465.470

Lin, W., B. Li, X. Yang and D. Zhang, 2013. Modelling and control of inverse dynamics for a 5-DOF parallel kinematic polishing machine. Int. J. Adv. Robotic Sys. DOI: 10.5772/54963

Liu, H., W. Zhou, X. Lai and S. Zhu, 2013. An efficient inverse kinematic algorithm for a PUMA560-structured robot manipulator. IJARS. DOI: 10.5772/56403

Lubis, Z., A.N. Abdalla, Mortaza and R. Ghon, 2009. Mathematical modeling of the three phase induction motor couple to DC motor in hybrid electric vehicle. Am. J. Eng. Applied Sci., 2: 708-712. DOI: 10.3844/ajeassp.2009.708.712

Madani, D.A. and A. Dababneh, 2016. Rapid entire body assessment: A literature review. Am. J. Eng. Applied Sci., 9: 107-118. DOI: 10.3844/ajeassp.2016.107.118

Malomar, G.E.B., A. Gueye, C. Mbow, V.B. Traore and A.C. Beye, 2016. Numerical study of natural convection in a square porous cavity thermally modulated on both side walls. Am. J. Eng. Applied Sci., 9: 591-598. DOI: 10.3844/ajeassp.2016.591.598

Mansour, M.A.A., 2016. Developing an anthropometric database for Saudi students and comparing Saudi dimensions relative to Turkish and Iranian peoples. Am. J. Eng. Applied Sci., 9: 547-557. DOI: 10.3844/ajeassp.2016.547.557

Maraveas, C., Z.C. Fasoulakis and K.D. Tsavdaridis, 2015. A review of human induced vibrations on footbridges. Am. J. Eng. Applied Sci., 8: 422-433. DOI: 10.3844/ajeassp.2015.422.433
Obaiys, S.J., O. Abbas, N.M.A. Nik Long, A.F. Ahmad and A. Ahmedov et al., 2016. On the general solution of first-kind hypersingular integral equations. Am. J. Eng. Applied Sci., 9: 195-201. DOI: 10.3844/ajeassp.2016.195.201

Odeh, S., R. Faqeh, L. Abu Eid and N. Shamasneh, 2009. Vision-based obstacle avoidance of mobile robot using quantized spatial model. Am. J. Eng. Applied Sci., 2: 611-619. DOI: 10.3844/ajeassp.2009.611.619

Ong, A.T., A. Mustapha, Z.B. Ibrahim, S. Ramli and B.C. Eong, 2015. Real-time artificial inspection system for the classification of PCB flux defects. Am. J. Eng. Applied Sci., 8: 504-518. DOI: 10.3844/ajeassp.2015.504.518

Opafunso, Z.O., I.I. Ozigis and I.A. Adetunde, 2009. Pneumatic and hydraulic systems in coal fluidized bed combustor. Am. J. Eng. Applied Sci., 2: 88-95. DOI: 10.3844/ajeassp.2009.88.95

Orlando, N. and E. Benvenuti, 2016. Advanced XFEM simulation of pull-out and debonding of steel bars and FRP-reinforcements in concrete beams. Am. J. Eng. Applied Sci., 9: 746-754. DOI: 10.3844/ajeassp.2016.746.754

Pannirselvam, N., P.N. Raghunath and K. Suguna, 2008. Neural network for performance of glass fibre reinforced polymer plated RC beams. Am. J. Eng. Applied Sci., 1: 82-88. DOI: 10.3844/ajeassp.2008.82.88

Pattanasethanon, S., 2010. The solar tracking system by using digital solar position sensor. Am. J. Eng. Applied Sci., 3: 678-682. DOI: 10.3844/ajeassp.2010.678.682

Pérez-de León, G., V.E. Lamberti, R.D. Seals, T.M. Abu-Lebdeh and S.A. Hamoush, 2016. Gas atomization of molten metal: Part I. Numerical modeling conception. Am. J. Eng. Applied Sci., 9: 303-322. DOI: 10.3844/ajeassp.2016.303.322

Padula, F. and V. Perdereau, 2013. An on-line path planner for industrial manipulators. Int. J. Adv. Robotic Sys. DOI: 10.5772/55063

Perumal, S. and N. Jawahar, 2013. Automated trajectory planner of industrial robot for pick-and-place task. IJARS. DOI: 10.5772/53940

Petrescu, F. and R. Petrescu, 1995a. Contributions to the optimization of the polynomial motion laws of the stick from the internal combustion engine distribution mechanism. Bucharest, 1: 249-256.

