Efficiency assessment of different high-speed tracked vehicle hybrid powertrain conceptions

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Abstract:

Introduction/purpose: Increased development of hybrid powertrains during the last decade brought high-speed tracked vehicles into the same spotlight as commercial and passenger hybrid vehicles. There are several hybrid powertrain conceptions for high-speed tracked vehicles that are mainly researched, but there is still no clear conclusion which conception is the most efficient. The main obstacle for more intense research is the increased difficulty to produce a battery storage system which provides both high power density and protection and shock resistance. However, there is a certain number of research studies and prototypes developed from simulation models that show satisfactory performance for both asymmetric and symmetric hybrid powertrain conceptions.

Methods: The developed and verified hybrid simulation model is improved in terms of command signal unit, so that the powertrain and electric motors in the auxiliary drive can easily be operated in the asymmetric hybrid working regime and the symmetric hybrid working regime. The main goal is to simulate specific working regimes where the asymmetric and symmetric hybrid powertrain performance and energy efficiency can be assessed in order to find the most efficient powertrain conception.

Results: The results indicate that the asymmetric hybrid powertrain will have less overall power consumption and a more simple control algorithm, because of controlling just one electric motor. For the same overall power, the asymmetric hybrid powertrain has a smaller turning radius, which is satisfactory. When driven in full power, the symmetric hybrid powertrain will have lower turning radius and better manoeuvrability, but serious increase of power consumption.

Conclusion: The asymmetric drive has clearly better power efficiency, but the symmetric drive has an advantage of maximum performance. Performing a pivot turn (around the vertical axis), and making a turn without reducing the vehicle velocity is of great importance, especially considering the most common special purpose of this vehicle and manoeuvring in challenging terrain conditions.

Key words: high-speed tracked vehicles, hybrid powertrains, turning process analysis, power balance analysis.

Introduction

Research and development of hybrid powertrains brought a new perspective on commercial and passenger transportation, but also on military and special purpose application (Kramer & Parker, 2011; Taira et al, 2017; Ramesh, 2017). High-speed tracked vehicle powertrains were also rapidly brought to attention of researchers and renowned manufacturers, as an almost infinite course for research of powertrain hybridization potential.

Unlike commercial vehicle hybrid powertrains, where basic interest in hybrid powertrain development lies in ecology and fuel consumption reduction, the core value for development of hybrid powertrains for high-speed tracked vehicles is performance enhancement and improving energy efficiency (Dalsjø, 2008; Walker et al, 2015; Salisa et al, 2011). The special purpose and utilization of high-speed tracked vehicles demand robust powertrain systems, due to rough terrain and other conditions which require optimal balance between performance and energy efficiency (Randive et al, 2021; Sabri et al, 2016). This has generated interest in developing powertrain conceptions which provide optimal performance and satisfy demands that stand before these vehicles, by incorporating electric drive machines in the powertrain system, along with ICE. Apart from propulsion, high-speed tracked vehicles have various specialized systems which have moderate to high energy consumption requirements from the ICE. This is also a significant argument to search for an alternative power source solution, with increased potential of storing and producing, as well as managing the required energy.

Even though there are numerous arguments for the implementation of hybrid high-speed tracked vehicle powertrains, only a few prototypes have ever been made. One of the main obstacles is the development of energy source and storage, i.e., batteries, which have the capacity to provide energy required for the expected operation conditions of the vehicle (Bhatia, 2015; Piancastelli et al, 2023; Rizzo, 2014).

This paper presents the continuation of the research into hybrid powertrains for specific high-speed tracked vehicles, with the goal of designing the most efficient hybrid conception and powertrain working regime. The assessment of energy efficiency throughout different hybrid powertrain configurations is a complex challenge, because these systems are influenced by numerous variables such as terrain and atmospheric conditions, driving regimes and specific powertrain configurations.

The assessment of energy efficiency, as well as performance improvement, is conducted on a previously developed and verified simulation model, for the most demanding powertrain working regimes, from the power balance point of view, especially during the turning process (Ponorac & Blagojević, 2023). The hybrid powertrain model is developed so it can work as both an asymmetric and symmetric turning mechanism. Based on these two conceptions, the vehicle is analyzed in different turning scenarios, as well as full electric and hybrid movement scenarios, in order to identify the most efficient working regime of the hybrid powertrain.

Method

Replacing the friction clutches with electric motors in the auxiliary drive of the subject vehicle powertrain, as shown in Figure 1, has led to essential improvement because the hybrid powertrain can work in various working regimes, depending on the user's demand. The mentioned upgrade allows the powertrain system, which incorporates the turning mechanism, to operate both as an asymmetric and a symmetric vehicle turning mechanism, depending on the electric motor engagement scheme and the direction of electric motor shaft rotation.

By engaging the electric motor on the inner track, the powertrain output shaft, i.e., the inner track drive shaft angular velocity is reduced. The vehicle center of mass velocity is also reduced, while the outer track maintains the rectilinear movement velocity. The described working regime represents a classic case of an asymmetric vehicle turning mechanism.

If both electric motors are engaged, with the angular velocity of the same intensity, but different directions, the outer track velocity is increased proportionally to the inner track velocity decrease while the vehicle center of mass velocity is maintained. The described working regime represents a classic case of a symmetric vehicle turning mechanism (Muždeka & Perić, 2012).