Petrescu, F. and R. Petrescu, 1995b. Contributions to the synthesis of internal combustion engine distribution mechanisms. Bucharest, 1: 257-264.

Petrescu, F. and R. Petrescu, 1997a. Dynamics of cam mechanisms (exemplified on the classic distribution mechanism). Bucharest, 3: 353-358.

Petrescu, F. and R. Petrescu, 1997b. Contributions to the synthesis of the distribution mechanisms of internal combustion engines with a Cartesian coordinate method. Bucharest, 3: 359-364.

Petrescu, F. and R. Petrescu, 1997c. Contributions to maximizing polynomial laws for the active stroke of the distribution mechanism from internal combustion engines. Bucharest, 3: 365-370.

Petrescu, F. and R. Petrescu, 2000a. Synthesis of distribution mechanisms by the rectangular (Cartesian) coordinate method. Proceedings of the 8th National Conference on International Participation, (CIP’00), Craiova, Romania, pp: 297-302.

Petrescu, F. and R. Petrescu, 2000b. The design (synthesis) of cams using the polar coordinate method (triangle method). Proceedings of the 8th National Conference on International Participation, (CIP’00), Craiova, Romania, pp: 291-296.

Petrescu, F. and R. Petrescu, 2002a. Motion laws for cams. Proceedings of the International Computer Assisted Design, National Symposium with Participation, (SNP’02), Braşov, pp: 321-326.

Petrescu, F. and R. Petrescu, 2002b. Camshaft dynamics elements. Proceedings of the International Computer Assisted Design, National Participation Symposium, (SNP’02), Braşov, pp: 327-332.

Petrescu, F. and R. Petrescu, 2003. Some elements regarding the improvement of the engine design. Proceedings of the National Symposium, Descriptive Geometry, Technical Graphics and Design, (GTD’03), Braşov, pp: 353-358.

Petrescu, F. and R. Petrescu, 2005a. The cam design for a better efficiency. Proceedings of the International Conference on Engineering Graphics and Design, (EGD’05), Bucharest, pp: 245-248.

Petrescu, F. and R. Petrescu, 2005b. Contributions at the dynamics of cams. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’05), Bucharest, Romania, pp: 123-128.

Petrescu, F. and R. Petrescu, 2005c. Determining the dynamic efficiency of cams. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’05), Bucharest, Romania, pp: 129-134.

Petrescu, F. and R. Petrescu, 2005d. An original internal combustion engine. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’05), Bucharest, Romania, pp: 135-140.

Petrescu, F. and R. Petrescu, 2005e. Determining the mechanical efficiency of Otto engine’s mechanism. Proceedings of the 9th IFToMM International Symposium on Theory of Machines and Mechanisms, (TMM’05), Bucharest, Romania, pp: 141-146.
Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017a. Unmanned helicopters. J. Aircraft Spacecraft Technol., 1: 241-248. DOI: 10.3844/jastsp.2017.241.248

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017ac. Project HARP. J. Aircraft Spacecraft Technol., 1: 249-257. DOI: 10.3844/jastsp.2017.249.257

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017ad. Presentation of Romanian engineers who contributed to the development of global aeronautics-part I. J. Aircraft Spacecraft Technol., 1: 258-271. DOI: 10.3844/jastsp.2017.258.271

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017ae. A first-class ticket to the planet mars, please. J. Aircraft Spacecraft Technol., 1: 272-281. DOI: 10.3844/jastsp.2017.272.281

Petrescu, R.V., R. Aversa, A. Apicella, M.M. Mirsayar and S. Kozaïtis et al., 2018a. NASA started a propeller set on board voyager 1 after 37 years of break. Am. J. Eng. Applied Sci., 11: 66-77. DOI: 10.3844/ajeassp.2018.66.77