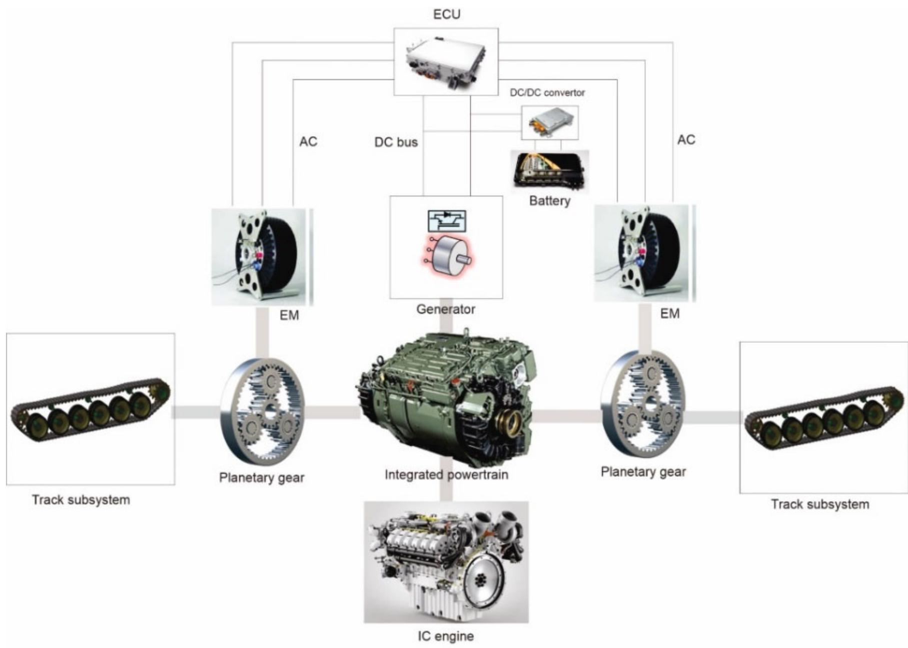

Figure 1 – Hybrid powertrain conception scheme

In a general case, the overall power required to achieve the turning manoeuver must be sufficient to overcome moving resistance, internal powertrain resistance and resistance in the turning mechanism (Muždeka, 2012)

that is:

$$P_{mz} = P_o + P_{tr} + P_{sz} \tag{1}$$

where:

- P_o is the power required to overcome moving resistance,
- P_{tr} is the power required to overcome internal powertrain resistance, and
- P_{sz} is the power lost in the turning mechanism elements.

The power lost in the turning mechanism is not taken into consideration because, in the specific case, this power is not delivered from the ICE, but from the electric motors. Also, since there are friction clutches, there are no slipping losses, so the power lost in the turning mechanism is assessed by the electric motor efficiency. Since the electric motors are used in the most efficient working regimes, the overall power lost in the turning mechanism is insignificant.

The power required to overcome the internal resistance in the powertrain is taken into account through the efficiency of the powertrain components.

The power required to overcome moving resistance depends on the turning mechanism conception.

In the case of the asymmetric turning mechanism, the power required to overcome moving resistance is:

$$P_o = F_2 v_0 - F_1 v_0 \frac{R-\frac{B}{2}}{R+\frac{B}{2}} = \frac{F_2\left(R+\frac{B}{2}\right)-F_1\left(R-\frac{B}{2}\right)}{\left(R+\frac{B}{2}\right)} v_0 \quad (2)$$

In order to make a symmetric turn, the ICE and electric motors need to supply greater power than the asymmetric turning mechanism, because the vehicle keeps the center of mass velocity by increasing the velocity of the outer track and decreasing the velocity of the inner track. This can be concluded from (3):

$$P_o = F_2 v_0 \frac{R+\frac{B}{2}}{R} - F_1 v_0 \frac{R-\frac{B}{2}}{R} = \frac{F_2\left(R+\frac{B}{2}\right)-F_1\left(R-\frac{B}{2}\right)}{R} v_0 \quad (3)$$

where:

- F2, F1 are the forces on the outer and inner track, respectively,
- v_0 is the vehicle center of mass velocity during rectilinear movement,
- R is the vehicle turning radius, and
- B is the track width.

Efficiency assessment

Energy efficiency

In order to asses and compare the energy efficiency of the symmetric and asymmetric hybrid powertrains, the simulation has to be set up in such a manner that the same turning conditions are provided, i.e., the same turning radius and resistance. The developed hybrid simulation model is verified in the previous research papers, by comparing the simulation results with the real vehicle simulation model and the experimental testing results (Ponorac et al, 2022).

The simulation starts from a steady state for both hybrid powertrain conceptions, where the main vehicle brakes K1 and K2 are engaged. The simulation conditions are controlled from the corresponding input signal block, as shown in Figure 2 and Figure 3. By disengaging the brakes and applying throttle, the vehicle starts rectilinear movement. In both symmetric and asymmetric turning scenarios, the vehicle turning process starts at t≈4s.

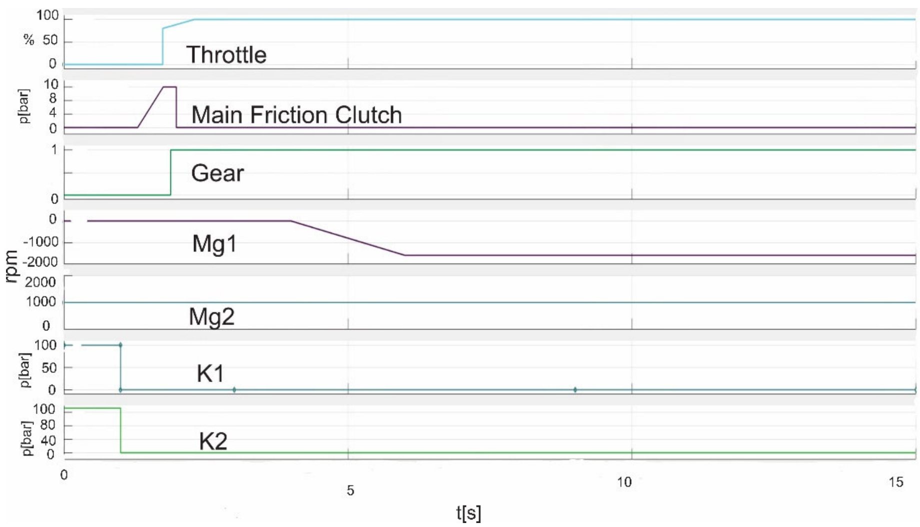

Figure 2 – Asymmetric hybrid powertrain model input signals

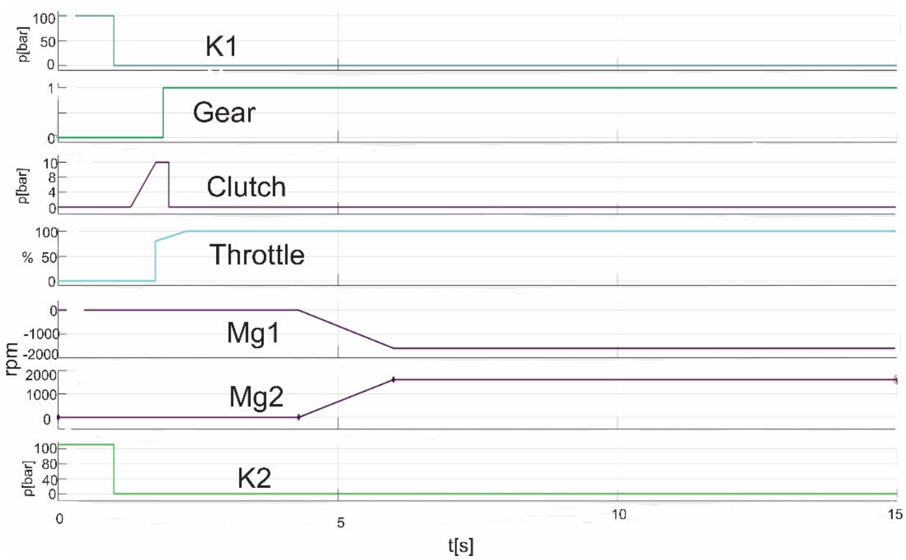

Figure 3 – Symmetric hybrid powertrain model input signals

The vehicle with the asymmetric turning mechanism starts the turning process by engaging the electric motor Mg1 on the inner track, as shown in Figure 2. The electric motor is engaged with n=1600 rpm.

The vehicle with the symmetric turning mechanism starts the turning process at the same moment, but in order to achieve the same turning radius, the electric motor on the inner track, labeled Mg1, is engaged with n=1100 rpm, while the electric motor on the outer track, Mg2, is engaged with the same rpm value but in the opposite direction, as shown in Figure 3.

Performance review

In order to assess the vehicle performance benefits for both developed conceptions, it is needed to provide equal energy consumption conditions. Different working principles of symmetric and asymmetric hybrid turning mechanisms make this a complicated task, so it will be divided in two scenarios.

The first scenario is assessing the turning process performance while the overall power consumption for both symmetric and asymmetric hybrid powertrains is equivalent. This means that the power provided by the ICE and the inner track electric motor in the asymmetric hybrid powertrain is equivalent to power provided by the ICE and the inner and outer track electric motors in the symmetric hybrid powertrain.

The second scenario includes assessing the turning process performance while the power delivered on the inner track is equivalent for both symmetric and asymmetric hybrid powertrains.

Results

Assessing the energy efficiency of symmetric and asymmetric hybrid powertrains of a high speed tracked vehicle requires equal turning conditions, i.e., the equivalent turning radius. Figure 4 shows the turning radius during the symmetric and asymmetric turning process.

Both symmetric and asymmetric hybrid powertrain vehicles achieve the requested turning radius R=3 m at t=6s.

In order to achieve the equal turning radius as the asymmetric hybrid powertrain, the symmetric hybrid powertrain engages the inner track electric motor with lower rpm, n=1100 rpm, but the same rpm is required on the outer track, as shown in Figure 5. In other words, the vehicle center of mass maintains its former velocity, while the inner and outer track velocities are decreased/increased. On the other hand, it is obvious that the outer track of the asymmetric hybrid powertrain maintains the rectilinear movement velocity, the center of mass and inner track velocities are decreased.