Petrescu, R.V., R. Aversa, A. Apicella, M.M. Mirsayar and S. Kozaïtis et al., 2018b. There is life on mars? Am. J. Eng. Applied Sci., 11: 78-91. DOI: 10.3844/ajeassp.2018.78.91

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018c. Friendly environmental transport. Am. J. Eng. Applied Sci., 11: 154-165. DOI: 10.3844/ajeassp.2018.154.165

Petrescu, R.V., R. Aversa, B. Akash, T.M. Abu-Lebdeh and A. Apicella et al., 2018d. Buses running on gas. Am. J. Eng. Applied Sci., 11: 186-201. DOI: 10.3844/ajeassp.2018.186.201

Petrescu, R.V., R. Aversa, B. Akash, T.M. Abu-Lebdeh and A. Apicella et al., 2018e. Some aspects of the structure of planar mechanisms. Am. J. Eng. Applied Sci., 11: 245-259. DOI: 10.3844/ajeassp.2018.245.259

Petrescu, R.V., R. Aversa, T.M. Abu-Lebdeh, A. Apicella and F.I.T. Petrescu, 2018f. The forces of a simple carrier manipulator. Am. J. Eng. Applied Sci., 11: 260-272. DOI: 10.3844/ajeassp.2018.260.272

Petrescu, R.V., R. Aversa, T.M. Abu-Lebdeh, A. Apicella and F.I.T. Petrescu, 2018g. The dynamics of the otto engine. Am. J. Eng. Applied Sci., 11: 273-287. DOI: 10.3844/ajeassp.2018.273.287

Petrescu, R.V., R. Aversa, T.M. Abu-Lebdeh, A. Apicella and F.I.T. Petrescu, 2018h. NASA satellites help us to quickly detect forest fires. Am. J. Eng. Applied Sci., 11: 288-296. DOI: 10.3844/ajeassp.2018.288.296

Petrescu, R.V., R. Aversa, T.M. Abu-Lebdeh, A. Apicella and F.I.T. Petrescu, 2018i. Kinematics of a mechanism with a triad. Am. J. Eng. Applied Sci., 11: 297-308. DOI: 10.3844/ajeassp.2018.297.308

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018j. Romanian engineering "on the wings of the wind". J. Aircraft Spacecraft Technol., 2: 1-18. DOI: 10.3844/jastsp.2018.1.18

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018k. NASA Data used to discover eighth planet circling distant star. J. Aircraft Spacecraft Technol., 2: 19-30. DOI: 10.3844/jastsp.2018.19.30

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018l. NASA has found the most distant black hole. J. Aircraft Spacecraft Technol., 2: 31-39. DOI: 10.3844/jastsp.2018.31.39

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018m. Nasa selects concepts for a new mission to titan, the moon of saturn. J. Aircraft Spacecraft Technol., 2: 40-52. DOI: 10.3844/jastsp.2018.40.52

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018n. NASA sees first in 2018 the direct proof of ozone hole recovery. J. Aircraft Spacecraft Technol., 2: 53-64. DOI: 10.3844/jastsp.2018.53.64

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018o. NASA Data used to discover eighth planet circling distant star. J. Aircraft Spacecraft Technol., 2: 66-77. DOI: 10.3844/ajeassp.2018.66.77

Petrescu, R.V., R. Aversa, A. Apicella and F.I.T. Petrescu, 2018p. Friendly environmental transport. Am. J. Eng. Applied Sci., 11: 78-91. DOI: 10.3844/ajeassp.2018.78.91
Raptis, K.G., G.A. Papadopoulos, T.N. Costopoulos and A.D. Tsalakos, 2011. Experimental study of load sharing in roller-bearing contact by caustics and photoelasticity. Am. J. Eng. Applied Sci., 4: 294-300. DOI: 10.3844/ajeassp.2011.294.300

Rama, G., D. Marinovic and M. Zehn, 2016. Efficient co-rotational 3-node shell element. Am. J. Eng. Applied Sci., 9: 420-431. DOI: 10.3844/ajeassp.2016.420.431

Rea, P. and E. Ottaviano, 2016. Analysis and mechanical design solutions for sit-to-stand assisting devices. Am. J. Eng. Applied Sci., 9: 1134-1143. DOI: 10.3844/ajeassp.2016.1134.1143