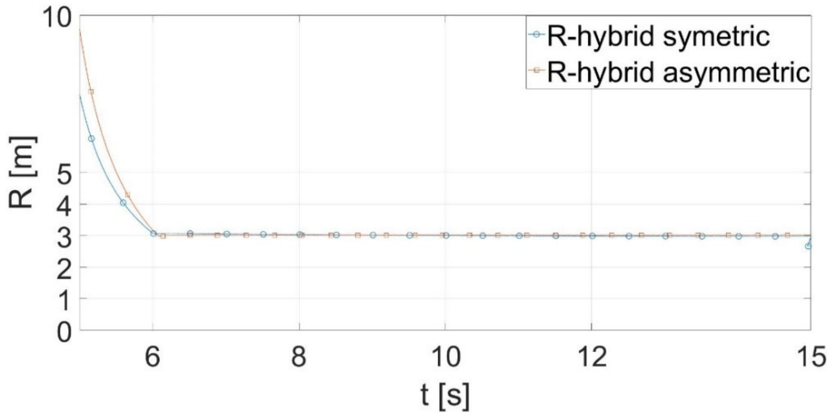

Figure 4 – Vehicle turning radius comparison- asymmetric vs symmetric

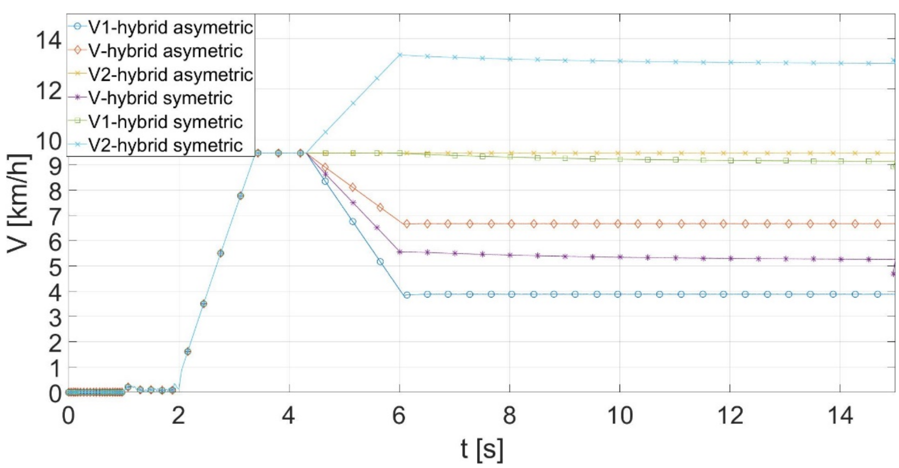

Figure 5 – Asymmetric vs symmetric hybrid vehicle velocities-equal turning radius

The power balance curve for the considered scenarios is shown in Figure 6. The overall power needed to achieve the required turning radius for asymmetric turning mechanism is Pasymmetric=84 kW. This power is supplied by the ICE Pice-hybrid asymmetric=41 kW, and the electric motor on the inner track PMG1-asymmetric=42 kW.

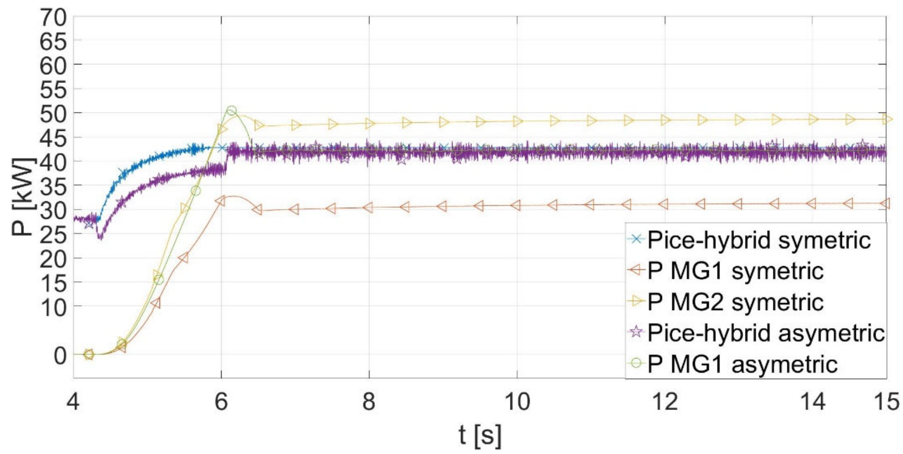

Figure 6 – Asymmetric vs symmetric hybrid powertrain power consumption-equal turning radius

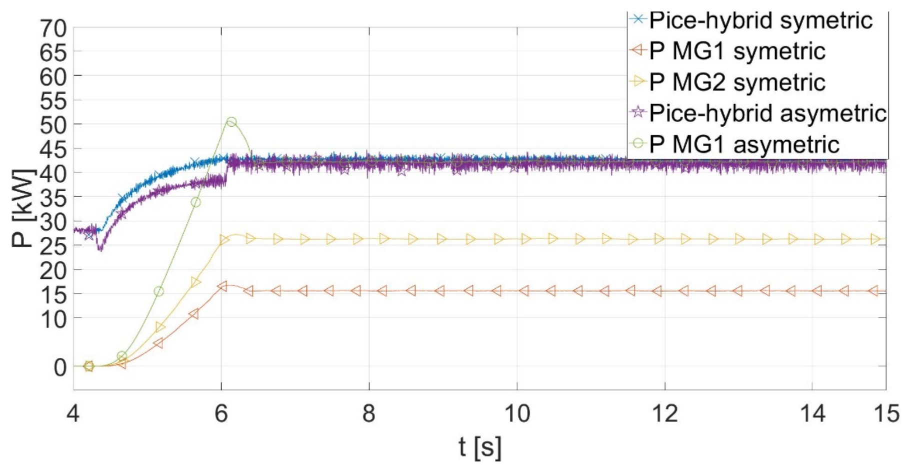

Figure 7 – Asymmetric vs symmetric hybrid powertrain power consumption-equal overall power

The symmetric hybrid powertrain requires less power on the inner track electric motor, PMG1-symmetric=30kW, but in order to maintain the vehicle velocity in turn, the power delivered from the outer track electric motor is PMG2-symmetric=48 kW. The ICE supplies the same power in both scenarios, 41 kW, so the overall power required for the requested turning radius is P-symmetric=118 kW. This means that the symmetric

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hybrid powertrain requires more overall power than the asymmetric hybrid powertrain for the same turning radius; therefore, in this turning scenario, the asymmetric powertrain consumes less energy.

When the overall power required for the turning process of both symmetric and asymmetric hybrid powertrains is equal, the power is distributed as shown in Figure 7.

As in the previous cases, the ICE power for both hybrid powertrain conceptions is equal, Pice asymmetric=Pice symmetric=41 kW. In order to achieve the requested overall power required for the turning process Pasymmetric=84 kW, the inner track electric motor of the asymmetric hybrid powertrain delivers the remaining P MG1 asymmetric=43 kW.

Since the overall power requested for the symmetric hybrid powertrain is also Psymmetric=84 kW, the remaining 43 kW are delivered from both electric motors, where PMG1 symmetric=15 kW and PMG2=26 kW. Even though the track velocities are symmetrically increased/decreased, the power consumption of the electric motors is not equal. This is because the turning resistance is not equal on both tracks.

When the overall power for both hybrid powertrains is equal, the turning radius for both hybrid powertrains change as shown in Figure 7. The asymmetric hybrid powertrain turns with a turning radius of R=3m, which is the same turning radius as the calculated turning radius of the real vehicle. However, the symmetric hybrid powertrain turns with a larger turning radius of Rsymmetric=5 m.

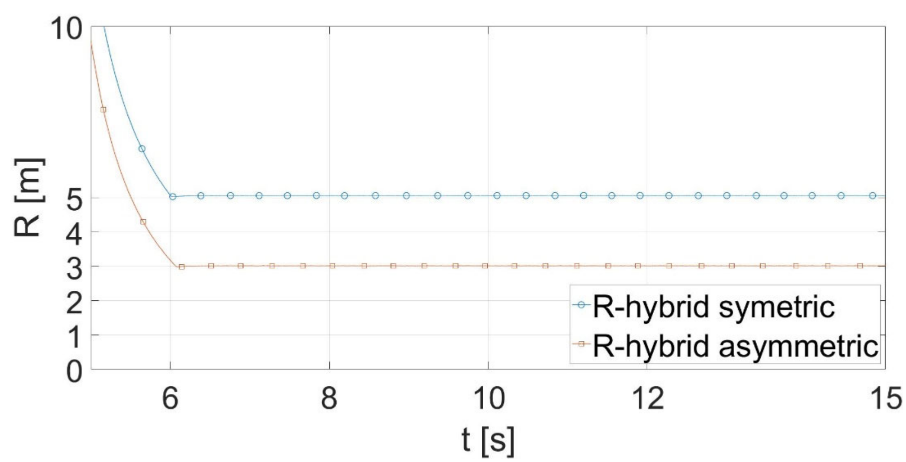

Figure 8 – Asymmetric vs symmetric hybrid powertrain turning radius-equal overall power

The track velocities, shown in Figure 9, confirm the obtained results and conclusions. With the same overall power consumption, the inner track velocity of the symmetric hybrid powertrain is significantly larger than in the asymmetric hybrid powertrain. The inner and outer tracks are driven by electric motors at n≈700 rpm. The vehicle center of mass maintains the rectilinear movement velocity, while the asymmetric hybrid vehicle center of mass velocity is near the velocity value of the symmetric hybrid inner track. In other words, the asymmetric hybrid vehicle turns with almost equal velocity as the symmetric hybrid vehicle inner track; thus the turn radius of the asymmetric hybrid powertrain vehicle is significantly lower.

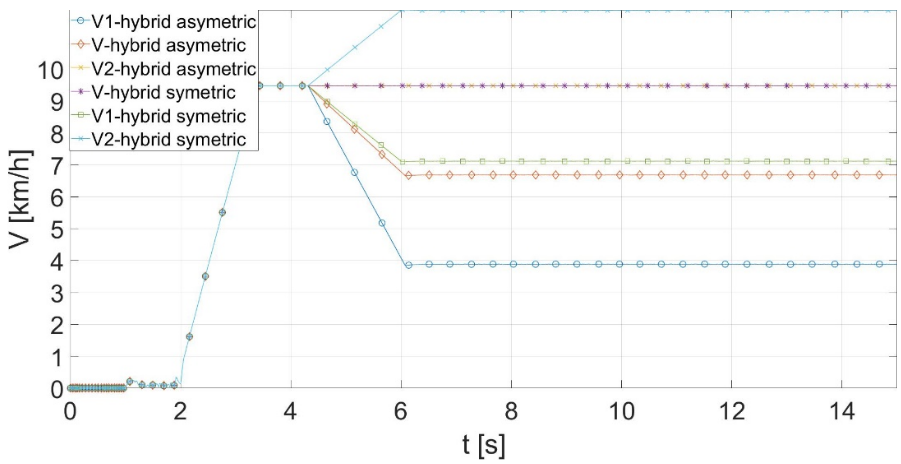

Figure 9 – Asymmetric vs symmetric hybrid powertrain vehicle velocities-equal overall power

When delivering equal power on the inner track of both hybrid powertrains, the inner track of both hybrid conceptions will have equal velocities, which is needed to assess the turning performance of the symmetric hybrid powertrain. The power balance curves are shown in Figure 10.

The asymmetric powertrain has the same power distribution as in the previous cases. The ICE delivers 41 kW and the inner track electric motor delivers 43 kW, making the overall power requested for the turning process P asymmetric =84 kW.

If the tracks of the symmetric hybrid powertrain are driven with at n=1600 rpm, which is equal to the rotational speed of the asymmetric hybrid inner track electric motor, the power delivered to the inner track of both hybrid conceptions will be equal, i.e., PMG1 symmetric=43 kW.