Rhode-Barbarigos, L., V. Charpentier, S. Adriaenssens and O. Baverel, 2015. Dialectic form finding of structurally integrated adaptive structures. Am. J. Eng. Applied Sci., 8: 443-454. DOI: 10.3844/ajeassp.2015.443.454

Riccio, A., U. Caruso, A. Raimondo and A. Sellitto, 2016a. Robustness of XFEM method for the simulation of cracks propagation in fracture mechanics problems. Am. J. Eng. Applied Sci., 9: 599-610. DOI: 10.3844/ajeassp.2016.599.610

Riccio, A., R. Cristiano and S. Saputo, 2016b. A brief introduction to the bird strike numerical simulation. Am. J. Eng. Applied Sci., 9: 946-950. DOI: 10.3844/ajeassp.2016.946.950

Rich, F. and M.A. Badar, 2016. Statistical analysis of auto dilution Vs manual dilution process in inductively coupled plasma spectrometer tests. Am. J. Eng. Applied Sci., 9: 611-624. DOI: 10.3844/ajeassp.2016.611.624

Rohit, K. and S. Dixit, 2016. Mechanical properties of waste Biaxially Oriented Polypropylene metallized films (BOPP), LDPE: LDPE films with sisal fibres. Am. J. Eng. Applied Sci., 9: 913-920. DOI: 10.3844/ajeassp.2016.913.920

Rulkov, N.F., A.M. Hunt, P.N. Rulkov and A.G. Maksimov, 2016. Quantization of map-based neuronal model for embedded simulations of neurobiological networks in real-time. Am. J. Eng. Applied Sci., 9: 973-984. DOI: 10.3844/ajeassp.2016.973.984

Saikia, A. and N. Karak, 2016. Castor oil based epoxy/clay nanocomposite for advanced applications. Am. J. Eng. Applied Sci., 9: 31-40. DOI: 10.3844/ajeassp.2016.31.40

Sallami, A., N. Zanzouri and M. Ksouri, 2016. Robust diagnosis of a DC motor by bond graph approach. Am. J. Eng. Applied Sci., 9: 432-438. DOI: 10.3844/ajeassp.2016.432.438

Samantaray, K.S., S. Sahoo and C.S. Rout, 2016. Hydrothermal synthesis of CuWO4-reduced graphene oxide hybrids and supercapacitor application. Am. J. Eng. Applied Sci., 9: 584-590. DOI: 10.3844/ajeassp.2016.584.590

Ramos, H.P., A.D. Baniotopoulos, S. Sotiropoulos, S. Stavridou, N., K. Karak, and E. Rea, 2016. Comparison in cover media under fatigue loading: Finite element analysis and experimental study. Am. J. Eng. Applied Sci., 8: 443-454. DOI: 10.3844/ajeassp.2016.443.454

Rohit, K. and S. Dixit, 2016. Mechanical properties of waste Biaxially Oriented Polypropylene metallized films (BOPP), LDPE: LDPE films with sisal fibres. Am. J. Eng. Applied Sci., 9: 913-920. DOI: 10.3844/ajeassp.2016.913.920

Rulkov, N.F., A.M. Hunt, P.N. Rulkov and A.G. Maksimov, 2016. Quantization of map-based neuronal model for embedded simulations of neurobiological networks in real-time. Am. J. Eng. Applied Sci., 9: 973-984. DOI: 10.3844/ajeassp.2016.973.984

Saikia, A. and N. Karak, 2016. Castor oil based epoxy/clay nanocomposite for advanced applications. Am. J. Eng. Applied Sci., 9: 31-40. DOI: 10.3844/ajeassp.2016.31.40

Sallami, A., N. Zanzouri and M. Ksouri, 2016. Robust diagnosis of a DC motor by bond graph approach. Am. J. Eng. Applied Sci., 9: 432-438. DOI: 10.3844/ajeassp.2016.432.438

Samantaray, K.S., S. Sahoo and C.S. Rout, 2016. Hydrothermal synthesis of CuWO4-reduced graphene oxide hybrids and supercapacitor application. Am. J. Eng. Applied Sci., 9: 584-590. DOI: 10.3844/ajeassp.2016.584.590

Santos, F.A. and C. Bedon, 2016. Preliminary experimental and finite-element numerical assessment of the structural performance of SMA-reinforced GFRP systems. Am. J. Eng. Applied Sci., 9: 692-701. DOI: 10.3844/ajeassp.2016.692.701

Sava, I., 1970. Contributions to dynamics and optimization of income mechanism synthesis. Ph.D. Thesis, I.P.B.