Meanwhile, the power on the outer track is significantly higher and is PMG2 symmetric=65 kW, which makes the overall power requirement for symmetric turn Psymmetric≈149 kW.

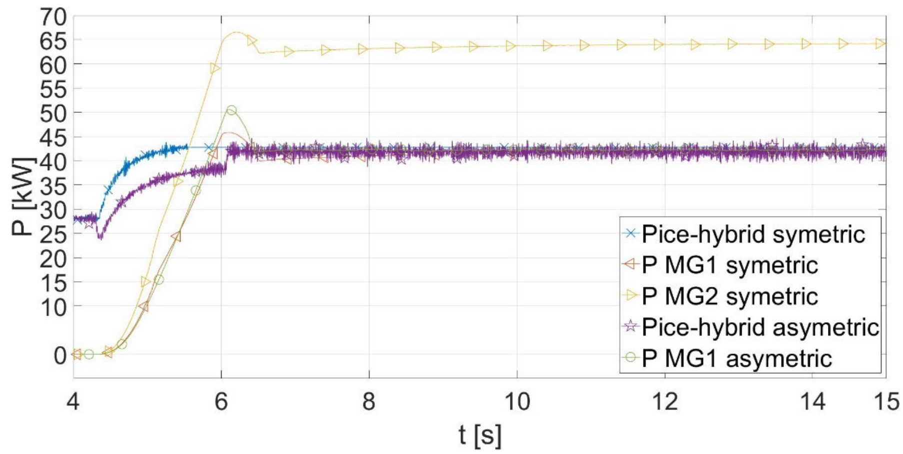

Figure 10 – Asymmetric vs symmetric hybrid powertrain power consumption- equal power on the inner track

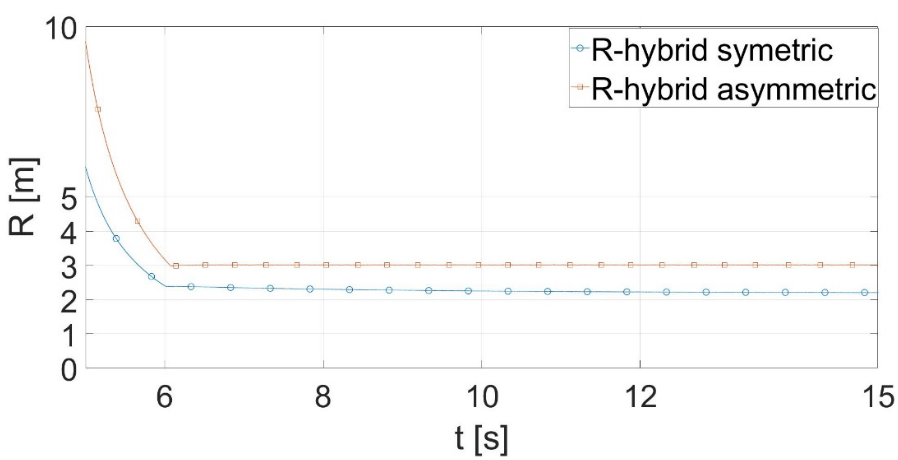

Figure 11 – Asymmetric vs symmetric hybrid powertrain turning radius- equal power on the inner track

The turning radius for the described scenario is shown in Figure 11.

When the inner track velocities are equal, i.e., is when the inner track electric motor delivers equal power in both symmetric and asymmetric hybrid powertrains, the vehicle with the symmetric hybrid powertrain has a lower turning radius Rsymmetric≈2 m, while Rasymmetric=3 m. The velocities follow the turning radius behavior, as shown in Figure 12.

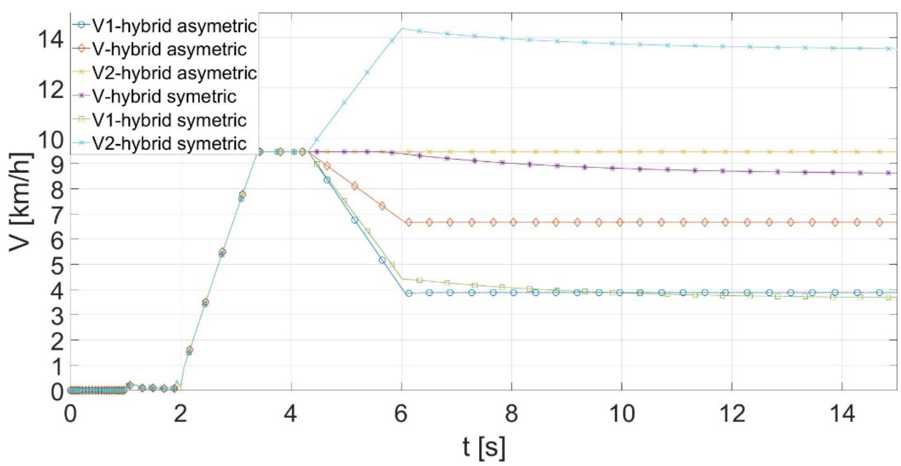

Figure 12 – Asymmetric vs symmetric hybrid powertrain vehicle velocities- equal power on the inner track

Discussion

The obtained results indicate that hybrid powertrains for high speed tracked vehicles, in most of cases, provide either increased power balance and efficiency or increased vehicle performances, compared to classic mechanical powertrains. The explanation for this lies in the fact that, in hybrid powertrains, the power required for the turning process is not provided by the ICE. The second reason is that the hybrid powertrain does not use friction clutches in the turning mechanism, so there are no slip losses.

Asymmetric hybrid powertrain vehicles will achieve the required turning radius with 40% lower overall power demands than the symmetric one, i.e., with the lowest electrical energy consumption. To achieve this, the vehicle velocity reduces. The symmetric hybrid powertrain has greater power consumption, but maintains vehicle velocity, which can be crucial in certain conditions.

For the same overall power demands, the asymmetric hybrid powertrain has a 40% lower turning radius in the analyzed working regime, which results in a lower manoeuvring area compared to the symmetric hybrid powertrain. In certain conditions, such as small manoeuvring space, or in urban conditions, a lower turning radius is more desirable.

When the inner track is loaded with the same turning resistance for both symmetric and asymmetric hybrid powertrains, the symmetric hybrid powertrain turns with a 33% lower turning radius than the asymmetric powertrain, but the overall power demand is 77% greater.

It would seem that, in almost all cases, the asymmetric powertrain is more efficient. However, the symmetric hybrid powertrain has two major advantages. First, the vehicle center of mass maintains the same velocity when the vehicle starts the turning process, which is very important given the nature of the vehicle utilization. The asymmetric hybrid powertrain vehicle reduces its velocity in every turning scenario.

The second significant advantage of the symmetric hybrid powertrain is the capability of making a pivot turn, around the central axis of the vehicle. During the years of high-speed tracked vehicle utilization, this advantage has shown to be extremely valuable, especially when the vehicle is utilized in urban conditions.

Conclusion

Improving the classic mechanical high-speed tracked vehicle powertrain into a hybrid powertrain improves the vehicle potential power efficiency and performance. The need to overcome the mechanical powertrain concept comes from the fact that mechanical powertrains lose significant amount of power due to losses in the friction elements due to slip, which has impact on the turning radius, manoeuvrability, stability and other vehicle performances.

Even though most of performance and power efficiency parameters go in favor of asymmetric hybrid powertrains where the same turning parameters are achieved with 40% less power, most of the world known manufacturers opted for symmetric hybrid powertrains. The symmetric hybrid powertrain has a great advantage - turning with a 33% lower turning radius than the asymmetric powertrain, and also the lowest theoretical turning radius, which is turning around the vertical axis of the vehicle, referred to as the pivot turn. Turning around the vertical axis allows the vehicle to turn in urban conditions and other areas that provide low manoeuvrability, which is one of the greatest advantages and parameters of a high-speed tracked vehicle. By utilizing electric motors as drive machines for the turning mechanisms, the turning algorithm can be fully controlled, making the turn with asymmetric increase/decrease of outer/inner track velocity. The suggested hybrid powertrain has the potential to be programmed in such a way that it provides the function of both asymmetric and symmetric turning mechanism, depending on the driver's demands.

Considering multiple improvements and virtues of the analyzed hybrid powertrain solutions, one obstacle stands before these powertrain solutions, and that is the power source which provides enough energy for the required working regimes. The capacity and power of the power sources have to be analyzed in detail, especially in the case of fully electric working regime of the powertrain and other conceptions including using electric motors for purposes other than trajectory correction. Opposite to the vehicle turning regime where electric motors are briefly used, rectilinear movement would demand significantly more electric energy from batteries which are charged by the ICE. Analyzing the ICE power needed for battery charging is obligatory in the mentioned working regimes.

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Evaluación de la eficiencia de diferentes concepciones de sistemas de propulsión híbridos para vehículos de orugas de alta velocidad

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CAMPO: ingeniería mecánica
TIPO DE ARTÍCULO: artículo científico original

Resumen:

Introducción/objetivo: El aumento en el desarrollo de sistemas de propulsión híbridos durante la última década puso a los vehículos de orugas de alta velocidad en el mismo centro de atención que los vehículos híbridos comerciales y de pasajeros. Hay varias concepciones de sistemas de propulsión híbridos para vehículos de orugas de alta velocidad que se *están investigando principalmente, pero todavía no hay una conclusión clara sobre cuál es la más eficiente. El principal obstáculo para una investigación más intensa es la creciente dificultad para producir un sistema de almacenamiento de batería que proporcione una potencia de alta densidad y protección y resistencia a los golpes. Sin embargo, existe un cierto número de estudios de investigación y prototipos desarrollados a partir de modelos de simulación que muestran un rendimiento satisfactorio para concepciones de sistemas de propulsión híbridos tanto asimétricos como simétricos.*

Métodos: El modelo de simulación híbrido desarrollado y verificado se mejora en términos de unidad de señal de comando, de modo que el sistema de propulsión y los motores eléctricos en el accionamiento auxiliar puedan operarse fácilmente en el régimen de trabajo híbrido asimétrico y en el régimen de trabajo híbrido simétrico. El objetivo principal es simular regímenes de trabajo específicos en los que se puedan evaluar el rendimiento y la eficiencia energética del sistema de propulsión híbrido simétrico y asimétrico para encontrar el concepto de sistema de propulsión más eficiente.

Resultados: Los resultados indican que el sistema de propulsión híbrido asimétrico tendrá menos consumo de energía general y un algoritmo de control más simple, debido a que controla un solo motor eléctrico. Para la misma potencia total, el sistema de propulsión híbrido asimétrico tiene un radio de giro menor, lo cual es satisfactorio. Cuando se conduce a máxima potencia, el sistema de propulsión híbrido simétrico tendrá un radio de giro más bajo y una mejor maniobrabilidad, pero aumentará considerablemente el consumo de energía.