Semin, A.R. Ismail and R.A. Bakar, 2009a. Combustion temperature effect of diesel engine convert to compressed natural gas engine. Am. J. Eng. Applied Sci., 2: 212-216. DOI: 10.3844/ajeassp.2009.212.216

Semin, A.R. Ismail and R.A. Bakar, 2009b. Effect of diesel engine converted to sequential port injection compressed natural gas engine on the cylinder pressure Vs crank angle in variation engine speeds. Am. J. Eng. Applied Sci., 2: 154-159. DOI: 10.3844/ajeassp.2009.154.159

Semin, S., A.R. Ismail and R.A. Bakar, 2009c. Diesel engine convert to port injection CNG engine using gaseous injector nozzle multi holes geometries improvement: A review. Am. J. Eng. Applied Sci., 2: 268-278. DOI: 10.3844/ajeassp.2009.268.278

Semin and R.A. Bakar, 2008. A technical review of compressed natural gas as an alternative fuel for internal combustion engines. Am. J. Eng. Applied Sci., 1: 302-311. DOI: 10.3844/ajeassp.2008.302.311

Sepúlveda, J.A.M., 2016. Outlook of municipal solid waste in Bogota (Colombia). Am. J. Eng. Applied Sci., 9: 477-483. DOI: 10.3844/ajeassp.2016.477.483

Serebrennikov, A., D. Serebrennikov and Z. Hakimov, 2016. Polyethylene pipeline bending stresses at an installation. Am. J. Eng. Applied Sci., 9: 350-355. DOI: 10.3844/ajeassp.2016.350.355

Shannugam, K., 2016. Flow dynamic behavior of fish oil/silver nitrate solution in mini-channel, effect of alkane addition on flow pattern and interfacial tension. Am. J. Eng. Applied Sci., 9: 236-250. DOI: 10.3844/ajeassp.2016.236.250

Shruti, 2016. Comparison in cover media under stagnography: Digital media by hide and seek approach. Am. J. Eng. Applied Sci., 9: 297-302. DOI: 10.3844/ajeassp.2016.297.302

Stavridou, N., E. Efthymiou and C.C. Baniotopoulos, 2015a. Welded connections of wind turbine towers under fatigue loading: Finite element analysis and comparative study. Am. J. Eng. Applied Sci., 8: 489-503. DOI: 10.3844/ajeassp.2015.489.503

Stavridou, N., E. Efthymiou and C.C. Baniotopoulos, 2015b. Verification of anchoring in foundations of wind turbine towers. Am. J. Eng. Applied Sci., 8: 717-729. DOI: 10.3844/ajeassp.2015.717.729

Savin, A.D. Tsolakis, 2011. Experimental study of load sharing in roller-bearing contact by caustics and photoelasticity. Am. J. Eng. Applied Sci., 4: 294-300.

Serrano, A., T. Valverde and P. Ortega, 2016. Characterization of a high performance carbon fiber reinforced plastic developed for vehicle applications. Am. J. Eng. Applied Sci., 9: 477-483.

Seyfried, J., 2016. Design and analysis of a new type of high-speed wind turbine blade. Am. J. Eng. Applied Sci., 9: 259-268.

Seyfried, J., 2016. Design and analysis of a new type of high-speed wind turbine blade. Am. J. Eng. Applied Sci., 9: 259-268.