Conclusión: El accionamiento asimétrico tiene una eficiencia energética claramente mejor, pero el accionamiento simétrico tiene la ventaja de un rendimiento máximo. Realizar un giro de pivote (alrededor del eje vertical) y realizar un giro sin reducir la velocidad del vehículo es de gran importancia, especialmente considerando el propósito especial más común de este vehículo y las maniobras en condiciones de terreno difíciles.

Palabras claves: vehículos de orugas de alta velocidad, sistemas de propulsión híbridos, análisis del proceso de giro, análisis del equilibrio de potencia.

Оценка эффективности различных концепций гибридных систем передачи мощности высокоскоростных гусеничных машин

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Резюме:

Введение/цель: Прогрессирующее развитие гибридных силовых установок в течение последнего десятилетия привлекло внимание к высокоскоростным гусеничным транспортным средствам. Существует несколько устойчивых концепций гибридных систем передачи мощности для высокоскоростных гусеничных машин, которые были тщательно исследованы и доведены до стадии прототипа, однако конкретного анализа и заключения о наиболее эффективной концепции нет. Основным препятствием для более глубоких исследований является проблема создания системы хранения аккумуляторных батарей, т.е. аккумулятора достаточной емкости и удельной мощности, устойчивому к ударам и нагрузкам, возникающим при использовании вышеупомянутых транспортных средств. Однако существует определенное количество научных исследований и прототипов, разработанных на основе имитационных моделей, которые демонстрируют удовлетворительную производительность как для асимметричных, так и для симметричных гибридных силовых установок.

Методы: Разработанная и проверенная гибридная имитационная модель усовершенствована с точки зрения блока командных сигналов, так что управление силовой установкой и электродвигателями вспомогательного привода максимально упрощено как в асимметричном, так и симметричном гибридном рабочем режиме. Основная цель состоит в моделировании конкретных режимов работы, при которых можно оценить производительность и энергоэффективность асимметричных и симметричных гибридных силовых установок для того, чтобы найти наиболее эффективную концепцию силового агрегата.

Результаты: Результаты показывают, что у асимметричной гибридной силовой установки будет меньшее

энергопотребление и более простой алгоритм управления благодаря управлению всего одним электродвигателем. При той же общей мощности у асимметричной гибридной силовой установки радиус поворота будет меньше, что является удовлетворительным показателем. При работе на полной мощности симметричный гибридный силовой агрегат будет иметь меньший радиус поворота и лучшую маневренность, но значительно увеличит энергопотребление.

Вывод: Асимметричный привод явно обладает большей энергоэффективностью, но преимущество симметричного привода заключается в максимальной производительности. Выполнение разворота (вокруг вертикальной оси) и выполнение разворота без снижения скорости транспортного средства имеет большое значение, особенно учитывая наиболее распространенное специальное назначение этого транспортного средства и маневрирование в сложных условиях местности.

Ключевые слова: высокоскоростные гусеничные машины, гибридные силовые установки, анализ процесса разворота, анализ баланса мощности.

Оцена ефикасности различитих концепција хибридних система за пренос снаге брзоходних гусеничних возила

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ОБЛАСТ: машинство
КАТЕГОРИЈА (ТИП) ЧЛАНКА: оригинални научни рад

Сажетак:

Увод/циљ: Захваљујући убрзаном развоју хибридних система за пренос снаге у последњој деценији, у центру пажње нашли су се и системи за пренос снаге брзоходних гусеничних возила. Постоји неколико устаљених концепција хибридних система за пренос снаге ових возила која су у великој мери истражена и доведена до фазе прототипа, али нема конкретних анализа и закључка о најефикаснијој концепцији. Главну препреку за интензивнија истраживања представља проблем производње складишта електричне енергије, односно батерија довољног капацитета и густине снаге, која би била отпорна на ударе и оптерећења која настају услед употребе наведених возила. Ипак, постоји одређени број истраживања и произведених прототипа, развијених из *симулационих модела, који показују задовољавајуће перформансе и карактеристике и за симетрични и за несиметрични хибридни систем за пренос снаге брзоходних гусеничних возила.*

Методе: Развијени и верификовани симулациони модел хибридне трансмисије специфичног брзоходног гусеничног возила унапређен је новом управљачком јединицом која омогућава олакшано управљање електромоторима у помоћном погону ради управљања несиметричним и симетричним заокретом возила. Главни циљ је симулирање специфичних режима рада помоћу којих се може извршити оцена перформанси и енергетске ефикасности несиметричних и симетричних хибридних система за пренос снаге брзоходних гусеничних возила, како би се установила најефикаснија концепција.

Резултати: Резултати указују да несиметрични хибридни систем за пренос снаге захтева мање укупне снаге за извршење заокрета и има знатно једноставнији алгоритам управљања, имајући у виду да се управљање врши само једним електромотором. За исту уложену снагу, несиметрични хибридни систем за пренос снаге имаће мањи полупречник заокрета, што је задовољавајуће. У режиму максималне ангажоване снаге, симетрични систем за заокрет имаће мањи полупречник заокрета и бољу управљивост, али и знатно повећање утрошка снаге у односу на несиметрични систем.

Закључак: Несиметрични систем за пренос снаге има, очигледно, бољу енергетску ефикасност. Међутим, предност симетричног система за пренос снаге је у максималним перформансама. Извођење пивот заокрета (заокрет око вертикалне осе возила) и заокрет без смањења брзине тежишта возила од великог су значаја, посебно имајући у виду специјалну намену ових возила и кретање у захтевним теренским условима.

Кључне речи: брзоходно гусенично возило, хибридни систем за пренос снаге, анализа заокрета возила, анализа биланса снаге.

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