Shen, L., 2016. An experimental investigation of the effect of blade angle on the performance of a wind turbine. Am. J. Eng. Applied Sci., 9: 259-268.
Suarez, L., T.M. Abu-Lebedeh, M. Picornell and S.A. Hamoush, 2016. Investigating the role of fly ash and silica fume in the cement hydration process. Am. J. Eng. Applied Sci., 9: 134-145. DOI: 10.3844/ajeassp.2016.134.145

Syahbullah, O.I. and N. Sinaga, 2016. Optimization and prediction of motorcycle injection system performance with feed-forward back-propagation method Artificial Neural Network (ANN). Am. J. Eng. Applied Sci., 9: 222-235. DOI: 10.3844/ajeassp.2016.222.235

Sylvester, O., I. Bibobra and O.N. Ogbon, 2015a. Well test and PTA for reservoir characterization of key properties. Am. J. Eng. Applied Sci., 8: 638-647. DOI: 10.3844/ajeassp.2015.638.647

Sylvester, O., I. Bibobra and O. Augustina, 2015b. Report on the evaluation of Ugua J2 and J3 reservoir performance. Am. J. Eng. Applied Sci., 8: 678-688. DOI: 10.3844/ajeassp.2015.678.688

Taher, S.A., R. Hematti and M. Nemati, 2008. Comparison of different control strategies in GA-based optimized UPFC controller in electric power systems. Am. J. Eng. Applied Sci., 1: 45-52. DOI: 10.3844/ajeassp.2008.45.52

Takeuchi, T., Y. Kinouchi, R. Matsui and T. Ogawa, 2015. Optimal arrangement of energy-dissipating members for seismic retrofitting of truss structures. Am. J. Eng. Applied Sci., 8: 455-464. DOI: 10.3844/ajeassp.2015.455.464

Tesar, D. and G.K. Matthew, 1974. The Design of Modeled Cam Systems. In: Cams and Cam Mechanisms, Rees Jones, J. (Ed.), MEP, London and Birmingham, Alabama.

Theansuwan, W. and K. Triratanasirichai, 2011. The biodiesel production from roast Thai sausage oil by transesterification reaction. Am. J. Eng. Applied Sci., 4: 130-132. DOI: 10.3844/ajeassp.2011.130.132

Thongwan, T., A. Kangrang and S. Homwuttiwong, 2011. An estimation of rainfall using fuzzy set-genetic algorithms model. Am. J. Eng. Applied Sci., 4: 77-81. DOI: 10.3844/ajeassp.2011.77.81

Tourab, W., A. Babouri and M. Nemamcha, 2011. Experimental study of electromagnetic environment in the vicinity of high voltage lines. Am. J. Eng. Applied Sci., 4: 209-213. DOI: 10.3844/ajeassp.2011.209.213

Tsoulakis, A.D. and K.G. Raptis, 2011. Comparison of maximum gear-tooth operating bending stresses derived from niemann's analytical procedure and the finite element method. Am. J. Eng. Applied Sci., 4: 350-354. DOI: 10.3844/ajeassp.2011.350.354

Vernardos, S.M. and C.J. Gantes, 2015. Cross-section optimization of sandwich-type cylindrical wind turbine towers. Am. J. Eng. Applied Sci., 8: 471-480. DOI: 10.3844/ajeassp.2015.471.480

Wang, L., T. Liu, Y. Zhang and X. Yuan, 2016. A methodology for continuous evaluation of cloud resiliency. Am. J. Eng. Applied Sci., 9: 264-273. DOI: 10.3844/ajeassp.2016.264.273

Wang, L., G. Wang and C.A. Alexander, 2015. Confluenes among big data, finite element analysis and high-performance computing. Am. J. Eng. Applied Sci., 8: 767-774. DOI: 10.3844/ajeassp.2015.767.774

Wang, J. and Y. Yagi, 2016. Fragment-based visual tracking with multiple representations. Am. J. Eng. Applied Sci., 9: 187-194. DOI: 10.3844/ajeassp.2016.187.194

Waters, C., S. Ajinola and M. Saleh, 2016. Dissolution sintering technique to create porous copper with sodium chloride using polyvinyl alcohol solution through powder metallurgy. Am. J. Eng. Applied Sci. 9: 155-165. DOI: 10.3844/ajeassp.2016.155.165

Wessels, L. and H. Raad, 2016. Recent advances in point of care diagnostic tools: A review. Am. J. Eng. Applied Sci., 9: 1088-1095. DOI: 10.3844/ajeassp.2016.1088.1095

Wiederrich, J.L. and B. Roth, 1974. Design of Low Vibration Cam Profiles. In: Cams and Cam Mechanisms, Rees Jones, J. (Ed.), MEP, London and Birmingham, Alabama.

Yan, C., F. Gao and W. Guo, 2009. Coordinated kinematic modeling for motion planning of heavy-duty manipulators in an integrated open-die forging center. J. Eng. Manufacture, 223: 1299-1313.

Yang, M.F. and Y. Lin, 2015. Process is unreliable and quantity discounts supply chain integration inventory model. Am. J. Eng. Applied Sci., 8: 602-610. DOI: 10.3844/ajeassp.2015.602.610

Yeargin, R., R. Ramey and C. Waters, 2016. Porosity analysis in porous brass using dual approaches. Am. J. Eng. Applied Sci., 9: 91-97. DOI: 10.3844/ajeassp.2016.91.97

You, M., X. Huang, M. Lin, Q. Tong and X. Li et al., 2016. Preparation of LiCoMnO4 assisted by hydrothermal approach and its electrochemical performance. Am. J. Eng. Applied Sci., 9: 396-405. DOI: 10.3844/ajeassp.2016.396.405

Zeferino, R.S., J.A.R. Ramón, E. de Anda Reyes, R.S. González and U. Pal, 2016. Large scale synthesis of ZnO nanostructures of different morphologies through solvent-free mechanochemical synthesis and their application in photocatalytic dye degradation. Am. J. Eng. Applied Sci., 9: 41-52. DOI: 10.3844/ajeassp.2016.41.52

Zhao, K., H. Wang, G.L. Chen, Z.Q. Lin and Y.B. He, 2010. Compliance process analysis for forging manipulator. J. Mech. Eng., 46: 27-34.
Zhao, B., 2013. Identification of multi-cracks in the gate rotor shaft based on the wavelet finite element method. Am. J. Eng. Applied Sci., 6: 309-319. DOI: 10.3844/ajeassp.2013.309.319
Zheng, H. and S. Li, 2016. Fast and robust maximum power point tracking for solar photovoltaic systems. Am. J. Eng. Applied Sci., 9: 755-769. DOI: 10.3844/ajeassp.2016.755.769
Zotos, I.S. and T.N. Costopoulos, 2009. On the use of rolling element bearings' models in Precision maintenance. Am. J. Eng. Applied Sci., 2: 344-352. DOI: 10.3844/ajeassp.2009.344.352
Zulkifi, R., K. Sopian, S. Abdullah and M.S. Takriff, 2008. Effect of pulsating circular hot air jet frequencies on local and average nusselt number. Am. J. Eng. Applied Sci., 1: 57-61. DOI: 10.3844/ajeassp.2008.57.61
Zulkifi, R., K. Sopian, S. Abdullah and M.S. Takriff, 2009. Experimental study of flow structures of circular pulsating air jet. Am. J. Eng. Applied Sci., 2: 171-175. DOI: 10.3844/ajeassp.2009.171.175
Zurfi, A. and J. Zhang, 2016a. Model identification and wall-plug efficiency measurement of white LED modules. Am. J. Eng. Applied Sci., 9: 412-419. DOI: 10.3844/ajeassp.2016.412.419
Zurfi, A. and J. Zhang, 2016b. Exploitation of battery energy storage in load frequency control-a literature survey. Am. J. Eng. Applied Sci., 9: 1173-1188. DOI: 10.3844/ajeassp.2016.1173.1188

Source of Figures
Petrescu and Petrescu, 2015a; 2015b; 2015d; Aversa et al., 2017b.

Nomenclature

$c_1$
c_2
c_3$
l_1, l_2, l_3$
$A-L$
$A, B, K, F$
$\phi_1, \phi_3, \phi_6, \phi_8, \phi_{10}$
$\alpha, \gamma$
$x_B, y_B, x_K, y_K, x_F, y_F$
$\beta, 0, \phi_4$
$\phi$
$F_{m_1}, F_{m_2}, F_{m_3}$

lifting hydraulic cylinder
the buffer hydraulic cylinder
leaning hydraulic cylinder
variable lengths
linkages
fixed linkages
variable angles
constant lengths
constant coordinates
constant angles
an angle which must be maintained constant ($\phi = \pi - \theta$) to keep permanently the segment GM horizontally
the driving forces of the mechanism.